ORGANIC REACTIONS

CHAPTER 1

ALKENE CROSS-METATHESIS REACTIONS

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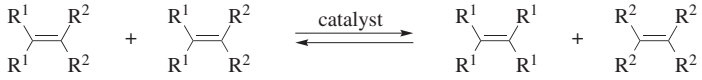
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INTRODUCTION

The term metathesis means "transposition" and comes from the Greek words μετα ("meta", meaning "change") and θεσις ("thesis", meaning "position"). The term "olefin metathesis" was coined in 1967[1] and refers to the metal-catalyzed redistribution of carbon–carbon double bonds. Thus, in olefin metathesis, carbons at the termini of two alkenes are exchanged to afford two new alkenes (Scheme 1).



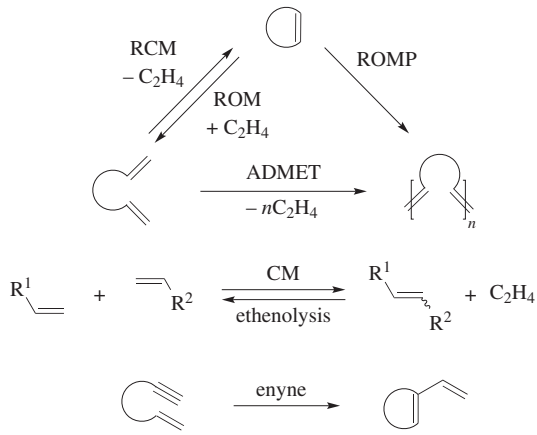
Scheme 1

Transition-metal-catalyzed olefin metathesis is one of the most powerful tools in organic chemistry for the formation of carbon–carbon double bonds.[2−4] This method has revolutionized the synthesis of a wide variety of useful organic molecules, with far-reaching applications in natural product synthesis,[5−8] medicinal chemistry,[9] macromolecular architectures,[10,11] solid-phase chemistry,[12,13] polymerization,[14−17] fine chemicals,[18] and target-oriented synthesis.[19] The spectacular success of this reaction culminated in the 2005 Nobel Prize in Chemistry being awarded to three primary contributors to this field: Grubbs, Schrock, and Chauvin.[20]

Types of Olefin Metathesis

The main advantage of this method is that several types of olefin metathesis transformations can be performed with the same catalysts, depending on the

reaction conditions and on the structural features of the substrates, as illustrated in Scheme 2.[3,7,19,22] Since the metathesis process is energetically neutral and reversible, a mixture of both starting substrates and products is obtained at equilibrium. Nevertheless, this intrinsic problem can be circumvented by the judicious choice of substrates and/or reaction conditions, so that one product type can be prepared selectively.



Scheme 2

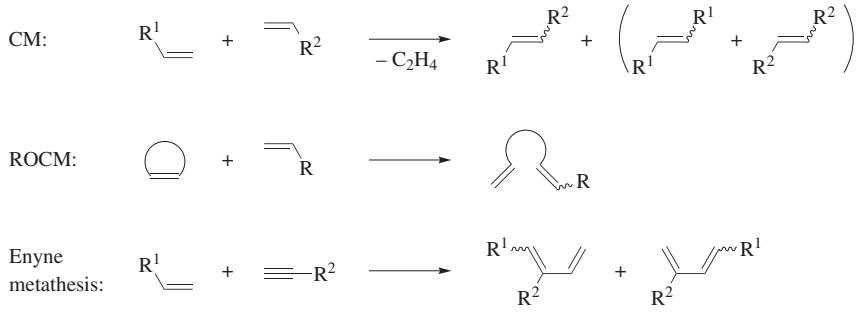
To date, the most widely used olefin metathesis reaction among synthetic organic chemists is the ring-closing metathesis (RCM) of dienes.[10,23–26] The formation of a ring is usually accompanied by the production of an equivalent of a volatile alkene (e.g., ethylene), which can be easily removed, thereby shifting the equilibrium toward the desired product. RCM facilitates the formation of many ring sizes, from five-membered rings to macrocycles of greater than 20 atoms.

The energy gained upon release of strain with cyclic alkenes (e.g., norbornene derivatives) is the driving force behind ring-opening metathesis polymerization (ROMP).[14,16,27] In many cases, the ROMP of strained cyclic alkenes initiated by metal alkylidene complexes exhibits the characteristic features of a living polymerization, and therefore, block copolymers can be prepared by sequential addition of different alkene monomers.

Acyclic diene metathesis polymerization (ADMET) is a second metathetical method for making polymers.[28–31] Dienes are polymerized with concomitant release of a low-molecular-weight, volatile alkene, usually ethylene. The polymer chain can grow further, usually in a living manner, by reaction with the double bond of a second diene molecule. ROMP and ADMET have been used to construct polymeric materials with a wide range of properties, including those with biological activity.

Intermolecular mutual exchange of alkylidene (or carbene) fragments between two alkene partners is known as cross-metathesis (CM).[32–36] The biggest challenge in

cross-metathesis is the chemo- and stereoselective formation of the desired compound from several potential reaction products. There are a few variations on the theme of cross-metathesis (Scheme 3): (1) cross-metathesis, (2) ring-opening cross-metathesis (ROCM),[37,38] and (3) enyne metathesis.



Scheme 3

Enyne metatheses are unique and interesting transformations that involve the reaction of an alkene and an alkyne. Two main types of enyne metathesis exist, namely, intermolecular and intramolecular variations. The products from these processes are synthetically useful butadiene derivatives, which lend themselves to structural elaboration, for example by Diels–Alder reactions and other cycloaddition processes. The intramolecular variant (sometimes called metathetical cycloisomerization of enynes) leads to cyclic products, including four-membered rings.[39,40]

Compounds containing several double and triple carbon–carbon bonds can undergo sequential or domino metathesis.[41–44]

Due to the importance of cross-metathesis reactions, several reviews have appeared on this topic.[45–50] Reviews by Blechert,[45] Astruc,[2,51] Fürstner,[19,52] and Grela[47] discuss olefin metathesis in general, whereas reviews by Grubbs,[46] Blechert,[34] Grela,[48,49] and O'Leary[50] address only cross-metathesis. This chapter focuses on state of the art methods in cross-metathesis, and the Tables provide examples through March 2020.

Metathesis (Pre)-Catalysts

Olefin metathesis catalysts are based on tungsten, molybdenum, and ruthenium. In general, ruthenium complexes are more stable towards air and moisture, while tungsten and molybdenum catalysts are more active and more resistant towards ethylene (the ruthenium methylidene complexes, [Ru]=CH_2, are relatively short-lived).[53–56] The most commonly used metathesis catalysts are presented in Figure 1 and are described in detail in "Metathesis Catalysts".

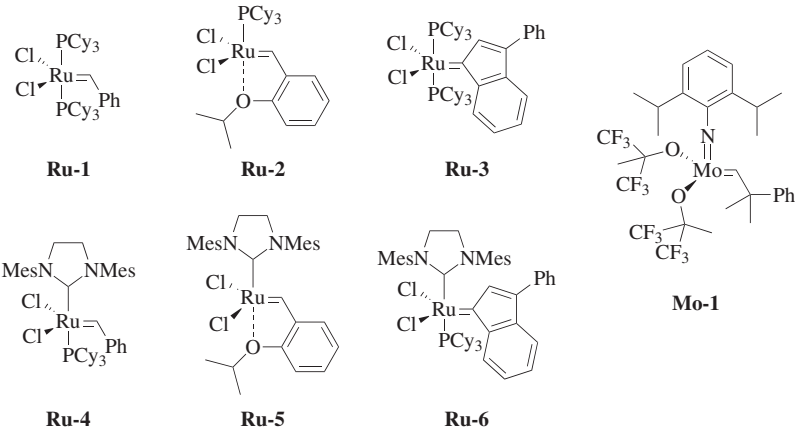
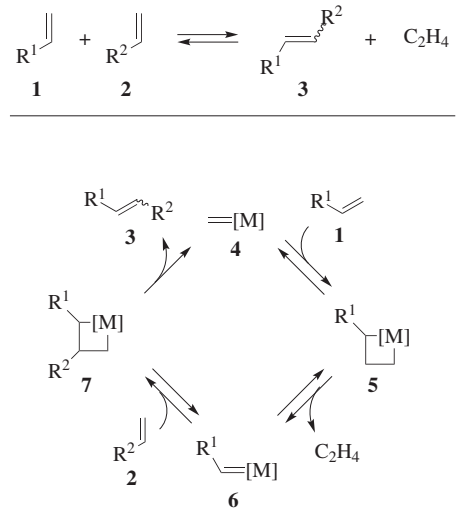


Figure 1. Grubbs (**Ru-1**, **Ru-4**), Hoveyda–Grubbs (**Ru-2**, **Ru-5**), indenylidene (**Ru-3**, **Ru-6**) and Schrock (**Mo-1**) complexes.

MECHANISM AND STEREOCHEMISTRY

General Mechanism for Olefin Metathesis

Several mechanistic hypotheses were proposed during early olefin metathesis exploration.[1,57,58] The commonly accepted mechanism involves first an alkylidene exchange between two reacting alkenes mediated by a transition-metal complex through formation of metallacyclobutanes as the pivotal intermediates (Scheme 4). The CM reaction is initiated when a metal alkylidene (methylidene) of type **4**—the



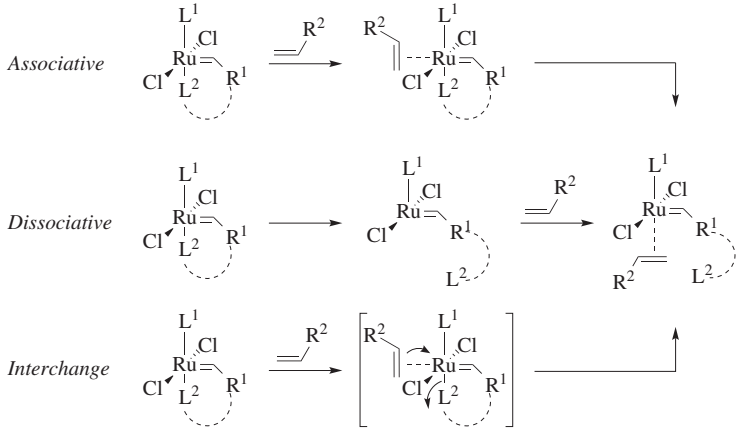
Scheme 4

active catalyst—reacts with the alkene substrate (**1**). Metallacyclobutane **5** is formed as an intermediate, in turn producing either ethylene and a new metal alkylidene **6**, or reverting back to the initiating species. Intermediate **6** reacts with the second alkene (**2**) to give, via metallacyclobutane **7**, the final product **3** and the complex **4**, which restarts the cycle.

Mechanism for Initiation of Metathesis Catalysts

Understanding the mechanisms for metathesis catalyst initiation is crucial for explaining the differences between Schrock (e.g., **Mo-1**) and Grubbs-type (e.g., **Ru-1** and **Ru-4**) complexes and can thus lead to the design of more active catalysts. Schrock-type complexes undergo the [2 + 2] cycloaddition with the alkene substrate directly to form the metallacyclobutane intermediate, which can be observed by NMR spectroscopy and, in some cases, can be isolated. An important feature of the Schrock $M(=NR^1)(=CHR^2)(OR^3)_2$ (e.g., **Mo-1**) species is the possibility of forming a *syn*-alkylidene, in which the alkylidene substituent R^2 is directed toward the imido ligand, or an *anti*-alkylidene, in which the alkylidene substituent points away from the imido nitrogen.[59] The fact that these alkylidenes can interconvert during a metathesis reaction has important consequences for developing (*Z*)-selective metathesis reactions and is discussed below (see Schemes 7 and 8).

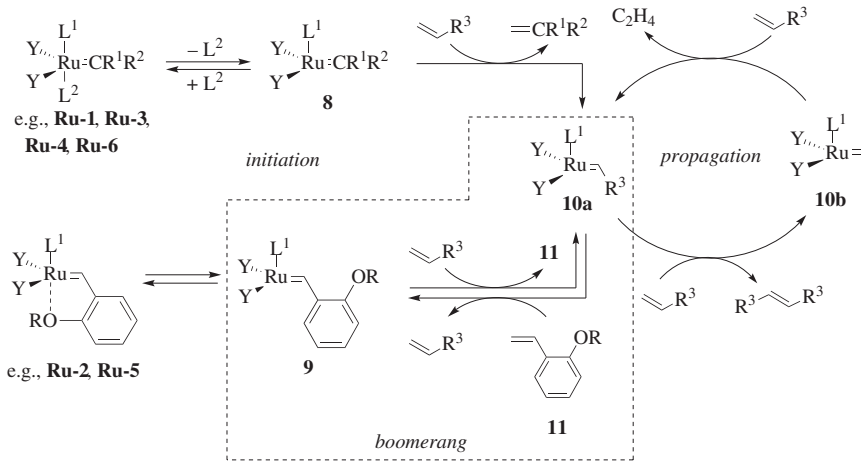
The mechanism can be even more complicated with ruthenium carbene complexes that bear neutral ligands capable of dissociation. Three mechanisms of ruthenium catalyst initiation have been proposed, based on experimental and theoretical studies: associative, dissociative, and interchange.[60] In the associative mechanism, the alkene binds ruthenium prior to the dissociation of a neutral ligand or its fragment; in contrast, the dissociative mechanism involves dissociation of the ligand first, and the resulting coordinatively unsaturated complex binds the alkene. In the interchange mechanism, the binding of the alkene and the loss of a ligand occur simultaneously (Scheme 5).



Scheme 5

Associative Mechanism. Experimental[60–62] and computational[63,64] studies indicate that the associative mechanism is generally disfavored owing to large energy barriers and steric repulsion between the ligands at an overcrowded six-coordinated center.

Dissociative Mechanism. According to the generally accepted mechanism, phosphine-containing catalysts (Grubbs-type, e.g., **Ru-1** and **Ru-4**, and indenylidene-type complexes, e.g., **Ru-3** and **Ru-6**) initiate by the dissociation of a neutral ligand to form 14-electron complex **8** (Scheme 6).[61] In the case of Hoveyda–Grubbs-type complexes (e.g., **Ru-2** or **Ru-5**), initiation according to the dissociative mechanism requires breakage of the oxygen–ruthenium coordination as a first step to form complex **9**.[65] Importantly, Grubbs-, indenylidene-, and Hoveyda–Grubbs-type catalysts should generate identical propagating species (**10a**) after a single turnover.



Scheme 6

The initiation of pyridine-bearing complexes[66] has been studied using DFT calculations, which conclude that the dissociative initiation mechanism is favored, although the associative mechanism is plausible with small substrates.[67]

Recent results challenge the belief that initiation of all ruthenium alkylidene complexes is identical and always begins with dissociation of a neutral ligand. For example, the simple dissociative mechanism has been questioned for Hoveyda–Grubbs-type catalysts,[68] and a process other than a dissociative mechanism was proposed for at least one of the phosphine-containing catalysts based on experimental and DFT studies.[69]

Interchange Mechanism. As mentioned above, the dissociative mechanism for Hoveyda–Grubbs-type catalysts has been challenged by experimental and in silico studies.[60] Computational analysis suggests that the interchange mechanism is the

most favorable from an energetic point of view.[70] Nevertheless, while most studies rule out the associative mechanism, in some cases the interchange and dissociative mechanisms cannot be clearly distinguished.[71] Initiation of Hoveyda–Grubbs-type catalysts is generally assumed to follow either the dissociative or the interchange pathway, depending on the nature and concentration of the alkene substrate.[60] Sterically small alkenes are thought to follow only the interchange mechanism, whereas larger ones typically follow the dissociative mechanism.[72]

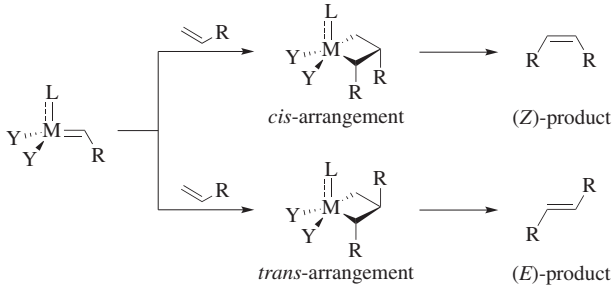
"Boomerang" Mechanism of Regeneration of Hoveyda–Grubbs-Type Complexes. To account for the high stability and the recoverability of Hoveyda–Grubbs-type complexes (e.g., **Ru-2**, **Ru-5**), a plausible "release–return" mechanism has been proposed.[73] The initiation step involves the release of alkoxystyrene **11** (Scheme 6); after the metathesis reaction is complete, the released alkoxystyrene **11** reacts with propagating species **10a** and **10b** to re-form the initial (pre)catalyst **9**. This release–return or "boomerang" mechanism has led to the design of a number of immobilized catalysts.[73] A study using deuterium labeling provides evidence that this mechanism is indeed operative under high catalyst-loading conditions (5 mol %).[74] However, the "boomerang" mechanism has been challenged, since there is no evidence for a release–return pathway when the olefin metathesis is carried out with a fluorophore-tagged Hoveyda–Grubbs catalyst.[75] A recent study involving crossover studies with a ^{13}C-labeled Hoveyda–Grubbs ligand demonstrates that the release–return mechanism is possible, at least under some conditions.[76] Consequently, there is currently no consensus on the validity of the release–return or "boomerang" mechanism, but regardless, this class of catalysts has been frequently, and with success, used in a number of challenging CM reactions.

Stereochemistry

Diastereoselectivity. A longstanding problem in olefin metathesis is lack of stereocontrol in the alkene product. The reversible character of olefin metathesis usually results in the formation of (*E*)- and (*Z*)-product mixtures. A higher proportion of the (*E*)-product is generally obtained using the ruthenium second-generation pre-catalysts, owing to their higher activity[77] and ability to equilibrate (*E*)/(*Z*) mixtures of products in the CM reaction to the thermodynamically more stable (*E*)-isomer. Similarly, α,β-unsaturated carbonyl compounds and alkenes with large substituents at the carbon–carbon double bond (such as vinyl sulfones, vinyl phosphine oxides, or alkenes with a *tert*-butyl group) give predominantly or exclusively (*E*)-products in CM, in which selective access to the corresponding (*Z*)-alkenes is limited in most cases.

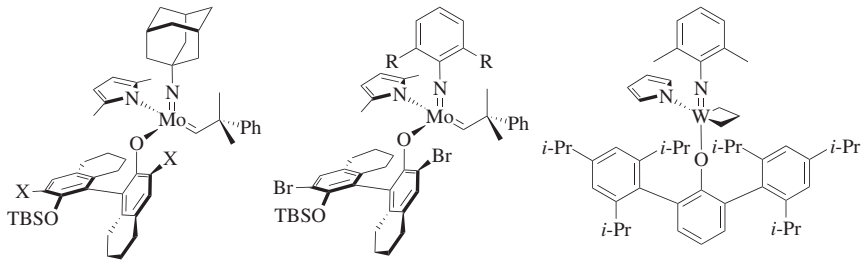
The (*E*)/(*Z*) selectivity in CM reactions can be linked to several factors. The geometry-determining step in the catalytic cycle is the formation of the metallacyclobutane. When substituents are placed in a *cis*-arrangement in the metallacyclobutane (Scheme 7), the (*Z*)-alkene forms upon cycloreversion of this intermediate. The *anti*-metallacycle produces the (*E*)-product, accordingly. Large

ligands placed in the proximity of the forming metallacyclobutane can force all the substituents into a *cis*-arrangement, leading to high (*Z*)-selectivity. However, the (*Z*)-alkene can re-enter the catalytic cycle and, in a so-called post-metathetic isomerization, can be transformed to the (*E*)-configured product, thereby eroding the stereoselectivity of the final product. The (*E*)-alkene, in contrast, is reluctant to coordinate with metal due to the distribution of substituents, leading to a kinetically controlled process.[78]



Scheme 7

Different families of catalysts, such as molybdenum-, tungsten-, and ruthenium-based complexes have been developed for (*Z*)-selective olefin metathesis reactions. The first (*Z*)-selective molybdenum-based olefin metathesis catalyst was described in 2008;[79] since then, significant advances in (*Z*)-selective catalysts have been described.[78] Typical molybdenum- and tungsten-based chiral complexes contain aryloxide ligands (usually biphenol or BINOL derivatives with different substitution patterns) and a pyrrolide moiety, and are referred to as monoalkoxide pyrrolide (MAP) complexes (Figure 2).



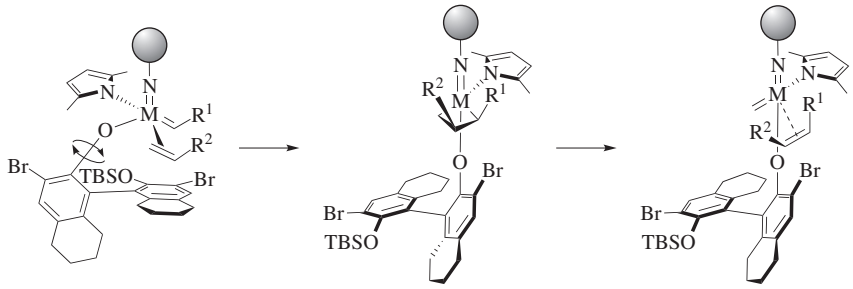
Mo-2 X = Cl
Mo-3 X = Br
Mo-4 X = I

Mo-5 R = Me
Mo-6 R = *i*-Pr

W-1

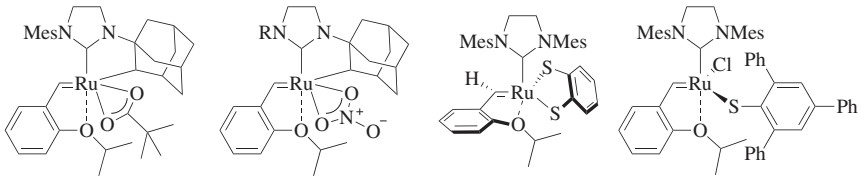
Figure 2. Representative monoalkoxide pyrrolide (MAP) molybdenum and tungsten complexes.

(*Z*)-Selectivity in the molybdenum-based catalyst family is the result of the interplay between the small imido group and the large and flexible monodentate aryloxide ligand. Rotation of the aryloxide ligand forces the substituents to orient toward the imido ligand, favoring formation of (*Z*)-alkenes (Scheme 8).[80] In homodimerizations of terminal alkenes, tungsten-based complexes usually lead to higher (*Z*)-selectivities than the analogous molybdenum catalysts.[81]



Scheme 8

Some carefully designed ruthenium complexes also exhibit enhanced (*Z*)-selectivity (Figure 3).[82–85]

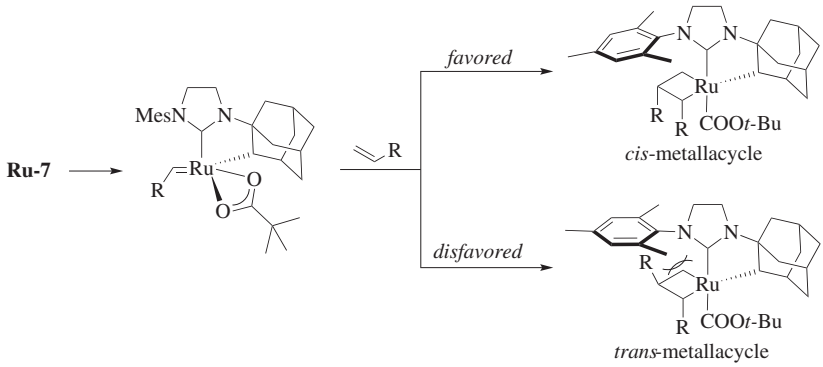


Ru-7 **Ru-8**, R = Mes; **Ru-9**, R = Mipp; **Ru-10**, R = Dipp **Ru-11** **Ru-12**

Figure 3. (*Z*)-Selective, ruthenium-based olefin metathesis catalysts.

Computational and experimental studies provide explanations for the (*Z*)-selectivity imparted by these catalysts.[86,87] The structure of these complexes favors formation of the *cis*-metallacycle, which leads to the (*Z*)-product. Formation of the (*E*)-product requires generation of a *trans*-substituted ruthenacycle, which in these cases is sterically unfavorable because the *N*-aryl group blocks the top of the ruthenacycle (Scheme 9).

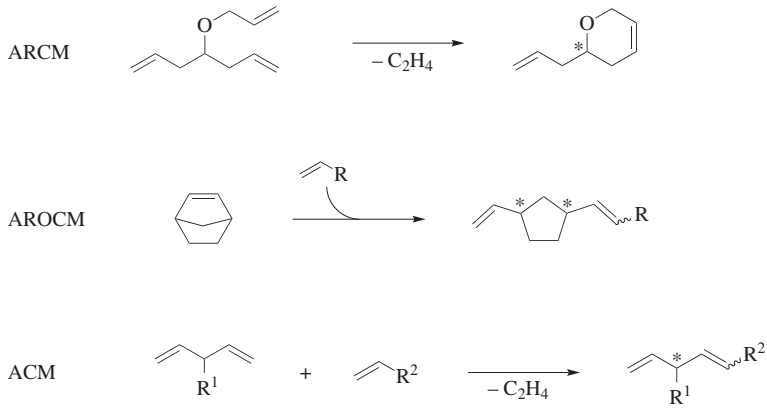
In the case of complex **Ru-12**, which possesses a 2,4,6-triphenylbenzenethiolate ligand, the rationale for the observed diastereoselectivity is similar.[85] A very large



Scheme 9

Y-type ligand blocks one side of the catalyst, forcing all of the substituents on the metallacycle to reside in a *cis* arrangement. However, so-called stereoretentive complexes like **Ru-11** exhibit preferential (*Z*)-selectivity with (*Z*)-configured substrates and (*E*)-selectivity when (*E*)-configured alkenes are used.[88,89]

Enantioselectivity. A chiral catalyst can, in principle, metathesize the two enantiomers of an alkene at different rates, thereby leading to a kinetic resolution; some examples exist in the context of RCM.[90] Stereocenters can also be created by CM-based desymmetrization of prochiral *meso*-compounds, as in the asymmetric ring-opening cross-metathesis (AROCM) and asymmetric cross-metathesis (ACM) reactions shown in Scheme 10. Figure 4 depicts chiral molybdenum-based catalysts that are used in enantioselective metathetical processes; tungsten catalysts may also be employed.[91]



Scheme 10

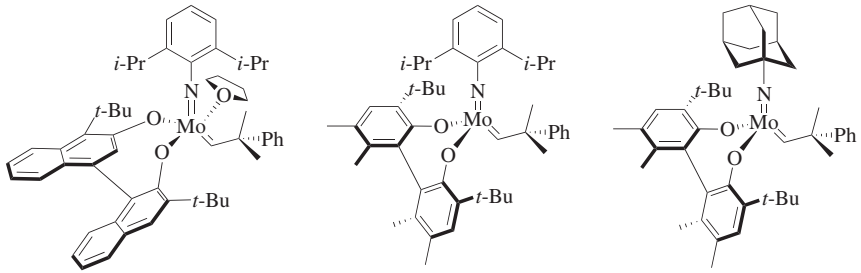


Figure 4. Chiral molybdenum-based complexes.

In ruthenium-based complexes, C_1- and C_2-symmetrical *N*-heterocyclic carbene ligands are employed to prepare chiral catalysts. The first chiral ruthenium-based metathesis catalyst was reported in 2001,[92] and a number of catalysts bearing C_2-symmetric NHC ligands have been developed. Bulky *ortho*-substituents on the *N*-aryl groups (Figure 5) exert beneficial influences on enantioselectivity in metathesis reactions.

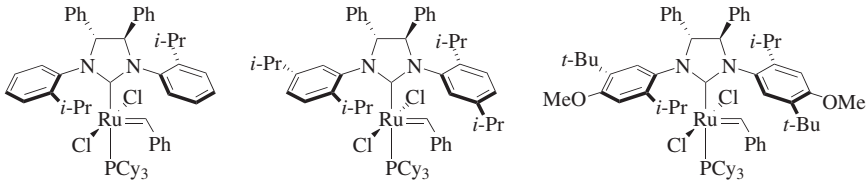


Figure 5. Ruthenium complexes with C_2-symmetric NHC ligands.

A conceptually unique class of ruthenium complexes bears axially chiral C_1-symmetric bidentate ligands (Figure 6). This type of chelating NHC group prevents free rotation of the ligand and generates a stereogenic center at the metal.[93] Complexes with a C_1-symmetric ligand provide higher enantioselectivity in model reactions compared to those with a C_2-symmetric ligand.[94–96]

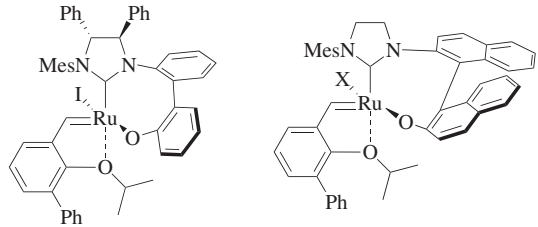
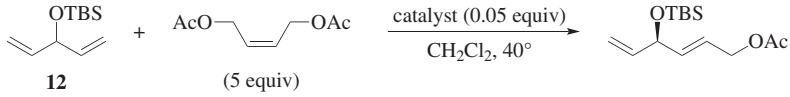


Figure 6. Ruthenium complexes with C_1-symmetric NHC ligands.

Asymmetric Cross-Metathesis (ACM). ACM processes are the most challenging enantioselective reactions because secondary metathesis events, which would generate symmetrically disubstituted products, must be avoided. Only terminal dienes can be used in such transformations. For example, the ACM of diene **12** can be accomplished with C_1- and C_2-symmetric catalysts (Scheme 11).[97,98] In the case of **Ru-8**, the product of ACM is formed with exclusive (*E*)-selectivity and is obtained in 35% yield and with 75:25 er.

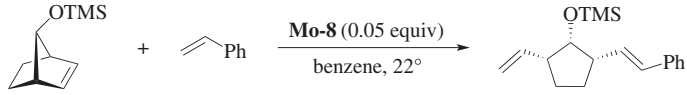


12 (5 equiv)

Cat.	Yield (%)	er
Ru-8	35	75:25
Ru-13	15	61:39
Ru-14	28	72:28
Ru-15	12	72:28

Scheme 11

Asymmetric Ring-Opening Cross-Metathesis (AROCM). AROCM reactions can be classified as a variant of ACM reactions, in which one of the substrates is a prochiral cycloalkene. A representative example is illustrated in Scheme 12.[99] The AROCM process is conducted using an achiral norbornene derivative in the presence of a chiral molybdenum complex, and the product is formed with excellent geometrical selectivity and enantioselectivity.

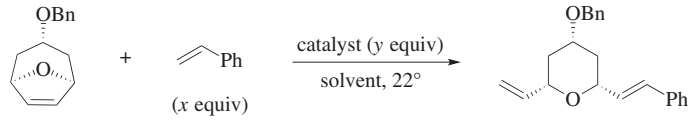


(85%) (*E*)/(*Z*) = 99:1
er 99:1

Scheme 12

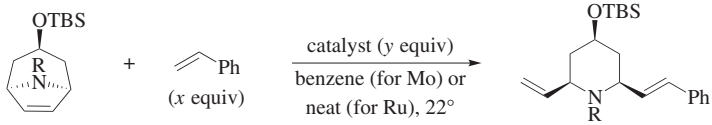
Desymmetrization of symmetrical, unsaturated oxabicyclic compounds provides direct access to a range of enantiomerically enriched tetrahydropyrans, which are versatile building blocks for target-oriented synthesis. Scheme 13 illustrates the efficiency and selectivity of various chiral metathesis catalysts.[91,100,101]

AROCM of azabicyclic compounds provides access to chiral *cis*-2,6-disubstituted piperidines, which are particularly important intermediates (Scheme 14).[102] The ruthenium-based catalyst **Ru-17** leads to higher enantioselectivity than **Mo-9** for the *N*-benzyl protected substrate, whereas the opposite is true for the *N*-methyl derivative. The Cbz-protected azabicycle reacts only in the presence of the molybdenum complex, and no product is obtained using **Ru-17**.



x	Cat.	y	Solvent	Time (h)	Yield (%)	er
5	**Mo-9**	0.05	benzene	1	0	—
5	**Ru-16**	0.02	neat	1	90	94:6
5	**Ru-17**	0.02	neat	1	70	98:2
2	**Ru-17**	0.02	neat	6	87	90:10
2	**Ru-18**	0.05	neat	36	85	95:5

Scheme 13



R	x	Cat.	y	Time (h)	Yield (%)	er
Me	10	**Mo-9**	0.05	1	95	97:3
Me	20	**Ru-17**	0.05	36	30	66.5:33.5
Bn	10	**Mo-9**	0.05	1	85	60:40
Bn	20	**Ru-17**	0.05	24	80	>99:1
Cbz	10	**Mo-9**	0.1	12	93	95:5
Cbz	10	**Ru-17**	0.1	12	0	—

Scheme 14

SCOPE AND LIMITATIONS

Introduction

Formation of a new carbon–carbon double bond by CM facilitates access to complex organic compounds from simple molecules.[103] Nevertheless, in addition to the desired reaction between cross partners, one or both of the starting alkenes can undergo unwanted homodimerization, thereby leading to complex mixtures of products. Studies by many academic and industrial research groups have led to the introduction of methods and reaction conditions for selective cross-metathesis. One of the key factors was the development of rules for attaining selectivity in CM reactions. If both of the CM partners exhibit similar reactivities with a given metathesis catalyst, the simplest way to achieve an acceptable yield of the cross-product is to employ the cheaper or more accessible alkene in excess (sometimes >10 equivalents) and then separate the resulting mixture of the homodimers and CM products. However, not all alkenes exhibit the same reactivity in metathesis and, for example, acrylonitrile and some trisubstituted alkenes do not readily undergo homodimerization. Therefore, a judicious choice of alkene partners can lead to

Table A Alkene Types for Selective Cross-Metathesis (as defined in 2003 by Grubbs et al.[36] Please note that classifications may differ for some catalysts).

Type	Properties	Examples
I	fast homodimerization homodimers consumed	α-alkenes, terminal alkenes with functional groups at distant positions, allylic silanes, allylic halides, primary allylic alcohols, allyl boronates, allylic phosphonates, protected allylic amines, styrenes (with no large *ortho* substituent), allylic sulfides, allyl ethers
II	slow homodimerization homodimers sparingly consumed	styrenes with a large *ortho* substituent, allylic stannanes, acrylates, acrylamides, acrylic acid, acrolein, vinyl ketones, vinyl epoxides, vinyl boronates, vinyl dioxolanes, alkenes bearing perfluoroalkyl groups, secondary allylic alcohols, unprotected tertiary allylic alcohols
III	no homodimerization	tertiary allylic amines, vinyl sulfones, vinyl sulfonamides,* 1,1-disubstituted alkenes, acrylonitrile, vinyl siloxanes, vinyl phosphonates, protected tertiary allylic alcohols, quaternary allylic carbons (all alkyl substituents), vinyl halides,* allylic nitro compounds*
IV	spectators to cross-metathesis	1,1-disubstituted alkenes, vinyl nitroalkenes, quaternary allylic carbon-containing alkenes, perfluorinated alkyl alkenes, protected tertiary allylic amines, *O*-protected trisubstituted allylic alcohols

(*denotes newer additions to this classification table)

enhancement of the CM reaction selectivity. A commonly accepted classification system of CM partners that can be used to predict selectivity was established by Grubbs et al. in 2003.[36] CM partners are divided into four categories depending on their rate of homodimerization with three prototypical catalysts: Schrock molybdenum alkylidene (**Mo-1**) and Grubbs first-generation (**Ru-1**) and second-generation (**Ru-4**) complexes. The four categories include CM partners that (I) undergo rapid homodimerization, (II) undergo slow homodimerization, (III) undergo no homodimerization, or (IV) do not participate in CM (Table A).

Using this table, the reactivity of each class of CM partners in a reaction with another class can be predicted. For example, alkenes of Type III should undergo selective CM with alkenes of Types I and II (Table B). In case of Type IV alkenes, CM reactions do not proceed but also do not cause deactivation of the metathesis catalyst

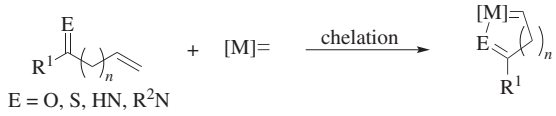
Table B Rules for Selectivity in CM.

	Type I	**Type II**	**Type III**	**Type IV**
Type IV	no reaction	no reaction	no reaction	no reaction
Type III	selective	selective	non-selective	no reaction
Type II	selective	non-selective	selective	no reaction
Type I	non-selective	selective	selective	no reaction

(those alkenes that do were omitted from the Grubbs classification). However, new complexes have been developed since 2003, and reactions of some alkenes initially classified as Type IV are now possible. Nonetheless, this model serves as a useful predictor of which alkenes will undergo selective cross-metathesis and, similarly, which combinations of substrates should be avoided.

The list of CM partners is updated regularly (e.g., substrates added recently are marked in Table A with an asterisk). In addition, some alkenes previously classified as inert in cross-metathesis (e.g., vinyl chlorides) can now successfully be employed using more recently developed molybdenum and ruthenium catalysts.[104–106]

In the following discussion, the most common CM partners belonging to Types I–III are arranged by the functional groups that they contain. With only a few exceptions, a functional group impacts reactivity only if it is attached directly to the double bond or in an allylic position; substituents situated in homoallylic or more distal positions usually have negligible effects on the metathesis reaction. Some Lewis basic groups present in the alkene can, however, form stable five- and six-membered ring chelates with the propagating species (Scheme 15), or can simply complex the organometallic catalyst, thereby partially or completely deactivating catalytic turnover.



Scheme 15

Metathesis Catalysts

Generally, olefin metathesis catalysts are based on tungsten, molybdenum, or ruthenium. Ruthenium complexes are generally less active, but they are more stable toward air and moisture than tungsten and molybdenum complexes, and as a result, the use of ruthenium catalysts is more common than that of the other metal catalysts. The development of active and robust ruthenium complexes has permitted the synthesis of many important building blocks. The most common ruthenium catalysts employed in organic synthesis are presented in Figure 1.

More recent studies have led to the development of ruthenium complexes with high activity, including the sterically activated complex **Ru-19** (Figure 7), the electronically altered complex **Ru-20**, and complexes with modified ethereal fragments (**Ru-21, Ru-22, Ru-23**). These catalysts have been successfully applied in target-oriented synthesis and in the pharmaceutical industry. Other modifications of the Hoveyda–Grubbs catalyst (**Ru-24, Ru-25, Ru-26**) have been made to increase solubility of the ruthenium catalyst in aqueous or protic solvents.

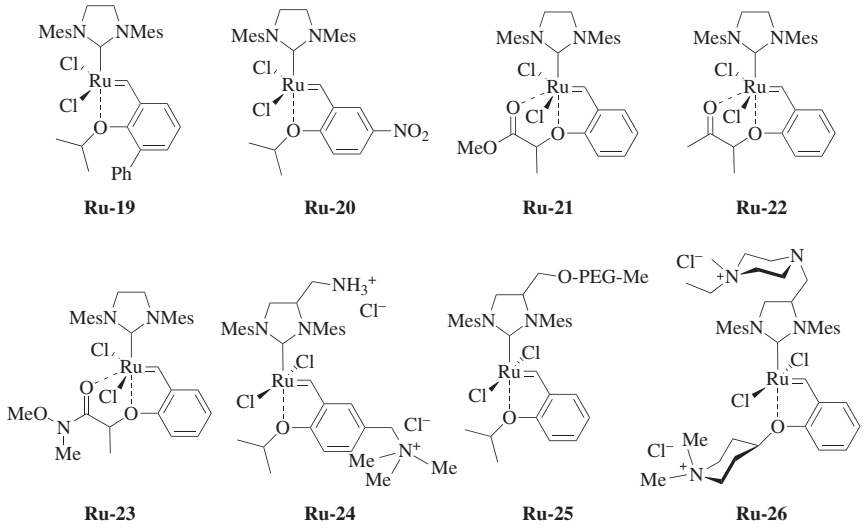


Figure 7. Analogues of the Hoveyda–Grubbs catalyst.

Molybdenum-based catalysts (Figure 8)[59,107] are generally more reactive than ruthenium-based catalysts, but they are sensitive to air and moisture. Nonetheless, modern molybdenum complexes have been widely used in enantioselective and diastereoselective metathesis,[2] and new, more user-friendly formulations of molybdenum catalysts have been introduced in recent years.[108,109]

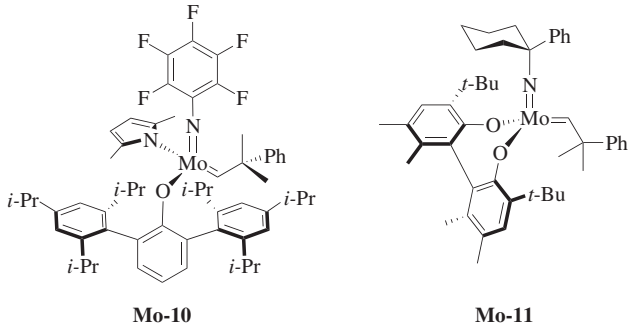


Figure 8. Selected molybdenum-based complexes used in metathesis.

Influence of Functional Groups on Alkene Classification and Selectivity

Hydrogen as a Functional Group (Ethenolysis). A synthetically valuable type of cross-metathesis involves the ethenolysis reaction, which uses ethylene as a cross-partner. Although not originally included in Table 1, ethylene can be classified as a terminal alkene with hydrogen as a functional group and can be formally recognized as a Type I partner, even though it cannot undergo homodimerization.[36] Ethenolysis of an internal alkene facilitates the selective production of a pair of terminal alkenes and has been successfully implemented in a number of syntheses.[110,111] One important industrial application of this process is the ethenolysis of unsaturated fatty acid esters, resulting in products (α-alkenes and unsaturated esters) that are valuable intermediates in the production of polymers and specialized materials and chemicals (Figure 9).[112−115]

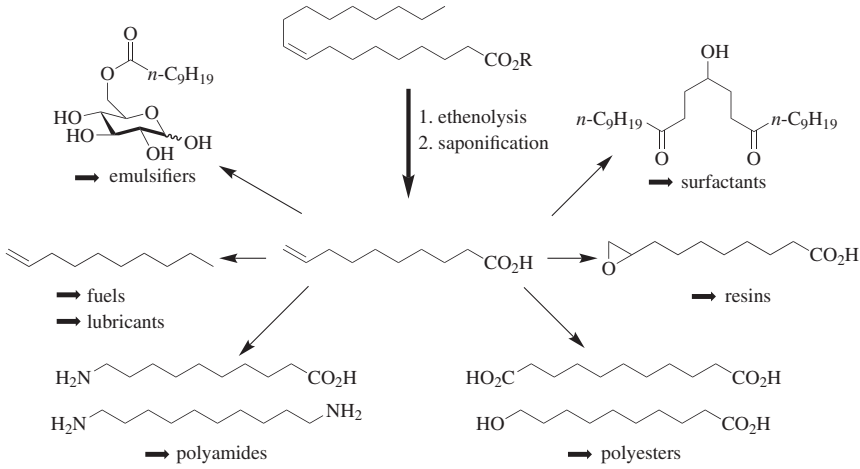
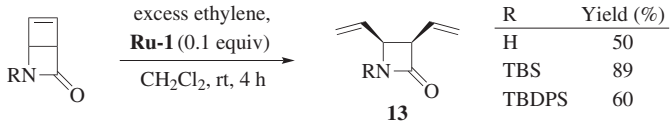


Figure 9. Valuable intermediates that can be derived from ethenolysis products.

Ethylene can also be used in other types of CM reactions.[116−118] For example, several β-lactams **13** are prepared in a ROM/CM process with ethylene (300 psi) at room temperature (Scheme 16).[119] The most effective catalyst for this particular transformation is Grubbs' first-generation complex **Ru-1**.

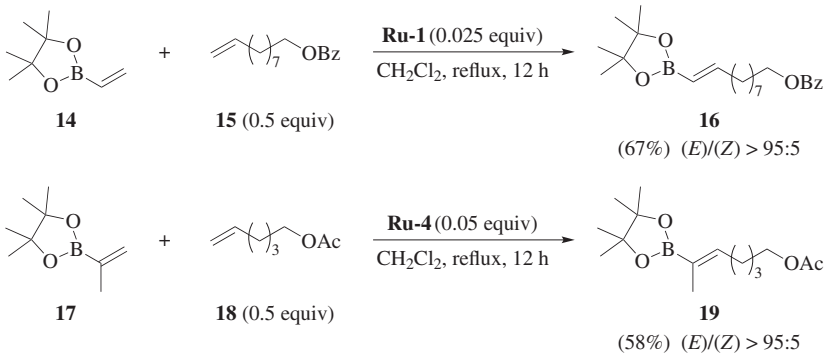


R	Yield (%)
H	50
TBS	89
TBDPS	60

Scheme 16

Boron-Bearing Alkenes. Alkenyl and allyl boronate esters are compounds of importance in organic synthesis, because they can be easily transformed into

many valuable products.[120−122] In addition, boron compounds are very useful intermediates in Suzuki-type cross-coupling reactions.[123] According to the general model of selectivity, allylic boronates are Type I alkenes, and alkenylboronates are Type II (e.g. **14**) or Type III (e.g. **17**) (they exhibit slow or no homodimerization).[36] Because of difficulties in preparing highly functionalized alkenylboron compounds, the cross-metathesis reaction represents a promising strategy for the formation of substituted alkenylboronates. Thus, reactions of pinacol boronic esters **14** and **17** with Type I terminal alkenes **15** and **18** in CH_2Cl_2 under reflux conditions lead to substituted alkenes **16** and **19**, respectively, in moderate yields (67% and 58%), favoring the less-hindered (*E*)-alkenes (Scheme 17).[124,125]



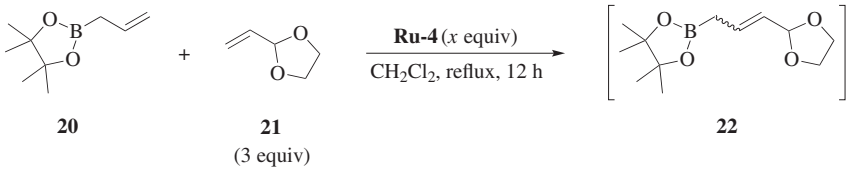
Scheme 17

Metathetical functionalization of allylboronates (Type I alkenes) proceeds more easily than CM of alkenylboronates, usually in higher yields and with high selectivities. In CM protocols, a pinacol allylboronate is usually treated with an excess of the alkene in the presence of the highly reactive Grubbs' second-generation catalyst (e.g., **Ru-4**).

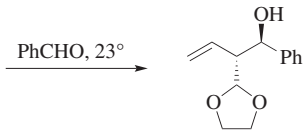
This approach has been employed in the one-pot formation of functionalized homoallylic alcohols that are synthetically useful intermediates. Thus, the reaction between pinacol allylboronate (**20**) and 2-vinyl-1,3-dioxolane (**21**) in the presence of Grubbs' second-generation catalyst **Ru-4** affords CM-product **22**, which is converted directly into homoallylic alcohol **23** in 69% yield and with excellent diastereoselectivity (Scheme 18).[126] Notably, reducing the loading of the catalyst from 5 mol % to 2 mol % does not impact the yield for this process.

Alkenes with Carbon-Based Functional Groups.

Alkenes Containing Linear Alkyl Groups. Terminal alkenes are classified as Type I substrates, and a typical procedure for CM is illustrated in Scheme 19 for the formation of lipidic amino acids.[127] In the CM of *N*-Fmoc-protected allyl glycine **24** and 1-decene, the best yields are obtained in either dichloromethane or ethyl acetate under reflux conditions with Hoveyda–Grubbs catalyst **Ru-5**. Optimization studies



20 + **21** (3 equiv) → **22**

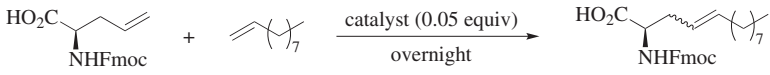


23

x	Yield (%)	*anti*/*syn*
0.02	69	>95:5
0.05	68	>95:5

Scheme 18

indicate that five equivalents of the *n*-alkene are required to minimize homodimerization of alkene **24** and thus afford the product **25** with high cross-selectivity.



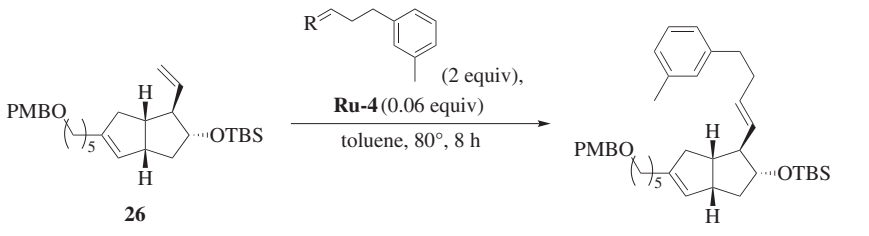
24 + (*x* equiv) → **25**

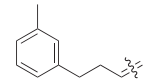
x	Cat.	Solvent	Temp	Conv (%)
1	**Ru-5**	CH_2Cl_2	rt	32
2	**Ru-5**	CH_2Cl_2	rt	65
5	**Ru-5**	CH_2Cl_2	reflux	93
5	**Ru-5**	EtOAc	reflux	90
5	**Ru-5**	CH_2Cl_2	rt	66
5	**Ru-4**	EtOAc	rt	52
5	**Ru-5**	EtOAc	rt	62
5	**Ru-5**	CH_2Cl_2	rt	52[a]
5	**Ru-5**	CH_2Cl_2	rt	87[b]
10	**Ru-5**	CH_2Cl_2	rt	70

[a] Molecular sieves were added to the reaction.
[b] The reaction was performed with an N_2 bleed.

Scheme 19

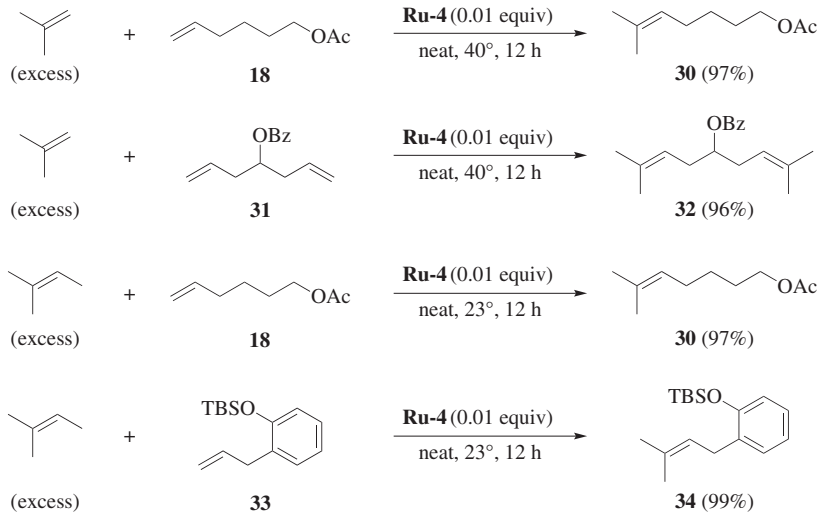
Another approach for selective CM with terminal alkenes that undergo fast homodimerization is illustrated in an elegant synthesis of an isocarbacyclin analogue (Scheme 20).[128] When bicyclic alkene **26** is treated with terminal alkene **27**, the expected product **29** is obtained in only 54% yield and with an (*E*)/(*Z*) selectivity of 88:12. However, changing the CM partner from terminal alkene **27** to symmetrical alkene **28**, which contains an internal double bond (formally a product of homodimerization of **27**), affords **29** in higher yield (69%) and with improved selectivity ((*E*)/(*Z*) = 90:10).



	R	Yield (%)	(*E*)/(*Z*)
27	CH_2	54	88:12
28		69	90:10

Scheme 20

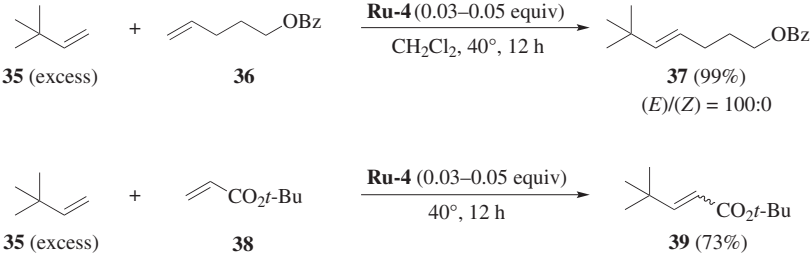
Sterically Hindered Alkenes. Carbon–carbon double bonds bearing bulky substituents are often unreactive in CM reactions. Sterically hindered di- or trisubstituted alkenes (Type III) do not undergo homodimerization but, due to the development of ruthenium complexes bearing NHC ligands, are effective in CM reactions with Type I and Type II alkenes leading to 1,1-disubstituted alkenes. Hence, the prenylation of terminal alkene **18** with isobutylene leads to **30** in high yield (Scheme 21);[129] isobutylene also reacts with other terminal carbon–carbon double bonds, as exemplified by the reaction with the prochiral homoallylic acetate **31** to form **32**. 2-Methyl-2-butene is a very useful CM partner that can be used in place of isobutylene, as illustrated



Scheme 21

in the reaction with alkene **18**. Similarly, 2-methyl-2-butene undergoes CM with the 2-substituted allylbenzene **33** to generate **34** in nearly quantitative yield (99%). In all of these cases, the Grubbs catalyst **Ru-4** provides the optimal results. Isobutylene and 2-methyl-2-butene are usually used in excess or the CM reactions are run neat, and very good product yields are obtained even with 1 mol % of the catalyst. Furthermore, because isobutylene and 2-methyl-2-butene have such low boiling points (–6.9° and 38.5°, respectively), they can be recovered from the crude reaction mixture.

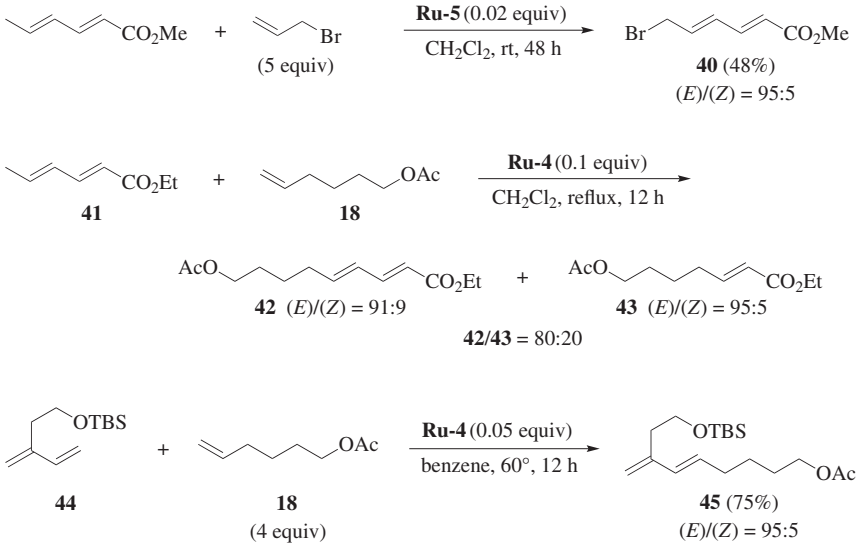
Alkenes containing sterically hindered allylic carbon centers (Type III alkenes) react smoothly with Type I and Type II alkenes using Grubbs' second-generation **Ru-4** and related catalysts. Steric hindrance at the allylic position inhibits homodimerization of alkene **35**, which can be used in excess, and the corresponding reaction with Type I substrate **36** provides the expected product **37** in high yield as only the (*E*)-isomer (Scheme 22).[36] Selective cross-metathesis between hindered alkenes (Type III) with Type II or Type III partners usually results in diminished conversions,[130] but good yields can be achieved with careful selection of reaction conditions. For example, in the CM with acrylic ester **38** (Type II), an excess of alkene **35** is required to afford a 73% yield of product **39**.[36]



Scheme 22

Alkenes Bearing Additional Carbon–Carbon Double Bonds. Cross-metathesis of conjugated dienes is possible, but in order for the reaction to occur with selectivity, one of the double bonds in the substrate must be significantly more reactive. For example, good selectivity is observed in reactions using a diene substituted with either an electron-withdrawing group or a bulky substituent. In general, the less-hindered double bond participates in the CM reaction, although sometimes a complex mixture of products is obtained. For example, methyl sorbate reacts with allyl bromide (a Type I alkene) to selectively afford the new diene **40**, albeit in modest yield (48%) (Scheme 23).[131] The cross-metathesis of ethyl sorbate (**41**) with another Type I partner, 5-hexenyl acetate (**18**), requires refluxing temperatures with a higher catalyst loading (10 mol %); the resulting nonselective metathesis of both carbon–carbon double bonds gives a mixture of products **42** and **43**.[132] If the two double bonds have sufficiently different reactivities, it is usually possible to obtain a single product in good yield. For example, the reaction of 2-substituted 1,3-butadiene **44** with terminal alkene **18** provides product **45** in 75% yield and with excellent (*E*)-selectivity.[132]

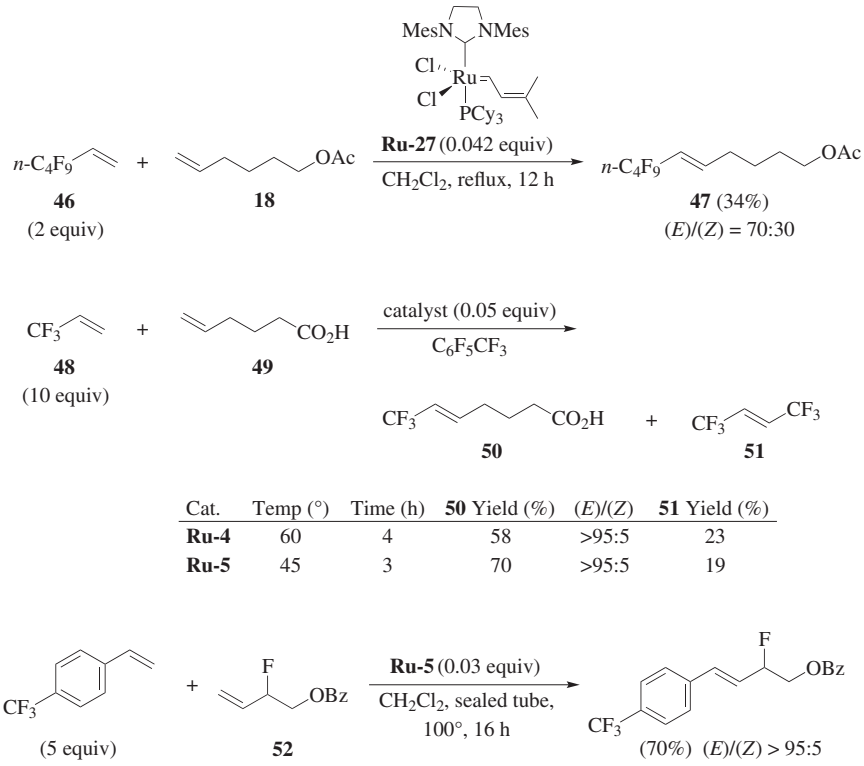
In these cases, the second-generation catalysts **Ru-4** and **Ru-5** exhibit better activities in the CM reactions, whereas the first-generation Grubbs catalyst either promotes homodimerization of the Type I partners (hex-5-en-1-yl acetate (**18**) or allyl bromide) or is deactivated by alkenes bearing electron-withdrawing groups.



Scheme 23

Alkenes Containing Perfluoroalkyl Groups. A number of examples that demonstrate the reactivity of perfluoroalkyl-substituted alkenes have been reported using both Hoveyda–Grubbs (**Ru-5**) and Grubbs (**Ru-4**) catalysts.[133−139] The CM reaction of Type I alkene **18** with **46** (Type II) results in the formation of the 1,2-disubstituted alkene **47** in 34% yield with moderate (*E*)/(*Z*)-selectivity (Scheme 24).[139] In the reaction between trifluoropropene (**48**, Type II) and Type I alkene **49**, improved yields of products **50** and **51** are obtained because a fluorinated aromatic hydrocarbon (FAH) is used as the reaction medium.[137] FAH solvents promote the initiation of the catalyst and also stabilize the propagating species, and therefore, can significantly improve the outcome of challenging cross-metathesis reactions.[140,141] Good yields can be also obtained when the reaction is conducted at high temperature in a sealed tube, as in the reaction between 4-(trifluoromethyl)styrene with the allylic fluoride **52**.[142] In some cases, the alkene partner that undergoes the faster homodimerization is used in excess.

Alkenes Bearing Aryl and Heteroaryl Substituents. Alkenes possessing an aromatic moiety at various distances from the reacting carbon–carbon double bond are common partners in olefin cross-metathesis. Such alkenes are typically classified as Type I and undergo facile CM and homodimerization reactions. Exceptions to this rule are styrenes bearing bulky substituents in the 2-position, which are considered to be Type II alkenes.



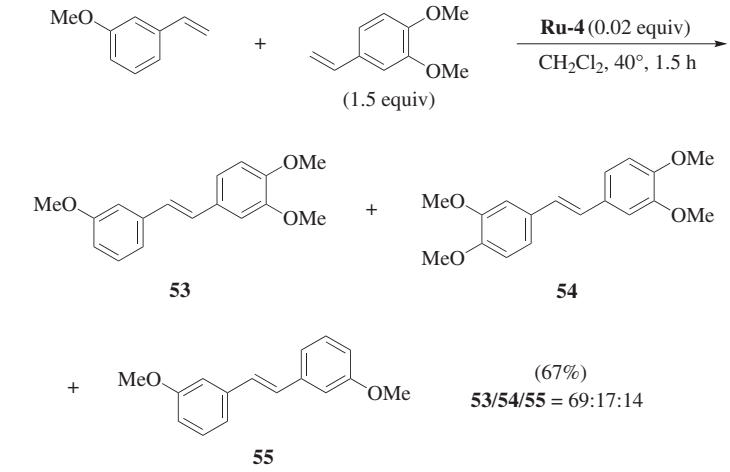
Cat.	Temp (°)	Time (h)	**50** Yield (%)	(*E*)/(*Z*)	**51** Yield (%)
Ru-4	60	4	58	>95:5	23
Ru-5	45	3	70	>95:5	19

Scheme 24

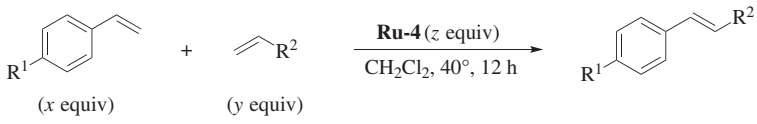
Coupling of Type I styrenes catalyzed by **Ru-4** has been applied in the synthesis of stilbenes, albeit they can sometimes suffer from statistical product distributions.[143] For example, Scheme 25 depicts the CM reaction of two similar styrenes (Type I) that results in a mixture of the desired product **53** and the homodimers **54** and **55**, which demonstrates a crucial limitation with specific types of CM reactions.

Type I terminal alkenes readily react with styrenes, as do α,β-unsaturated ketones **56**, terminal nitro alkenes **57**, α,β-unsaturated esters **58,** and vinylphosphonates **59** (i.e., alkenes of Types II and III) (Scheme 26).[144–146] These reactions are typically catalyzed by **Ru-4** or related second-generation catalysts, and provide the expected CM products in good-to-high yields and with stereoselectivities in favor of the (*E*)-isomer. Typically, the cheaper or more available CM partner is used in excess to diminish the homodimerization process of the other (more valuable) partner, thereby maximizing the yield for the desired CM product. Because many of the popular CM partners (acrylates, methyl vinyl ketone, acrolein, 1,4-dichloro-2-butene) are volatile, they can be readily removed from the reaction mixture, even when they are employed in excess.

For CM reactions between 2-substituted styrenes and simple Type I alkenes, the stoichiometry can dramatically impact the yield.[36] 2-Fluorostyrene (**60**) reacts



Scheme 25

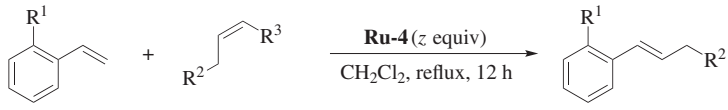


R^1	*x*		R^2	*y*	*z*	Yield (%)	(*E*)/(*Z*)
H	1	**56**	Et(O)C	2	0.05	99	95:5
H	1	**57**	$O_2N(CH_2)_4$	2	0.077	69	91:9
Br	1	**58**	MeO_2C	2	0.05	98	95:5
MeO	1.5	**59**	$(EtO)_2OP$	1	0.05	97	95:5

Scheme 26

with two equivalents of 1,4-diacetoxy-2-butene (**62**) (a cheap and easily removed CM partner) to furnish the expected product **63** in 98% yield and with exclusive (*E*)-selectivity (Scheme 27).[36] A nearly quantitative yield (98%) of CM product **64** is obtained in the reaction between 2-bromostyrene (**61**) and hex-5-en-1-yl acetate (**18**) when the former is used in excess. However, the yield decreases to 80% when a 1:1 ratio of **61** and **18** is employed.

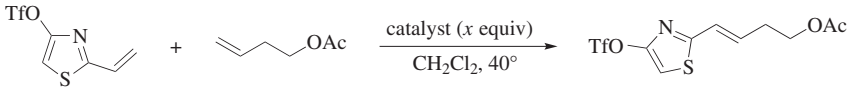
Similar to styrenes, vinyl-substituted heterocycles, such as **65**, are often used in cross-metathesis reactions (Scheme 28).[147] These molecules are classified as Type I or II partners and readily participate in CM transformations, usually proceeding in good yields and (*E*)/(*Z*) selectivities. Substrates containing heteroatoms that can coordinate to the metal catalysts (pyridine, thiophene, etc.) can be problematic, but such issues can often be circumvented with either an additive (e.g., a Lewis acid) or by modifying the reaction conditions (e.g., concentration, solvent, or the use of microwave irradiation).[148]



(*x* equiv) (*y* equiv)

	R^1	*x*		R^2	R^3	*y*	*z*		Yield (%)	(*E*)/(*Z*)
60	F	1	**62**	AcO	$AcOCH_2$	2	0.05	**63**	98	>99:1
61	Br	3	**18**	$AcO(CH_2)_3$	H	1	0.045	**64**	98	>99:1
61	Br	1	**18**	$AcO(CH_2)_3$	H	1	0.045	**64**	80	>99:1

Scheme 27



65 (1.5 equiv)

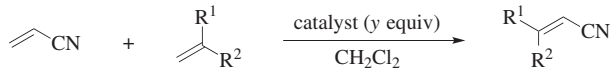
Cat.	*x*	Time (h)	Yield (%)	(*E*)/(*Z*)
Ru-4	0.1	18	63	89:11
Ru-5	0.05	24	58	87:13

Scheme 28

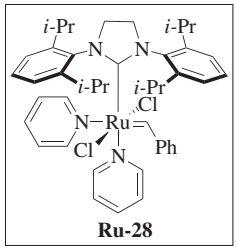
Unsaturated Nitriles. Alkenes bearing a cyano group are particularly useful CM partners because this substituent can be readily transformed into other functional groups, such as carboxylic acids, amides, and amines. The most common unsaturated nitrile used in CM reactions is acrylonitrile (Scheme 29).[149−151] Because acrylonitrile possesses a very electron-deficient double bond, it does not homodimerize easily and is classified as a Type III partner, which permits good chemoselectivity with most cross-coupling partners of Types I and II. Nevertheless, the use of acrylonitrile in a large excess is not advisable, as it can poison the more commonly employed ruthenium catalysts.[152] Interestingly, in contrast to the reactions with acrylic esters, the (*Z*)-product typically predominates in the CM reactions with acrylonitrile, albeit the stereoselectivity is rather poor ((*E*)/(*Z*) = 1:3 to 1:1).

Examples of CM with acrylonitrile reveal that the best results are achieved using Schrock's catalyst **Mo-1**.[149] Grubbs' second-generation catalyst usually affords lower yields compared to the **Ru-5** complex,[153] although the inclusion of copper(I) chloride can improve the product yields.[150] Surprisingly, a reasonable yield (61%) is observed for the CM reaction between acrylonitrile and methyl methacrylate (Type III) in the presence of the Grubbs' second-generation catalyst **Ru-28**, albeit the addition of the Lewis acid titanium(IV) isopropoxide (20 mol %) is necessary.[151] Cyclic alkyl amino carbene catalysts have also proven successful in this regard.[152]

The ability to employ a higher nitrile homologue, allyl cyanide, in CM has proven particularly challenging (Scheme 30).[154] The ligation of the CN group to the ruthenium is thought to decrease the efficiency of unsaturated nitriles as cross-metathesis partners.

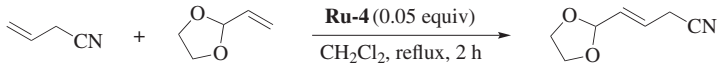


R^1	R^2	x	Cat.	y	Additive	Temp (°)	Time (h)	Yield (%)	(*E*)/(*Z*)
H	$TMSCH_2$	2	**Mo-1**	0.05	—	rt	3	76	25:75
H	$Br(CH_2)_3$	2	**Mo-1**	0.05	—	rt	3	45	12:88
H	$HO(CH_2)_3$	1	**Ru-4**	0.01	—	40	overnight	29	—
H	$HO(CH_2)_3$	1	**Ru-4**	0.01	CuCl	40	overnight	53	—
Me	MeO_2C	1	**Ru-28**	0.02	—	45	12	36	50:50
Me	MeO_2C	1	**Ru-28**	0.02	$Ti(Oi\text{-}Pr)_4$	45	12	61	50:50



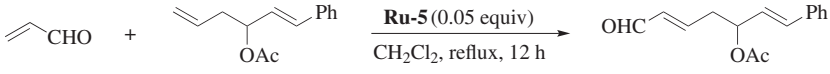
Ru-28

Scheme 29



Scheme 30

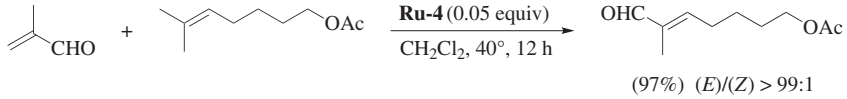
Unsaturated Aldehydes. Acrolein, the simplest unsaturated aldehyde (Type II), is difficult to work with because of its unpleasant odor and ease of polymerization, but it can be readily replaced by crotonaldehyde.[155] Although CM reactions with acrolein are catalyzed by **Ru-1**,[156] the second-generation Grubbs and Hoveyda–Grubbs catalysts provide improved results in most reactions; one such CM reaction is illustrated in Scheme 31.[157]



Scheme 31

Methacrolein can be employed in CM reactions with Grubbs second-generation complex **Ru-4** as the catalyst.[36] This transformation is characterized by high

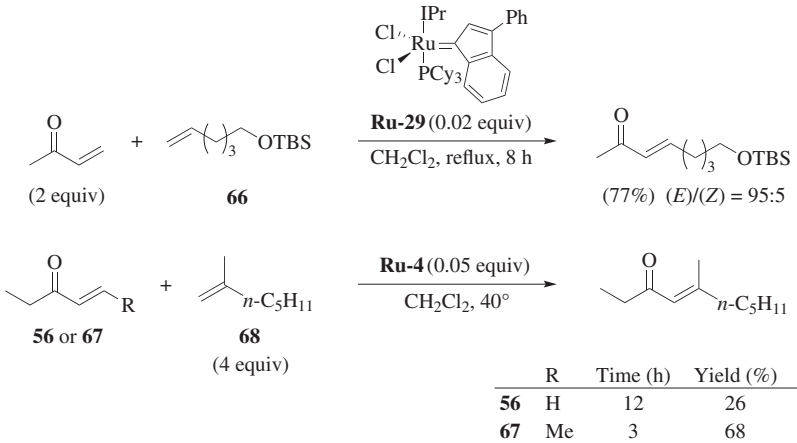
stereoselectivity in favor of the (*E*)-isomer (Scheme 32). Notably, methacrolein is a Type III alkene and is thus very slow to homodimerize.



Scheme 32

Alkenes containing a formyl group in an allylic or more distant position have reactivity similar to terminal alkenes (Type I) and can be used in CM without difficulty.[158,159]

Unsaturated Ketones. α,β-Unsaturated ketones are excellent Type II partners in cross-metathesis. Methyl vinyl ketone reacts in good yield and with high stereoselectivity ((*E*)/(*Z*) = 95:5) with alkenes of Type I (e.g., **66**, Scheme 33) and Type II. Hoveyda–Grubbs-type complexes usually provide the best results.[160] However, reactions of α,β-unsaturated ketones with less reactive cross-partners are more problematic, as is exemplified in the CM of ketones **56** and **67** with **68**, which afford poor geometrical control.[161]



	R	Time (h)	Yield (%)	(*E*)/(*Z*)
56	H	12	26	67:33
67	Me	3	68	67:33

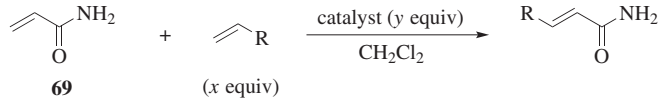
Scheme 33

Terminal alkenes containing a ketone moiety in a distal position are classified as Type I alkenes and react smoothly with cross partners of Types I–III.[162−164]

Unsaturated Carboxylic Acids and Their Derivatives. Applications of acrylic acid derivatives in cross-metathesis are widespread; these compounds, along with α,β-unsaturated acids, acid chlorides, esters, and amides, are Type II alkenes.

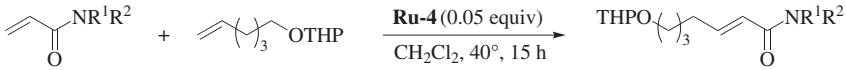
CM reactions between acrylic acid derivatives and terminal alkenes provide products in good-to-excellent yields and with very high (*E*)/(*Z*) selectivities.

A study on the reactivity of α,β-unsaturated amides with other types of alkenes is presented in Scheme 34.[165,166] Unsaturated amides are more demanding partners than esters and thus require more forcing conditions, such as reflux temperatures or higher catalyst loadings.[166] Unsaturated amides such as **69** and **70** react efficiently with terminal alkenes using Grubbs (**Ru-4**) and Hoveyda–Grubbs (**Ru-5**) complexes to afford the products with excellent (*E*)-selectivities.



69 (*x* equiv)

R	*x*	Cat.	*y*	Temp (°)	Time (h)	Yield (%)	(*E*)/(*Z*)
$H_2NC(O)$	1	**Ru-5**	0.005	100 (MW)	0.25	63	91:9
$AcO(CH_2)_4$	1.25	**Ru-4**	0.05	40	15	90	>99:1



70 (1.25 equiv)

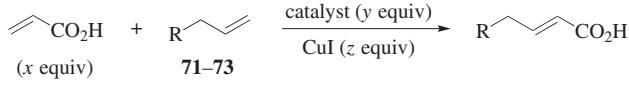
R^1	R^2	Yield (%)	(*E*)/(*Z*)
MeO	Me	89	98:2
Ph	Ph	100	98:2

Scheme 34

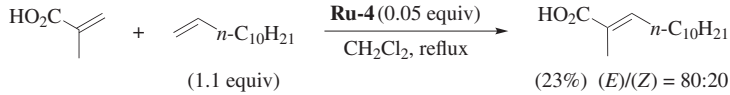
Acrylic acid is a Type II alkene and is well tolerated by most ruthenium catalysts. However, because of the electron-deficient character of the double bond, some transformations with less reactive alkenes are challenging. The reactions of acrylic acid with allylsilanes **71** and **72**, as well as with the allylbenzene derivative **73**, proceed in very good yields and with high (*E*)-selectivities (≥95:5) with second-generation ruthenium catalysts (**Ru-4** and **Ru-5**) (Scheme 35).[36,167,168] In the case of methacrylic acid (a Type III alkene), the CM yield decreases because of the increased steric bulk on this alkene component.[36]

Compounds bearing a carboxyl functionality at an allylic position (as in **74**) or in a more distant position typically exhibit the same reactivity as simple terminal alkenes (Scheme 36).[169]

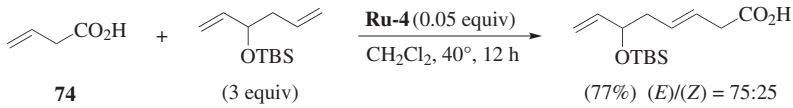
Cross-metathesis reactions of α,β-unsaturated esters and lactones provide important intermediates that are frequently used in target-oriented syntheses.[34] In this class of molecules, the most common substrates are acrylate esters **38** and **58**, which are classified as Type II alkenes (Scheme 37).[36,161,170,171] These substrates react with various alkenes using a range of catalysts, including Grubbs- (**Ru-4**), indenylidene- (**Ru-29**), and Hoveyda–Grubbs-type (**Ru-20**) complexes. Since the methyl and



	R	*x*	Cat.	*y*	*z*	Solvent	Temp	Time (h)	Yield (%)	(*E*)/(*Z*)
71	TMS	1	**Ru-5**	0.05	—	CH_2Cl_2	rt	12	60	97:3
72	Ph_3Si	1	**Ru-5**	0.05	—	CH_2Cl_2	rt	12	70	97:3
73	2-TBSOC_6H_4	3	**Ru-4**	0.02	0.03	Et_2O	35°	3	82	>95:5

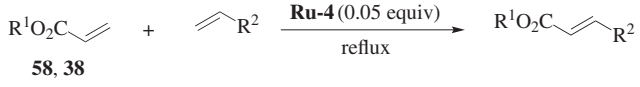


Scheme 35

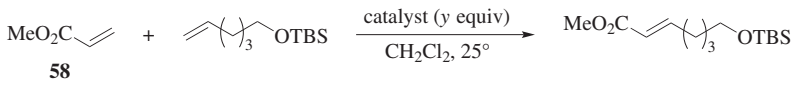


Scheme 36

tert-butyl acrylic acid esters are volatile, they can be used in excess and then removed under vacuum after the reaction is complete. In general, α,β-unsaturated esters react with alkene partners to afford (*E*)-products with excellent stereoselectivities ((*E*)/(*Z*) = 95:5 to 99:1).



	R^1	*x*	R^2	Solvent	Time (h)	Yield (%)	(*E*)/(*Z*)
58	Me	2	Ac	CH_2Cl_2	3	41	91:9
38	*t*-Bu	excess	*t*-Bu	—	12	73	—

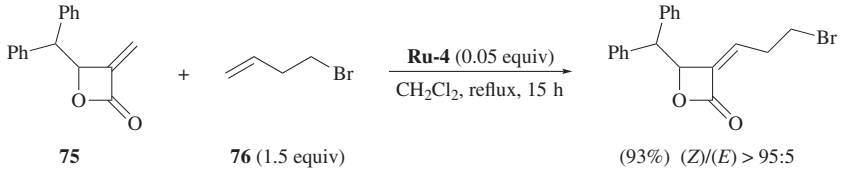


x	Cat.	*y*	Time (h)	Yield (%)	(*E*)/(*Z*)
0.5	**Ru-20**	0.01	0.5	95	95:5
2	**Ru-29**	0.02	3	88	>95:5

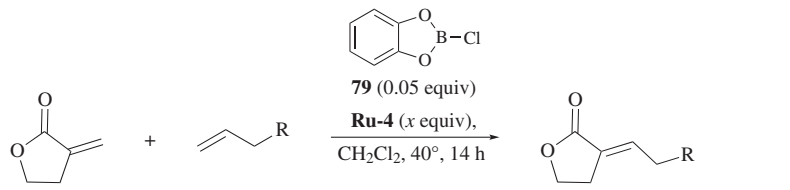
Scheme 37

Methylenelactones **75**[172] and **77**[173] (Type III alkenes) seem to be rather problematic partners in CM reactions, but transformations with less demanding substrates such as **71**, **76**, or **78** have provided good results (Scheme 38). In the case of lactone

75, 5 mol % of Grubbs' second-generation catalyst was needed to obtain the desired product in high yield (93%). Compound **77** was more problematic,[173] and in the metathesis reaction with 4-methylpentene, the catalysts **Ru-1** and **Ru-5** did not yield any of the desired product. The use of **Ru-4** was more successful, providing the desired product in up to 55% yield, along with unreacted substrate **77** and its isomer, 3-methyl-2(5*H*)-furanone. In an effort to further improve the yield, the influence of different additives was evaluated, and the Lewis acid *B*-chlorocatecholborane (**79**) was found to provide the best results. In the presence of this additive and **Ru-4**, the metathesis reactions of **71** and **78** with **77** generate the desired products in 81% and 59% yields, respectively (Scheme 38).



75 **76** (1.5 equiv) (93%) (*Z*)/(*E*) > 95:5

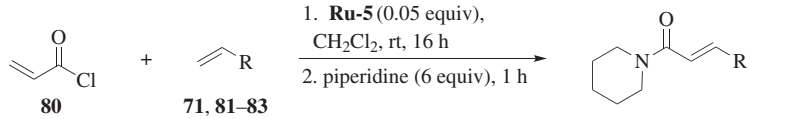


77 **71** or **78** (1.5 equiv)

	R	*x*	Yield (%)	(*E*)/(*Z*)
71	TMS	2 × 0.025	81	83:17
78	$(EtO)_2OP$	2 × 0.025	59	83:17

Scheme 38

Interestingly, the cross-metathesis of highly reactive acryloyl chloride (**80**) is efficiently catalyzed by the Hoveyda–Grubbs second-generation catalyst **Ru-5**, providing a product that can be easily functionalized further. To this end, the freshly distilled acryloyl chloride (**80**) reacts with various terminal alkenes (such as **71**, **81**–**83**) to provide an efficient one-pot preparation of α,β-unsaturated amides (Scheme 39).[174]



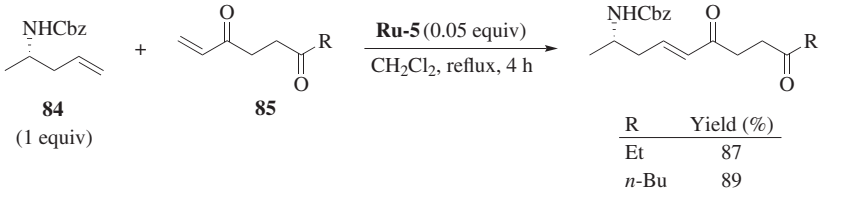
80 (1.5 equiv) **71**, **81**–**83**

	R	Yield (%)
71	$TMSCH_2$	87
81	n-C_6H_{13}	86
82	Ph	54
83	$PhCH_2$	86

Scheme 39

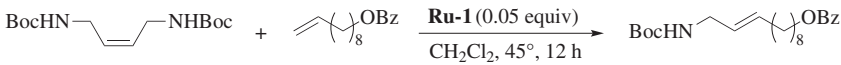
Alkenes That Have Nitrogen-Based Substituents. Alkenes containing a basic nitrogen atom (e.g., an unsaturated amine) are problematic substrates in cross-metathesis reactions because they form stable complexes with ruthenium-based catalysts. To circumvent this problem, the basic nitrogen is usually protected with Ts, Boc, Cbz, or other electron-withdrawing groups, or it is converted into an ammonium salt.

Allylic and Homoallylic Amines. *N*-Protected homoallyl- and allylamines (e.g., **84** and **86**, respectively) are classified as Type I alkenes. As illustrated in Scheme 40, Hoveyda–Grubbs catalyst **Ru-5** promotes CM reactions between the *N*-protected homoallylamine **84** with alkenes of Type II (e.g., **85**) in good yields (87% for R = *n*-Bu and 89% for R = Et).[175] Similarly, the *N*-protected allylamine **86** participates in CM with dec-9-en-1-yl benzoate (**15**) with Grubbs' first-generation complex **Ru-1** to furnishes **87** in 71% yield, albeit with moderate stereoselectivity ((*E*)/(*Z*) = 75:25) (Scheme 40).[176] Allylamines with additional substitution at the allylic position are classified as Type III alkenes and are challenging partners for this process. For example, *N*-benzoyl amine **88** reacts with Type I alkene **89** in

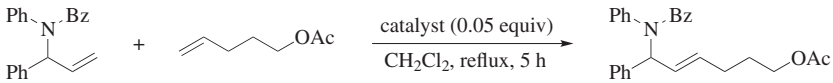


84 (1 equiv) **85**

R	Yield (%)
Et	87
n-Bu	89

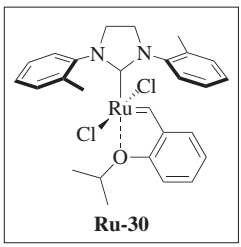


86 (4 equiv) **15** **87** (71%) (*E*)/(*Z*) = 75:25



88 **89** (3 equiv)

Cat.	Yield (%)	(*E*)/(*Z*)
Ru-5	19	>95:5
Ru-30	30	>95:5

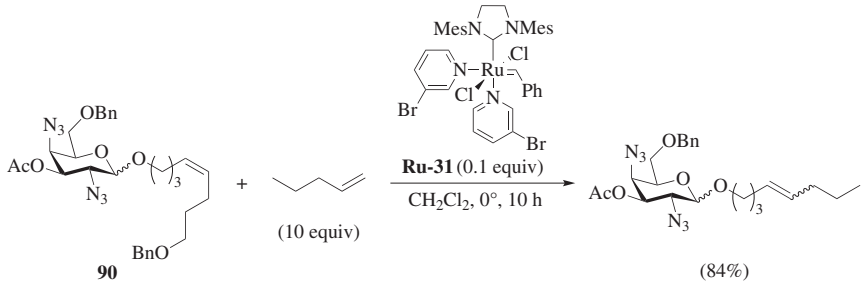


Ru-30

Scheme 40

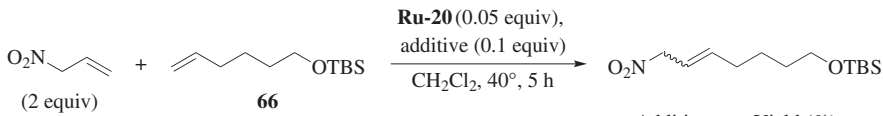
the presence of either Hoveyda–Grubbs second-generation complex **Ru-5** or its analogue, **Ru-30**, to produce the CM product in low-to-moderate yield, but with good (*E*)/(*Z*) selectivity.[177]

Unsaturated Azides. Unsaturated azides are uncommon as CM substrates. In one example, the bisazide **90** is subjected to CM using third-generation Grubbs catalyst **Ru-31** to furnish the product in good yield (Scheme 41).[178]



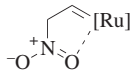
Scheme 41

Unsaturated Nitro Compounds. A nitro group can provide access to many other valuable functional groups. Although nitro-2-propene (Scheme 42) and higher homologues (**92**; see Scheme 43 below),[146] have been employed successfully in CM reactions, the use of nitroethylene has not been reported. According to the general model of reactivity, nitroethylene should be classified as a Type IV alkene (spectator), nitro-2-propene as a Type III alkene, and higher aliphatic nitro compounds as Type I alkenes. Nitro-2-propene undergoes CM with Type I substrates such as terminal alkene **66** to give the desired product in low-to-moderate yield (Scheme 42).[179] The most useful catalyst for this transformation is the nitro-analogue of Hoveyda–Grubbs second-generation catalyst, **Ru-20**; in this case, a Lewis acid (0.1 equiv) is required to prevent the propagating catalytic species from forming the stable five-membered chelate **91** (Figure 10), which inhibits the CM reaction.



Additive	Yield (%)
$Ti(O\textit{i}\text{-}Pr)_4$	16
Ph_2SnCl_2	58
$BF_3{\bullet}Et_2O$	58
$B(OMe)_3$	26
$B(OPh)_3$	68

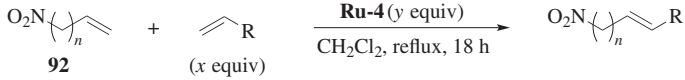
Scheme 42



91

Figure 10. Structure of the chelate that forms in the absence of a Lewis acid.

Grubbs second-generation catalyst **Ru-4** promotes CM of the higher homologues of 1-nitro-2-propene to afford the expected products in 51–85% yields (Scheme 43).[146,179]



92 (*x* equiv)

n	R	*x*	*y*	Yield (%)	(*E*)/(*Z*)
4	OHC	2.5	0.065	51	>99:1
4	*t*-BuO$_2$C	4	0.052	85	>99:1
2	Ph	4	0.048	68	>99:1
3	Ph	3.6	0.052	63	>99:1
4	Ph	3.5	0.077	69	>99:1

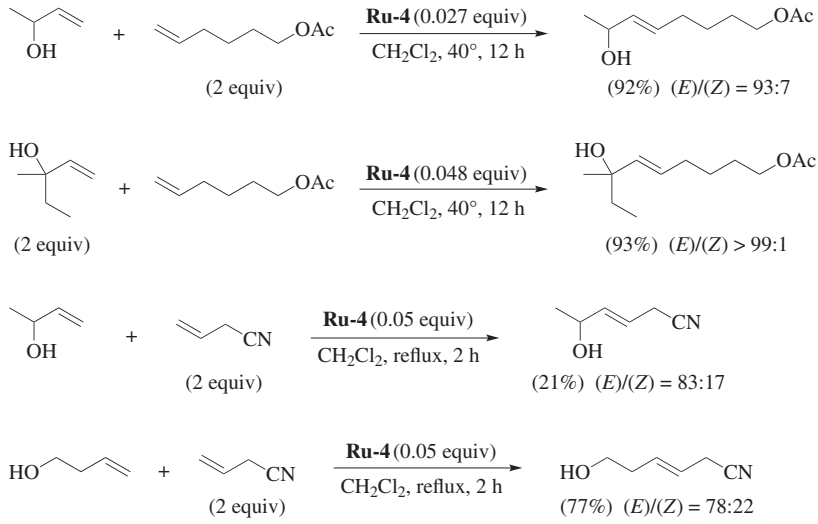
Scheme 43

Alkenes Containing an Oxygen Moiety. Free and protected alcohols, phenols, diols, ethers, acetals, epoxides, and similar oxygen-based functional groups are present in numerous CM partners.

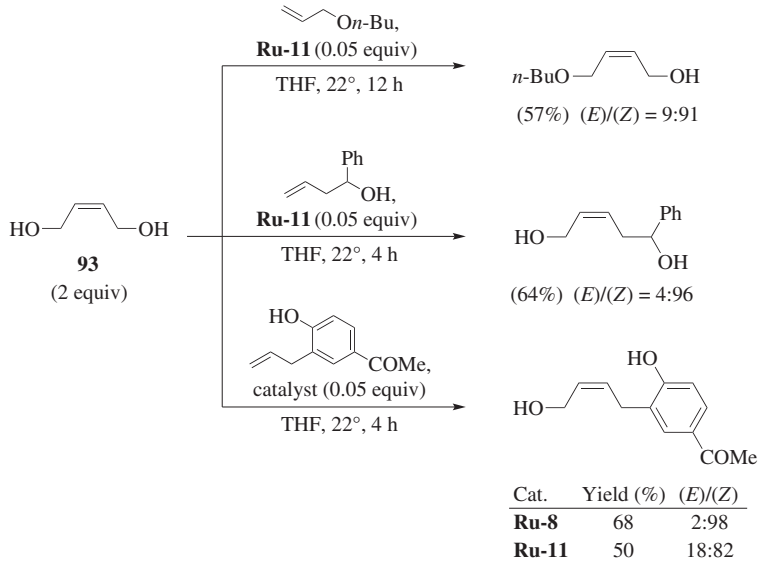
Unsaturated Alcohols. In general, the free hydroxyl group of alcohols and phenols is compatible with all ruthenium catalysts. 2-Buten-1,4-diol (**93**) is often used as a replacement for 3-propen-1-ol,[180] and it is also used for CM in aqueous media.[181] Homoallylic alcohols and higher unsaturated alcohol analogues (Type I alkenes) undergo CM with most of the established catalysts. Secondary and tertiary allylic alcohols (Type II alkenes) usually engage in CM with reactive alkenes, namely, Type I, but the more challenging CM partners (e.g., 3-butenenitrile) afford lower yields (Scheme 44).[36,182] Unless (*Z*)-selective catalysts are used, (*E*)-products are formed with moderate-to-good selectivities.

In contrast, the (*Z*)-selective ruthenium-, tungsten-, and molybdenum-catalysts facilitate stereoselective CM reactions that favor the (*Z*)-configured products with very good selectivity (Scheme 45).[183]

(*Z*)-Selective molybdenum- and tungsten-complexes can be used in the synthesis of substituted allylic alcohols with excellent (*Z*)/(*E*)-selectivity (Scheme 46).[184] However, in these cases, the free hydroxyl group in the substrate must be protected prior to the CM step. Molybdenum-catalysts (e.g., **Mo-3**) afford very high (*Z*)-selectivities even in CM reactions involving sterically crowded secondary allylic silyl ethers (Type II alkenes), such as **94**, with terminal alkenes.

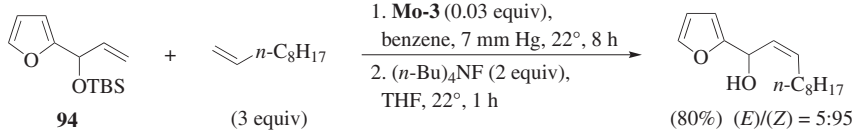


Scheme 44



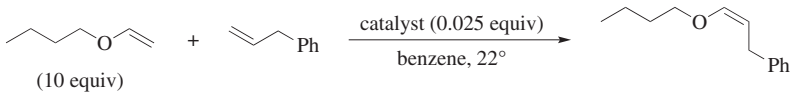
Cat.	Yield (%)	(E)/(Z)
Ru-8	68	2:98
Ru-11	50	18:82

Scheme 45



Scheme 46

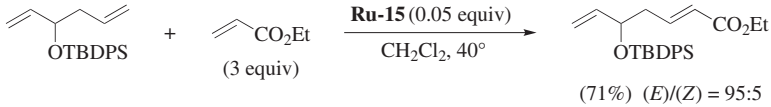
Unsaturated Ethers, Epoxides, and Peroxides. Vinyl ethers are problematic CM substrates for the current ruthenium-based catalysts, although there are some examples of successful RCM reactions with substrates that contain a vinyl ether fragment.[185] Using the standard Schrock catalysts, the reactions proceed in good yield, albeit with low (*E*)/(*Z*)-selectivity. However, modern (*Z*)-selective molybdenum catalysts make stereoselective CM involving vinyl ethers possible (Scheme 47).[5]



Cat.	Yield (%)	(*E*)/(*Z*)
Ru-5	<2	—
Mo-1	80	52:48
Mo-6	73	2:98

Scheme 47

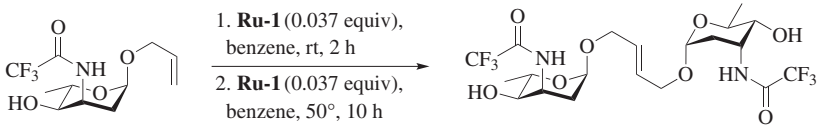
Allylic and homoallylic ethers, as well as higher protected unsaturated alcohols (Type I or II alkenes), are generally not problematic CM substrates and have been employed in numerous examples. In the case of CM reactions with Type II and III partners, bulky *O*-protected allylic alcohols react more slowly. This observation can be used to selectively functionalize the more reactive carbon–carbon double bond in a Type I alkene in the presence of an allylic alkene (Scheme 48).[169] Notably, trisubstituted allylic alcohols protected with bulky groups are unreactive in CM (i.e., they are Type IV alkenes).[36]



(71%) (*E*)/(*Z*) = 95:5

Scheme 48

Homodimerization of allylic ethers present in molecules of pharmaceutical interest (including some antibiotics, amino acids, peptides, carbohydrates, and steroids) is employed to prepare analogues with potentially increased biological activity (Scheme 49).[8,186–189]

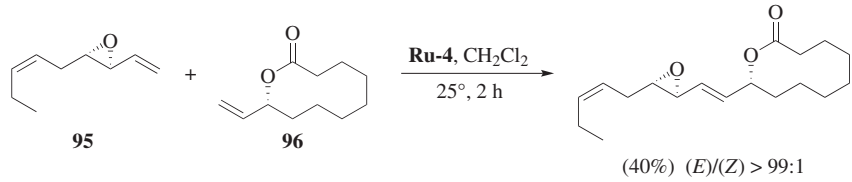


(46%) (*E*)/(*Z*) = 71:29

Scheme 49

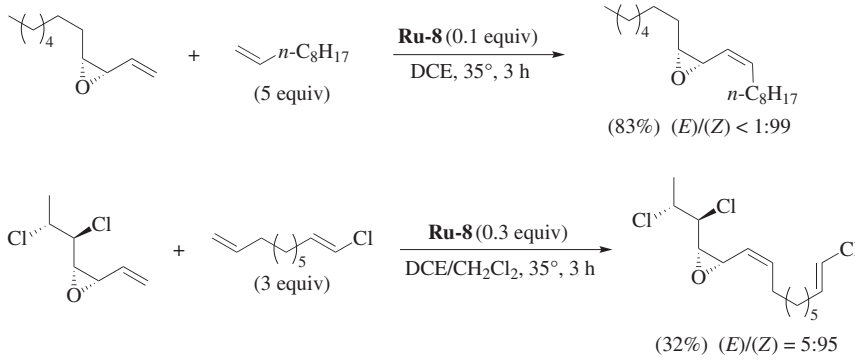
Epoxides are generally well tolerated by modern olefin metathesis catalysts; the epoxide may be present at various distances relative to the reacting carbon–carbon

double bond. Nevertheless, in the case of vinyloxiranes, the epoxide functionality deactivates the carbon–carbon double bond toward CM. For example, the CM reaction between vinyloxirane **95** and the crowded alkene **96** affords only a modest yield of the desired product (Scheme 50).[190]



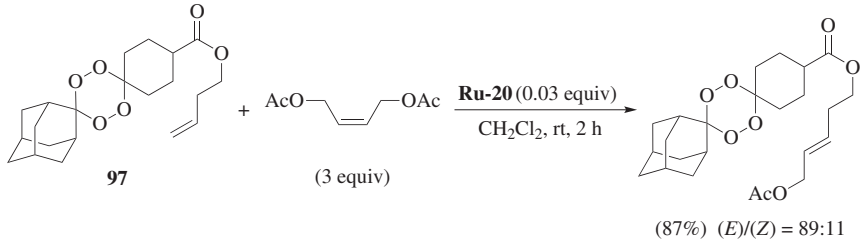
Scheme 50

Cross-metathesis of vinyl oxiranes with (*Z*)-selective catalysts (e.g., **Ru-8**) provides access to synthetically valuable (*Z*)-vinyloxiranes in moderate-to-good yields and with excellent stereoselectivities (Scheme 51).[191]



Scheme 51

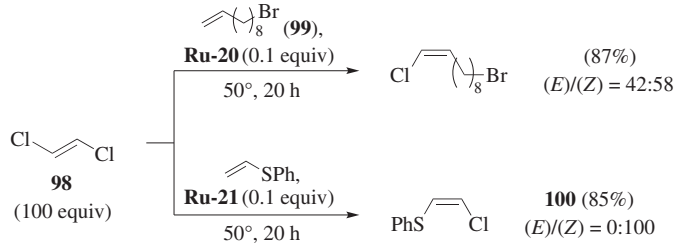
Many metathesis catalysts are destroyed by peroxides,[192–194] but some are compatible with medicinally important ones, including an artemisinin derivative[195] and tetraoxane fragment **97** (present in potential antimalarial drugs) (Scheme 52).[193]



Scheme 52

The ability of the CM catalysts to tolerate the presence of a peroxide is significant because CM can be employed at a late stage in the synthesis of these biologically important compounds to readily enable analogue preparation.

Haloalkenes. The ability to employ vinyl halides and 1,2-dihaloethylenes (Type III alkenes) in CM has not been widely explored, but a handful of examples have been reported. Molybdenum or phosphine-free ruthenium complexes must be employed as catalysts, because Grubbs-type complexes are deactivated by haloalkenes.[196] Cross-metathesis reactions with (*E*)-1,2-dichloroethene (**98**) are performed neat in the presence of Hoveyda-type catalysts using an excess of **98** that can be recovered after the reaction.[104,105] The CM with **98** is not stereoselective with terminal alkenes such as **99**, but electron-rich alkenes provide the corresponding products with a high degree of (*Z*)-selectivity, as exemplified in the reaction with phenyl vinyl sulfide to generate **100** (Scheme 53).[105] Relatively high catalyst loading is required for the ruthenium-catalyzed CM with vinyl chlorides, and unfortunately, vinyl bromides are even less reactive in the analogous CM reactions.



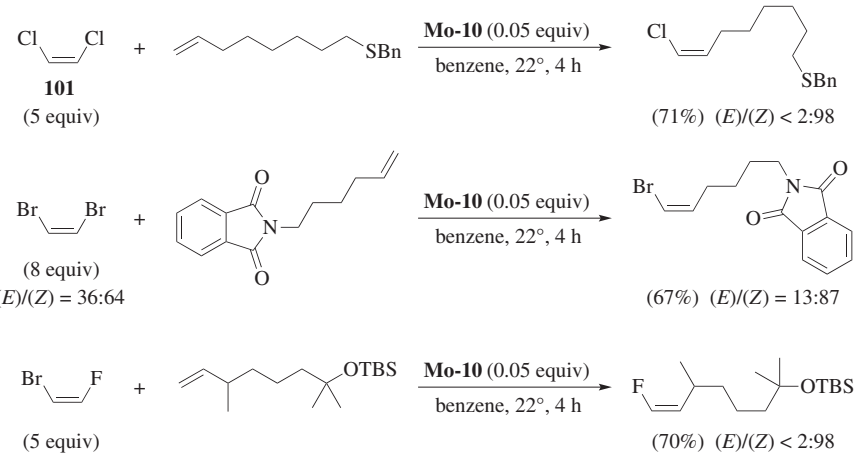
Scheme 53

The best yields and selectivities are obtained with the (*Z*)-selective molybdenum MAP catalysts and (*Z*)-1,2-dichloroethene (**101**). (*Z*)-Vinyl fluorides and even (*Z*)-vinyl bromides can be obtained with good-to-high stereocontrol (Scheme 54).[106] The reactivity of vinyl halides decreases in the order F > Cl > Br, and, in general, vinyl halides are challenging CM partners for ruthenium complexes, so the more active molybdenum catalysts are recommended in these cases.

Allyl halides (Type I) are very useful CM partners, and the commercially available (*Z*)-1,4-dichloro-2-butene serves as a convenient alternative to allyl chloride.[197–199] Halogen atoms at more distant positions do not impact the reactivity of an alkene double bond in CM.

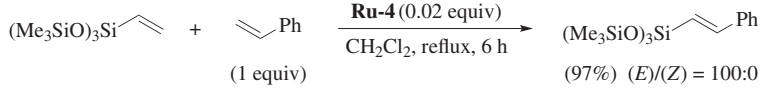
Unsaturated Compounds Containing Silicon and Tin.

Vinylsilanes. In the presence of a metathesis catalyst, vinylsilanes undergo CM with various alkenes, leading to functionalized alkenylsilicon compounds,[200] although with some ruthenium hydride complexes, the same products can be obtained by an alternative mechanism that is based on a silylative coupling process.[201]



Scheme 54

Vinylsiloxanes (Scheme 55),[202] vinylsilanes, polymeric oligosiloxanes,[202] divinylsilanes,[203] and vinyl-functionalized cubic silsesquioxanes (i.e., POSS)[204–207] also undergo CM reactions in the presence of Grubbs and Schrock catalysts.



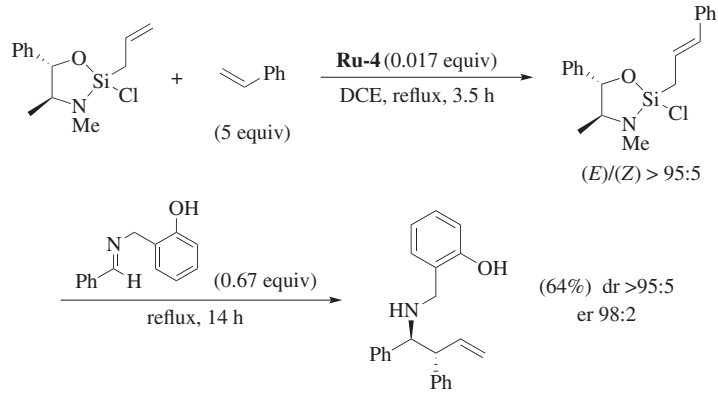
Scheme 55

Allylsilanes. Allylsilanes, such as allyltrimethylsilane[208–210] and allyltriphenylsilane,[168] are very useful CM partners. These substrates can be classified as Type I partners, because they undergo efficient homodimerization in the presence of both ruthenium and molybdenum catalysts.[108] Cross-metathesis affords functionalized allylsilane products with good (*E*)-selectivities, which represent useful synthetic intermediates for target-orientated synthesis (Scheme 56).[211]

Allyltriphenylstannane and allyltributylstannane successfully participate in CM reactions with a variety of alkenes using molybdenum catalyst **Mo-1**.[212] Moderate-to-good product yields are obtained in CM with a number of highly functionalized alkenes containing ester, cyano, acetal, and other functional groups. Notably, no significant quantities of allylstannane homodimerization products are formed in these experiments.[212]

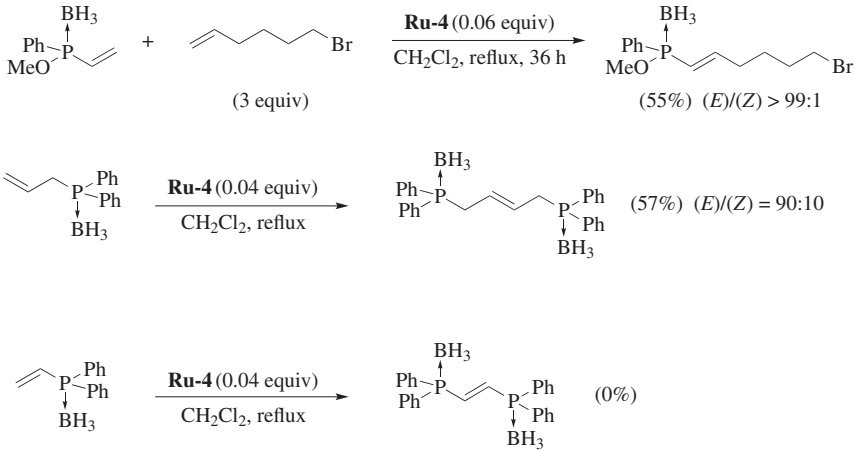
Unsaturated Phosphorus Compounds.

Alkenes Containing a Phosphine–Borane Moiety. Free phosphines bind strongly to transition metals, which necessitates the protection of the Lewis basic phosphorus atom with a borane prior to a CM reaction. In the presence of the



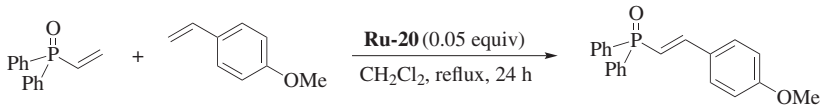
Scheme 56

catalyst **Ru-4**, vinyl- and allyl-substituted phosphine–boranes undergo smooth CM with various alkene partners, providing products with exclusive (*E*)-selectivity (Scheme 57).[213] Interestingly, no homodimerization of vinylphosphine–boranes (Type III substrates) is observed, whereas the allylic homologues (Type I) undergo facile dimerization.



Scheme 57

Alkenes Containing a Phosphine Oxide Moiety. Cross-metathesis reactions of substituted vinyl and allylic phosphine oxides catalyzed by ruthenium complexes provide a number of valuable products, including some *P*-ligand precursors, with exclusive (*E*)-stereochemistry,[164,214–216] one example of which is shown in Scheme 58.[215]

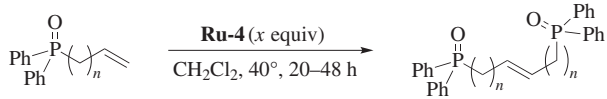


102 (3 equiv) (81%) $(E)/(Z) > 99:1$

Scheme 58

Cross-metathesis functionalization of di- and tri(vinyl) phosphine oxides with various alkene partners is known as well.[217] This reaction permits direct access to novel racemic *P*-stereogenic products bearing two or three different alkenyl groups.

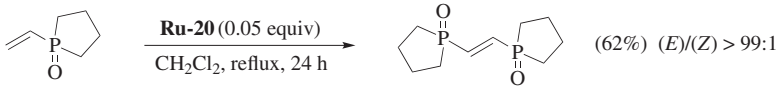
The usefulness of bisphosphines as bidentate ligands in catalysis has prompted the investigation of the homodimerization of unsaturated phosphine oxides. Despite many attempts, no dimerization of vinylphosphine oxide **102** has been achieved, thereby making it a Type III alkene partner. In contrast, the dimerization of the nonconjugated phosphine oxides **103** and **104** is promoted by **Ru-4** to afford the homodimeric products in high yields and with good (*E*)-selectivities (Scheme 59).[214]



	n	*x*	Yield (%)	$(E)/(Z)$
102	0	0.06	0	—
103	1	0.02	96	>99:1
104	3	0.04	95	>99:1

Scheme 59

Vinyl phosphine oxides that are less bulky than the diphenyl-substituted phosphine oxide **102** are successfully dimerized in the presence of the nitro analogue of the Hoveyda–Grubbs catalysts, which is exemplified in the dimerization of **105** (Scheme 60).[215] Hence, these substrates are between Types II and III in the Grubbs alkene classification for CM reactions.[215,216]

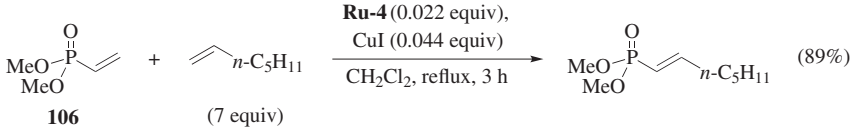


105 (62%) $(E)/(Z) > 99:1$

Scheme 60

P-Stereogenic vinylphosphine oxides undergo CM and homodimerization reactions to furnish products with exclusive (*E*)-selectivities and without epimerization at the phosphorus center.[164] This finding provides a potentially useful method for preparing chiral, nonracemic, functionalized bisphosphine ligands, which are omnipresent in asymmetric synthesis.

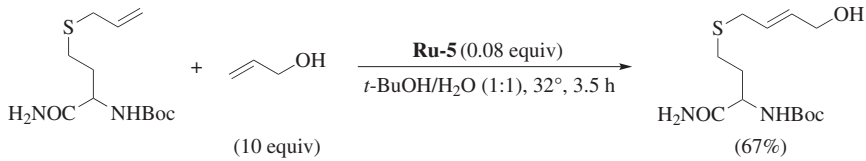
Unsaturated Phosphonates. Examples of CM involving vinyl- and allylphosphonates and related compounds have been reported,[144,218–220] and allylphosphonates undergo homodimerization.[221] For example, the reaction between phosphonate **106** and an excess of 1-heptene (seven equivalents) proceeds smoothly in the presence of Grubbs catalyst **Ru-4** and copper(I) iodide, which acts as a phosphine scavenger (Scheme 61).[220] (Copper iodide is sometimes used as an additive to enhance the cross-metathesis reaction, acting as an activator for Grubbs-type phosphine catalysts[167]).



Scheme 61

Alkenes Containing Sulfur and Selenium Moieties.

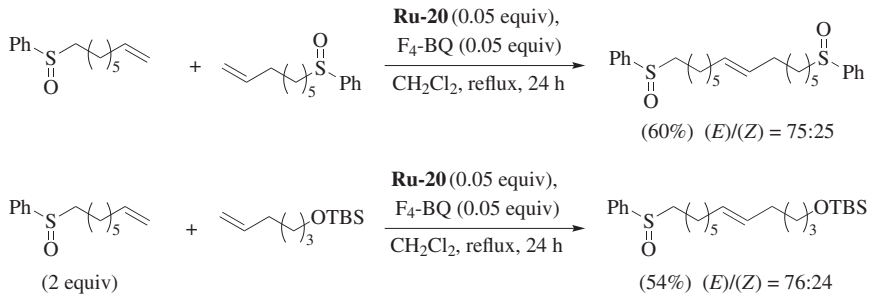
Unsaturated Thiols and Sulfides. Vinyl sulfides and selenides, with very few exceptions,[105,222,223] do not participate in olefin cross-metathesis reactions that are catalyzed by ruthenium complexes. In contrast, allyl sulfides—and even allyl mercaptan—undergo homodimerization,[224] and these compounds, along with their selenium analogues, are efficient partners in CM with various alkenes. Notably, these reactions can be conducted in aqueous media (Scheme 62),[225] which make them particularly useful for protein modification.[226] Interestingly, the reactivity of homoallyl sulfides is noticeably diminished as compared to allyl sulfides, likely owing to the formation of stable cyclic ruthenium chelates that attenuate the catalytic activity.[227]



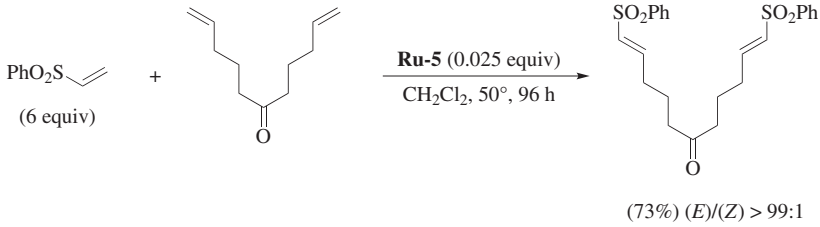
Scheme 62

Unsaturated Sulfoxides. Both vinyl and allyl sulfoxides are unreactive in CM with terminal alkenes in the presence of ruthenium catalysts.[228,229] While the origin of the observed impotence is not clear, it has been suggested that the formation of ruthenium chelates may render the catalyst unreactive. However, higher homologues of unsaturated sulfoxides undergo cross-metathesis and homodimerization relatively easily (Scheme 63).[230]

Unsaturated Sulfones. The CM reactions of phenyl vinyl sulfone (Scheme 64)[231] or divinyl sulfone (both Type III alkenes) with a variety of terminal alkenes



Scheme 63

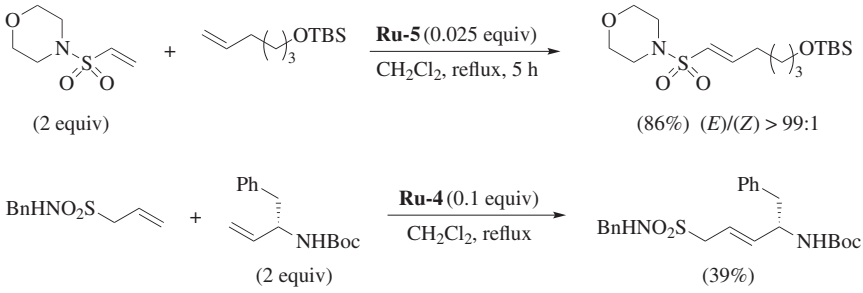


Scheme 64

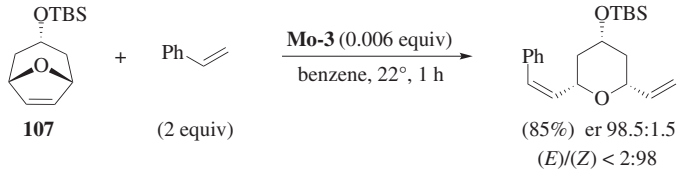
proceeds in moderate-to-high yields and with exclusive (*E*)-selectivity.[228,232,233] Cross-metathesis reactions of vinyl sulfones are particularly useful and have been featured in several target-oriented syntheses.[231,234–237] The introduction of a vinyl sulfone pharmacophore (sometimes called a warhead)[238] is interesting from a medicinal chemistry point of view[239,240] because it can act as a Michael acceptor, thereby allowing, for example, the addition of a thiol group of an active-site cysteine residue. Moreover, compounds bearing this functional group can be readily prepared by CM using vinyl sulfones.[238,239] Cross-metathesis reactions of phenyl allyl sulfone,[241] other allyl sulfones, and alkenes bearing a sulfone group in more distal position proceed uneventfully, which identifies such substrates as Type I alkenes.[229]

Unsaturated Sulfonamides. Vinyl sulfonamides (Type III partners) undergo CM with a number of terminal alkenes in the presence of second-generation Hoveyda–Grubbs complexes (Scheme 65).[154,230] Cross-metathesis reactions of allyl sulfonamides have also been demonstrated both in solution and on solid phase in the presence of up to 20 mol % of **Ru-4** or **Ru-5**. The presence of a Lewis acid (e.g., Cy_2BCl) increases the CM yields in some cases.[154]

(*Z*)-Selective Metathesis. The first successful (*Z*)-selective metathesis was the enantio- and diastereoselective ROCM reaction of cyclic ether **107** with styrene catalyzed by **Mo-3** (Scheme 66).[242]

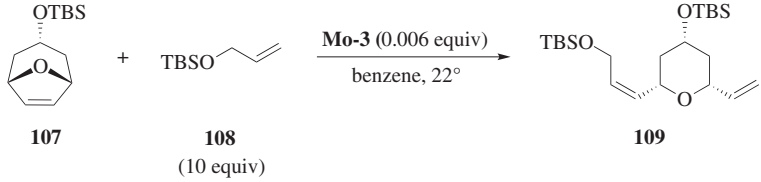


Scheme 65



Scheme 66

Low pressure conditions can have a dramatic effect on the yield and selectivity of a CM reaction. For instance, when oxabicycle **107** and (allyloxy)(*tert*-butyl)dimethylsilane (**108**) are combined in the presence of chiral complex **Mo-3** under atmospheric pressure, the desired product **109** is obtained in 45% yield, with good (*Z*)-selectivity ((*Z*)/(*E*) = 95:5) and modest enantioselectivity (er 84:16) (Scheme 67).[242] In surprising contrast, when the analogous process is carried out at lower pressure (7 mm Hg), the results are significantly improved (75% yield, (*Z*)/(*E*) = 98:2, er 93.5:6.5), even with a much shorter reaction time (a recent review explains the role of ethylene in various metathesis processes[243]).

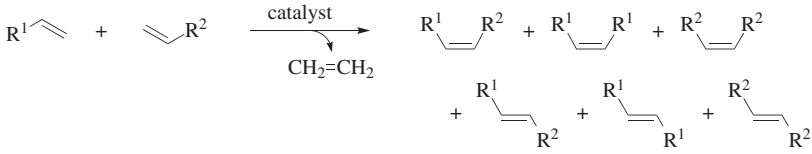


Pressure (mm Hg)	Time (min)	Yield (%)	(*E*)/(*Z*)	er
ambient	60	45	5:95	84:16
7	10	75	2:98	93.5:6.5

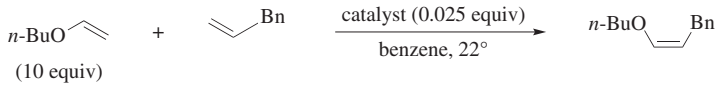
Scheme 67

The (*Z*)-selective CM of two different alkenes is difficult to achieve, because up to six different products can be generated (Scheme 68), which contrasts with homocoupling ($R^1 = R^2$) where only two stereoisomeric alkenes can be formed.[5]

Notably, molybdenum complexes promote (*Z*)-selective CM of enol ethers with Type 1 alkenes (Scheme 69).[5] Consequently, while the Hoveyda–Grubbs ruthenium catalyst is ineffective with these substrates, the **Mo-5** is effective in this process. With larger cross-partners, the 2,6-dimethylphenylimido complex **Mo-5** is more suitable than other molybdenum complexes that were examined.



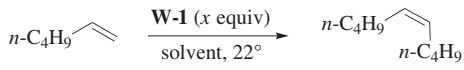
Scheme 68



Cat.	Time	Conv (%)	Yield (%)	(*E*)/(*Z*)
Mo-1	10 min	80	—	52.5:47.5
Mo-3	2 h	37	—	<2:98
Mo-5	2 h	85	73	2:98
Mo-6	2 h	47	—	<2:98
Ru-5	24 h	<2	—	—

Scheme 69

Tungsten MAP complexes, such as **W-1** (Figure 2), catalyze the homocoupling of alkenes with high (*Z*)-selectivities (Scheme 70).[244] Such catalysts are active at room temperature, and the reaction is usually performed neat in order to increase the rate and conversion.[244]

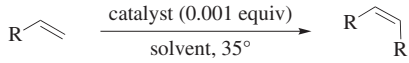


x	Conc (M)	Solvent	Time (h)	Conv (%)	(*E*)/(*Z*)
0.04	0.66	C_6D_6	16	32	<1:99
0.02	neat	—	4	74	<1:99

Scheme 70

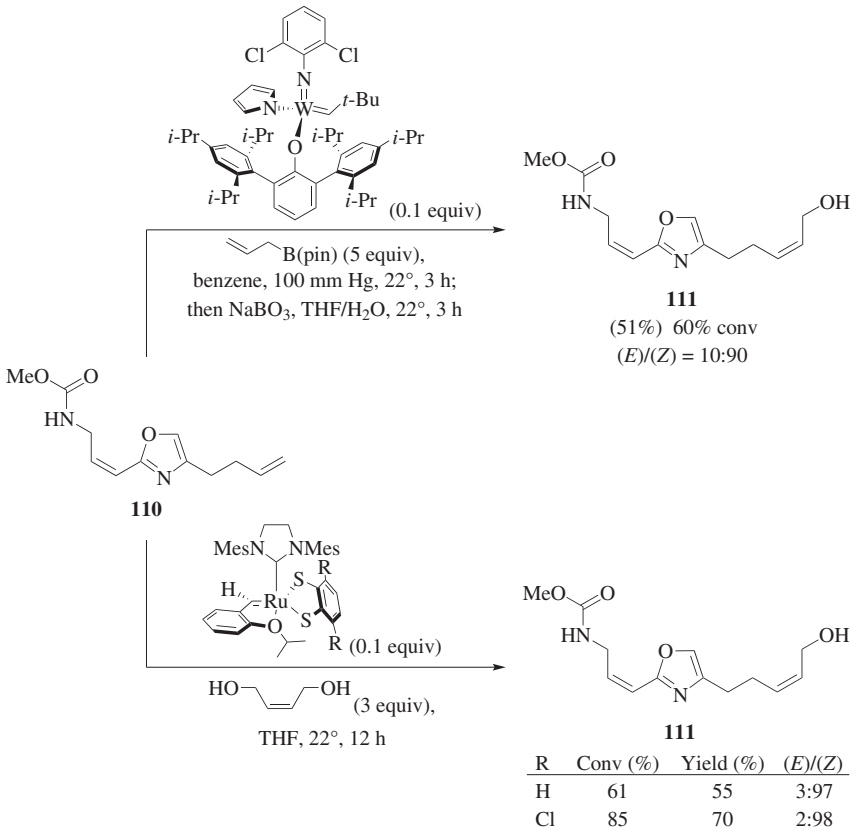
Similar conversions and selectivities can be obtained with ruthenium-based, (*Z*)-selective catalysts (Figure 3). In contrast to the molybdenum-based complexes, ruthenium catalysts are able to dimerize more challenging substrates, such as unprotected alcohols (Scheme 71).[82,245]

A (*Z*)-selective metathesis reaction was used in the preparation of an allylic alcohol in the synthesis of (+)-neopeltolide (Scheme 72).[246] A tungsten MAP complex



R	Cat.	Solvent	Time (h)	Conv (%)	(*E*)/(*Z*)
$HO(CH_2)_3$	**Ru-7**	THF	12	81	57:43
$HO(CH_2)_3$	**Ru-8**	THF	12	67	19:81
$HO(CH_2)_3$	**Ru-9**	DCE	2	7	<5:95
$HO(CH_2)_3$	**Ru-10**	THF	2	77	<5:95
$HO(CH_2)_3$	**Ru-10**	DCE	2	79	8:92
$MeO_2C(CH_2)_8$	**Ru-7**	THF	12	16	10:90
$MeO_2C(CH_2)_8$	**Ru-8**	THF	12	85	9:91
$MeO_2C(CH_2)_8$	**Ru-9**	DCE	6	65	<5:95
$MeO_2C(CH_2)_8$	**Ru-10**	THF	6	>95	<5:95

Scheme 71



R	Conv (%)	Yield (%)	(*E*)/(*Z*)
H	61	55	3:97
Cl	85	70	2:98

Scheme 72

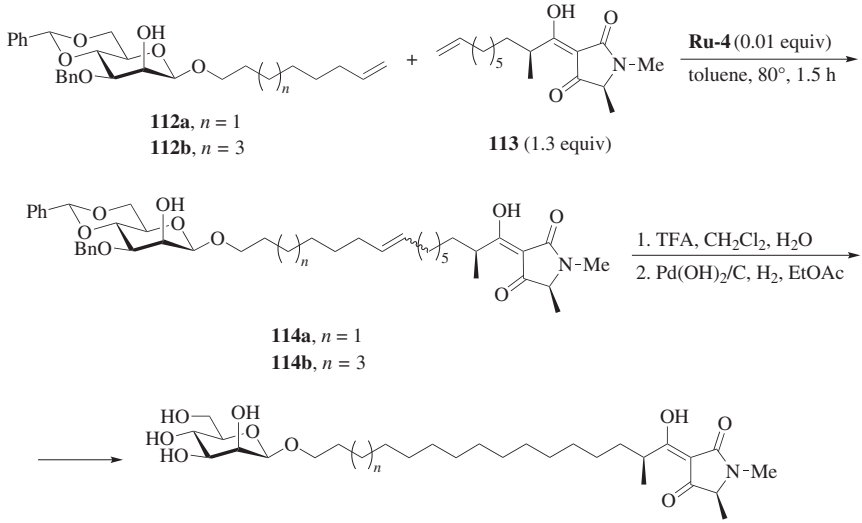
promotes the CM reaction of alkene **110** with allyl pinacol boronate, leading to 60% conversion after three hours (a longer reaction time did not result in higher conversion). After oxidation, the expected product **111** is obtained in 51% overall yield with a 10:90 (*E*)/(*Z*) ratio. In contrast, the direct CM with 1,4-but-2-endiol using a ruthenium catechothiolate catalyst furnishes the same product in 70% yield and with excellent stereoselectivity ((*E*)/(*Z*) = 2:98).

APPLICATIONS TO SYNTHESIS

Cross-Metathesis in Natural Products Synthesis

Cross-metathesis reactions are widely utilized in the total synthesis of complex natural products, not only because the reactions can be carried out under mild conditions, but because of their high tolerance to a variety of functional groups present in the molecules.[7,247]

A synthesis of epicoccamides A and D, which are potential anticancer agents, utilizes an olefin cross-metathesis as a key step in linking two terminal alkenes that do not contain any proximal functional groups (Scheme 73).[248] Hence, the reaction of alkenes **112a/b** and **113** in the presence of 1 mol % of Grubbs second-generation catalyst **Ru-4** gives the desired products **114a/b**, which were subjected to acetal hydrolysis with TFA and subsequent hydrogenolysis of the benzyl ether. Hydrogenation of the alkene with Pearlman's catalyst delivers the target natural products.



112a, *n* = 1
112b, *n* = 3

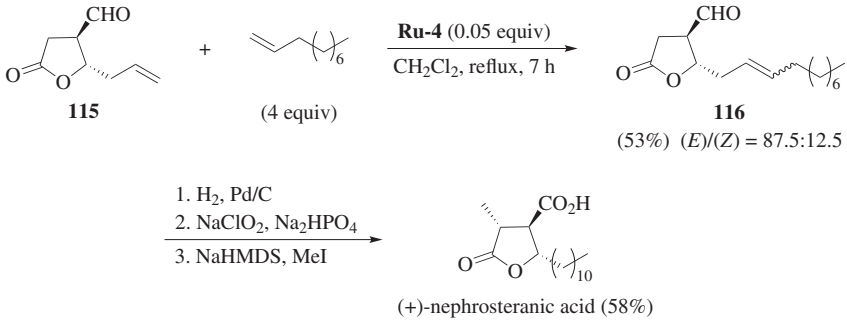
113 (1.3 equiv)

114a, *n* = 1
114b, *n* = 3

(5*S*,2'*S*)-epicoccamide A, *n* = 1, (20%) from **112a**
(5*S*,2'*S*)-epicoccamide D, *n* = 3, (16%) from **112b**

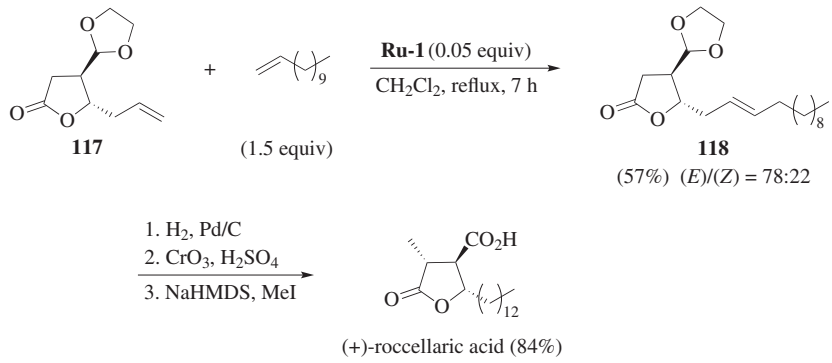
Scheme 73

The same strategy is used in an enantioselective synthesis of some paraconic acids, which are biologically active compounds that exhibit interesting antitumor and antibiotic properties.[249] For instance, in the synthesis of (+)-nephrosteranic acid, the lactone **115** undergoes CM with 1-decene in the presence of 5 mol % of Grubbs second-generation catalyst **Ru-4** (Scheme 74). Using 1.5 equivalents of 1-decene, the CM product **116** is obtained in only 45% yield along with 30% of recovered starting material. This yield can be improved by using four equivalents of 1-decene, providing **116** in 53% yield along with 27% of recovered **115**. Three additional steps (alkene hydrogenation, aldehyde oxidation, and lactone α-methylation) furnish (+)-nephrosteranic acid in 58% yield from **116**.



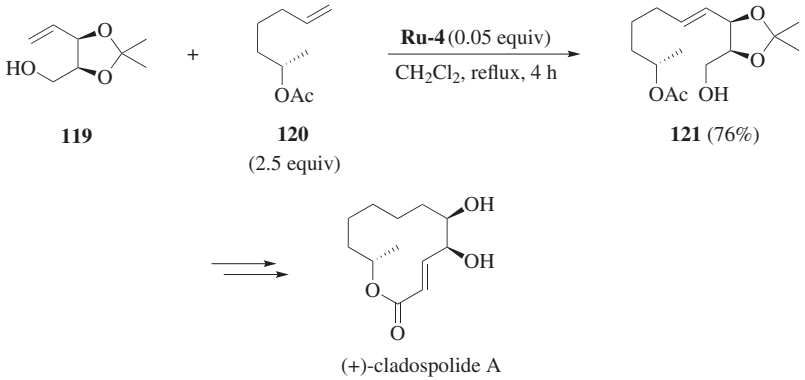
Scheme 74

The synthesis of (+)-roccellaric acid also begins from lactone **115**. Protection of the formyl group generates acetal **117**, which enables a CM reaction using the less reactive Grubbs first-generation catalyst and 1.5 equivalents of 1-dodecene to afford alkene **118** in 57% yield and as a 78:22 mixture of (*E*)- and (*Z*)-isomers (Scheme 75).[249] Notably, catalyst **Ru-4** gives higher (*E*)-selectivity in the cross-coupling than **Ru-1**. The synthesis of (+)-roccellaric acid is then completed using a similar sequence as for (+)-nephrosteranic acid.



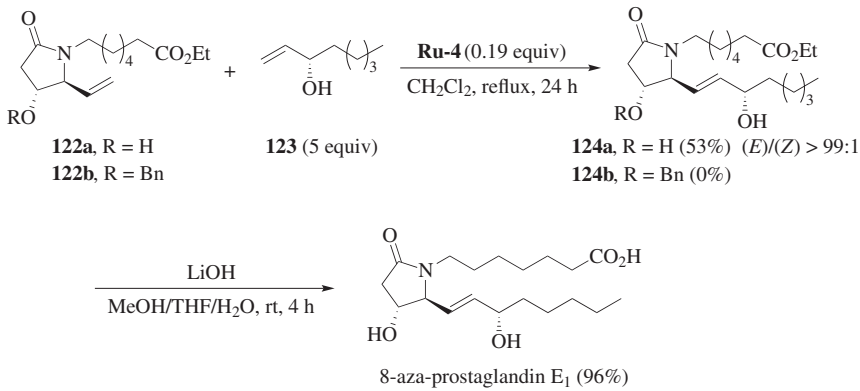
Scheme 75

The cladospolide family of natural products belongs to a class of 12-membered lactones that exhibit interesting plant-growth-regulatory activity as well as being plant-growth promoters. In the synthesis of (+)-cladospolide A,[250] alcohol **119** is subjected to olefin cross-metathesis with (*S*)-hept-6-en-2-yl acetate (**120**) to furnish the coupled product **121** in 76% yield (Scheme 76).[250] Several additional steps convert the metathesis product to (+)-cladospolide A in 9% overall yield over the 11-linear-step sequence from D-ribose, a popular building block.[251]



Scheme 76

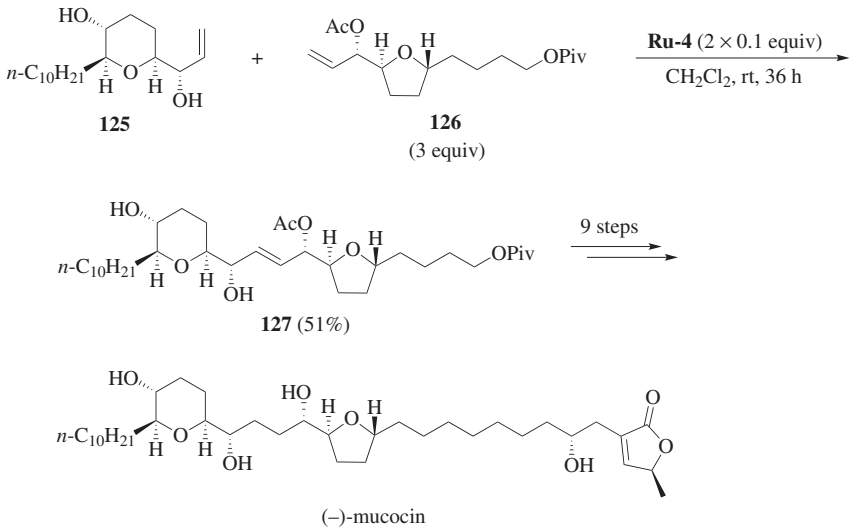
Prostaglandins are naturally occurring compounds that provide a promising platform for the development of new therapeutic agents for a number of diseases.[252] Among the strategies developed for the asymmetric synthesis of prostaglandin analogues, an olefin cross-metathesis-based strategy is attractive for the installation of the ω-chain.[128,253,254] In a synthesis of 8-aza prostaglandin E_1, olefin cross-metathesis is used to combine the 5-vinyl-γ-lactam subunit **122a** with the pre-ω-chain **123** (Scheme 77). The reaction is performed in the presence of 19 mol %



Scheme 77

of Grubbs second-generation catalyst **Ru-4** to give the desired alkene **124a** in 53% yield and with >99:1 (*E*)/(*Z*) selectivity.[255] In contrast, the metathesis reaction with the benzyl-protected derivative **122b** is unsuccessful; this result may be attributed to increased steric hindrance of this substrate. The synthesis of 8-aza prostaglandin E_1 is completed by the hydrolysis of the ethyl ester to afford the desired acid in excellent yield.

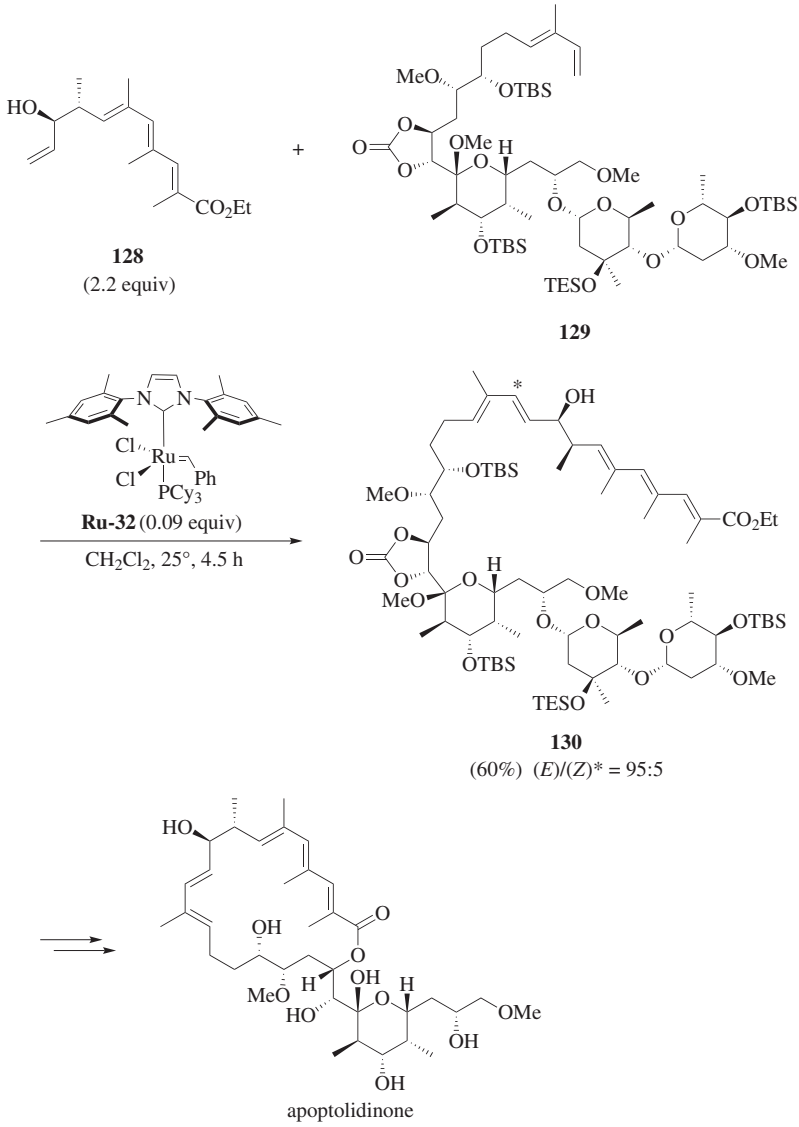
(–)-Mucocin belongs to the anonnaceous acetogenin family, which exhibits antimitotic and cytotoxic properties. The acetogenins are comprised of polycyclic ethers that contain either adjacent or non-adjacent tetrahydrofuran or tetrahydropyran rings, which are biosynthetically derived from an unsaturated fatty acid.[256] In a pertinent application of cross-metathesis to the synthesis of (–)-mucocin, the reaction between alkene **125**, which has an unprotected hydroxyl group, and an excess of the easily accessible, less reactive alkene **126**, which bears an acetate-protected hydroxyl group, was conceived. The formation of the cross-metathesis product **127** (together with unreacted **126**) was anticipated to be favored over the homodimeric products on the basis of statistical and reactivity considerations.[32,36] For instance, the reaction of **125** with three equivalents of **126** leads to heterodimer **127** as the major metathesis product in 51% yield; the homodimeric products are formed in less than 5% yield (Scheme 78).[257] Alkene **127** is obtained essentially as a single diastereoisomer, presumably the (*E*)-isomer, which is subjected to hydrogenation and several functional group transformations to complete the synthesis of (–)-mucocin.



Scheme 78

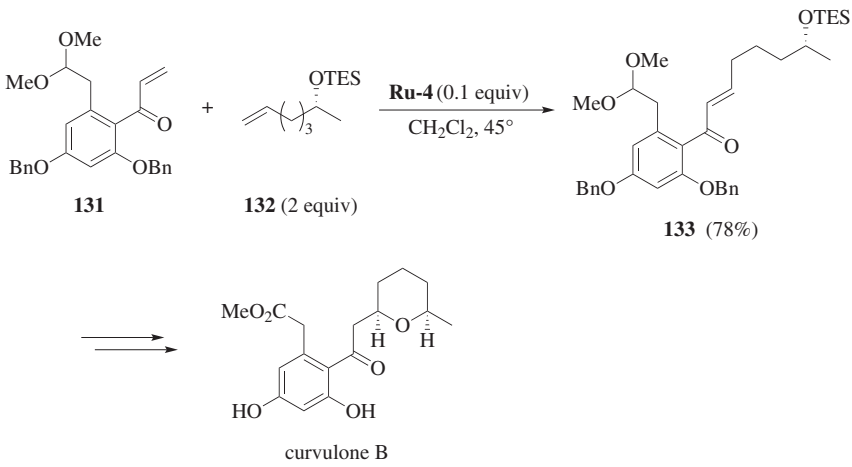
A synthesis of apoptolidinone, an analogue of the potent anticancer agent apoptolidin A,[258] illustrates an example of a selective cross-metathesis in the presence of differently substituted double bonds (Scheme 79).[259] To this end, the trisubstituted,

conjugated alkene moieties of tetraene **128** and the trisubstituted alkene of diene **129** were expected to be unreactive under the cross-metathesis conditions. Thus, the cross-metathesis reaction between the terminal alkenes in each of these compounds was anticipated to furnish the desired intermediate **130**.[36] In the event, exposure of alkenes **128** and **129** to the Grubbs second-generation catalyst **Ru-32** provides a 60% yield of the desired (*E*)-isomer **130**, which was further elaborated to the target natural product.



Scheme 79

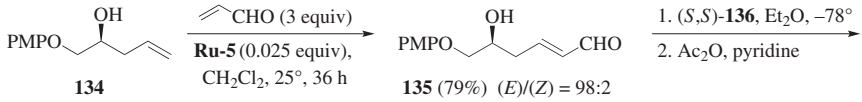
Cross-metathesis of α,β-unsaturated ketone **131** is employed as a key step in the synthesis of curvulone B, an antibacterial and antifungal agent (Scheme 80).[260] The metathesis reaction between acrylate **131** and the TES-protected alcohol **132** is performed in the presence of Grubbs second-generation catalyst **Ru-4** to deliver the desired product **133** in good yield. Subsequent oxy-Michael cyclization, isomerization, and functional group manipulation afford curvulone B.

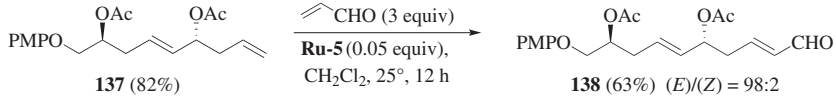


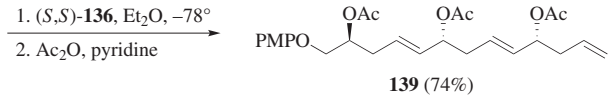
Scheme 80

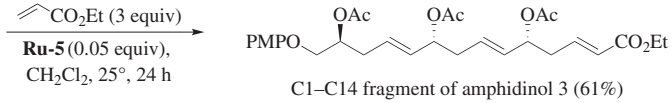
Multiple cross-metathesis reactions are employed in a synthesis of the C1–C14 fragment of the mis-assigned structure of amphidinol 3 (Scheme 81).[157] Aldehyde **135** is obtained stereoselectively ((*E*)/(*Z*) = 98:2) in 79% yield from the coupling of the secondary allylic alcohol **134** with three equivalents of acrolein in the presence of Hoveyda–Grubbs second-generation catalyst **Ru-5** (2.5 mol %). Conversion into bis-acetate **137** is accomplished with the allyltitanium complex (*S*,*S*)-**136**,[261] followed by acetylation. Compound **137** is then subjected to a second cross-metathesis with acrolein under the same conditions, leading to aldehyde **138** in 63% yield ((*E*)/(*Z*) = 98:2).[157] The formation of homoallylic acetate **139** and a third cross-metathesis reaction, this time with ethyl acrylate, affords the unsaturated C1–C14 fragment of amphidinol 3 in an overall yield of 17%.

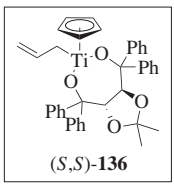
Cross-metathesis reactions are well suited to cascade and tandem reactions in natural products synthesis.[262] A cross-metathesis/ring-closing metathesis sequence is used to assemble the core structure of (–)-cylindrocyclophanes, which are potent anticancer agents.[263] Consequently, the dimerization of diene **140** with Schrock's catalyst **Mo-1** and subsequent ring-closing metathesis of the resulting dimer provides a single (*E*,*E*)-isomer of the [7,7]-paracyclophane **141** in 77% yield (Scheme 82).[157] The alternative "head-to-head" dimerization products are not detected in these experiments, suggesting that the [7,7]-paracyclophane skeleton is thermodynamically favored. This hypothesis has been proven by independently preparing the "head-to-head" and "head-to-tail" dimers of an analogue of **140** (with H in place of



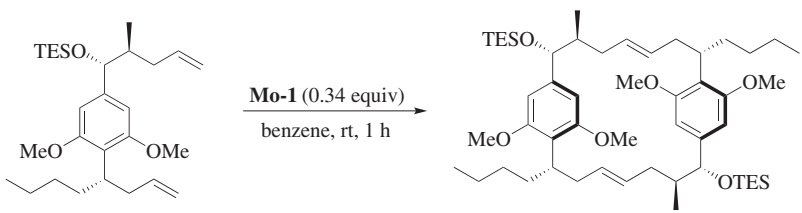


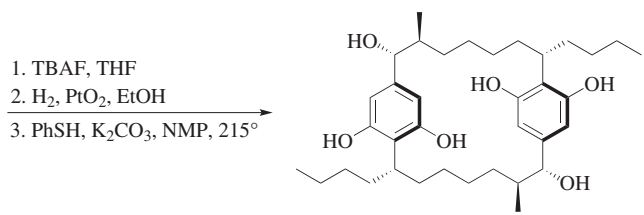






Scheme 81

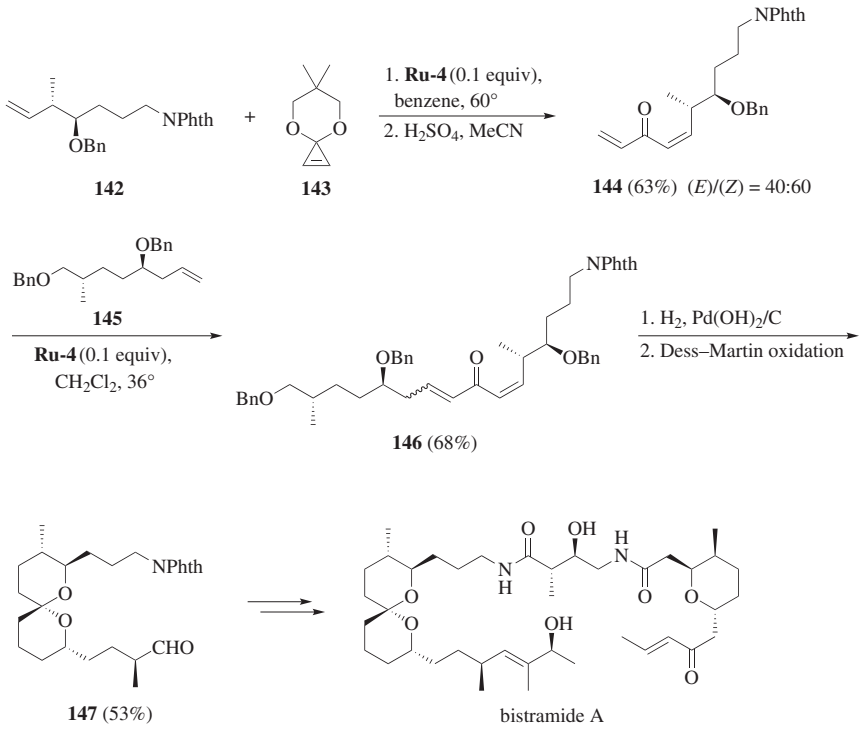




Scheme 82

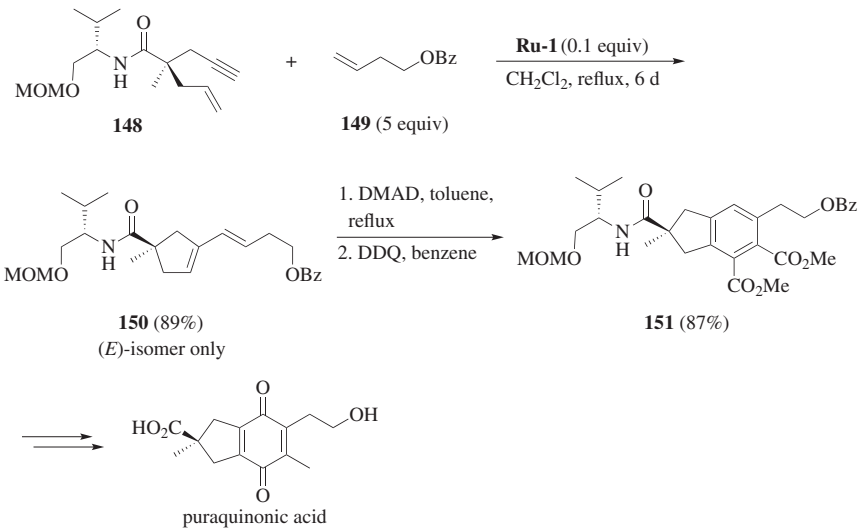
the TESO group), and then subjecting them to RCM in the presence of either Grubbs **Ru-1** and **Ru-4** or Schrock **Mo-1** catalysts to converge on the [7,7]-paracyclophane skeleton.[263] The synthesis of cylindrocyclophane A is accomplished in three steps from intermediate **141**.

Bistramide A exhibits significant neuro- and cytotoxic properties in addition to profound effects on cell cycle regulation.[264] The key spiroketal domain in the natural product is prepared by a sequence involving ROM followed by two CM reactions (Scheme 83).[265] In the first step, a mixture of terminal alkene **142** and cyclopropene acetal **143** undergo a ring-opening/cross-metathesis cascade in the presence of Grubbs second-generation catalyst **Ru-4** to afford, after acid-mediated removal of the ketal protecting group, divinyl ketone **144** as an inconsequential mixture of geometric isomers favoring the (*Z*)-isomer ((*E*)/(*Z*) = 40:60). Treatment of α,β-unsaturated compound **144** with the metathesis partner **145**, again using Grubbs second-generation catalyst **Ru-4**, affords the desired cross-metathesis product **146** in 68% yield. Hydrogenation of dienone **146** with concomitant cleavage of the three benzyl ethers induces the spiroketalization, which was followed by a Dess–Martin oxidation to afford the spiroketal **147** as a single diastereomer. This intermediate is converted to bistramide A in several additional steps.



Scheme 83

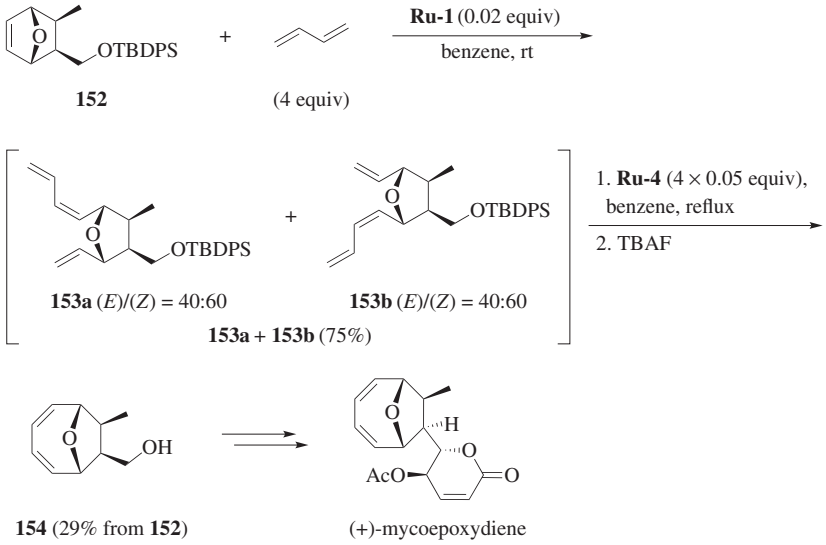
An elegant one-pot reaction sequence is used in a total synthesis of puraquinonic acid, a potent anticancer agent.[266] An enyne/cross-metathesis reaction of precursor **148** with protected 3-buten-1-ol derivative **149** in the presence of Grubbs first-generation catalyst **Ru-1** delivers diene **150** in 89% yield favoring only the (*E*)-isomer (Scheme 84). A Diels–Alder reaction with dimethyl acetylenedicarboxylate followed by oxidation by DDQ furnishes the desired indane skeleton **151** in 87% yield. Alternatively, **151** can be obtained in 83% yield via a one-pot sequence from **148** by simply removing the dichloromethane after the initial metathesis sequence and proceeding with the Diels–Alder and oxidation reactions. Compound **151** is then converted to puraquinonic acid in a few additional steps.



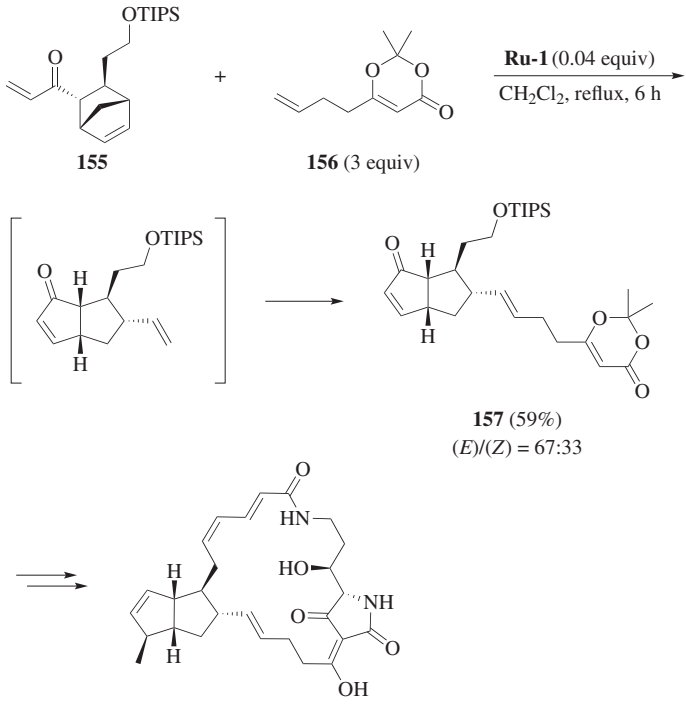
Scheme 84

A synthesis of (+)-mycoepoxydiene, which exhibits antimicrobial and anticancer activities, has been accomplished by a sequential ROM/CM/RCM process to construct the 9-oxabicyclo[4.2.1]nona-2,4-diene core (Scheme 85).[267] In initial investigations, the reactions were performed in a stepwise manner: ring-opening metathesis of **152** in the presence of 1,3-butadiene furnishes a mixture of trienes **153a** and **153b** in 75% yield; however, because only the (*Z*)-isomer can undergo subsequent ring closure, this reaction was optimized for the formation of this product using the Grubbs first-generation catalyst **Ru-1** in benzene at room temperature. In contrast, Grubbs second-generation catalyst **Ru-4** preferentially produces the undesired (*E*)-isomers, whereas the formation of cyclooctadiene **154** requires the more active Grubbs second-generation catalyst **Ru-4**. In a one-pot procedure, this complex is added to the reaction mixture after consumption of substrate **152** and removal of 1,3-butadiene to furnish the cyclooctadiene **154**, which is further elaborated to the target natural product.

A sequential ROM/RCM/CM sequence is a key feature in a total synthesis of (+)-cylindramide A, a potent anticancer agent (Scheme 86).[268] A mixture of the



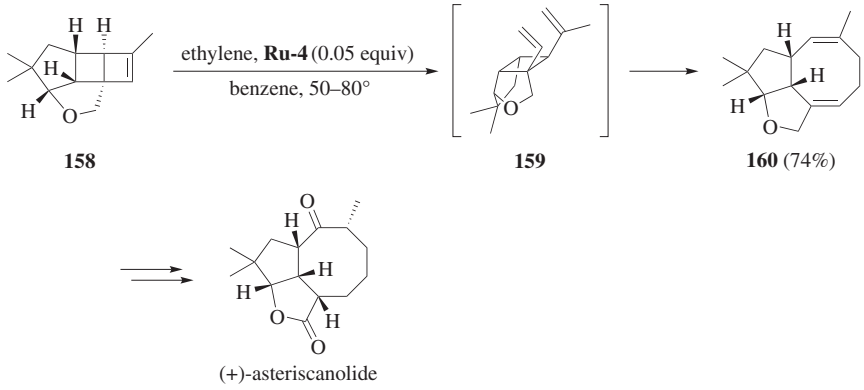
Scheme 85



Scheme 86

norbornene derivative **155** and the terminal alkene **156** is treated with 4 mol % of Grubbs first-generation catalyst **Ru-1** to promote ROM/RCM followed by cross-metathesis to afford **157** in 59% yield as a 67:33 mixture of separable (*E*)/(*Z*)-isomers. Compound **157** is converted into (+)-cylindramide A in several steps.

A synthesis of (+)-asteriscanolide involves a sequential ROM/CM/Cope rearrangement.[269] Consequently, treatment of cyclobutene **158** with 5 mol % of Grubbs second-generation catalyst **Ru-4** in benzene under an atmosphere of ethylene promotes ring-opening metathesis followed by cross-metathesis with ethylene to furnish the Cope-rearrangement precursor **159** (Scheme 87). This intermediate is not isolated, and under the reaction conditions, undergoes a Cope rearrangement to generate cyclooctadiene **160** in 74% yield. The synthesis of (+)-asteriscanolide is then completed from the tricyclic core by a series of functional group transformations.



Scheme 87

COMPARISON WITH OTHER METHODS

The formation of carbon–carbon double bonds is a key type of transformation on which much synthetic chemistry is based, and as such, several methods have been developed during the last century. The following is a brief discussion of three of the most important strategies for the construction of alkenes: (1) elimination reactions, (2) alkenation ("olefination") of carbonyl compounds, and (3) transition-metal-catalyzed cross-coupling reactions.[270–274]

Elimination Reactions

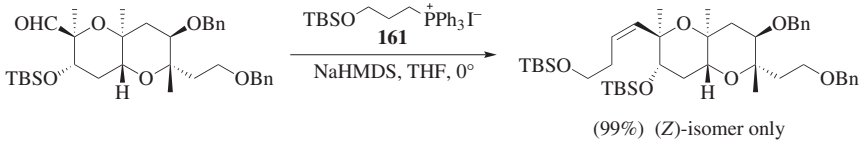
A number of molecules containing good leaving groups can undergo elimination reactions in the presence of bases,[275] at elevated temperatures,[276] or under the influence of agents such as cerium chloride[276] or samarium iodide.[277] This method usually exhibits low regio- and stereoselectivity, and in most cases a mixture of products is obtained. When the elimination process is base-dependent, the position of the double bond is determined by Zaitsev's rule,[278] which will lead predominantly to the more highly substituted alkene (where the base is sterically unhindered). However, if steric

nature of the base prohibits removal of a proton from the most substituted carbon, the less substituted alkene is preferred. Methods of converting 1,2-diols into alkenes have been comprehensively reviewed.[279] One important method is the elimination of cyclic thiocarbonates promoted by trialkyl phosphites (Corey–Winter reaction)[280,281] or metal carbonyls.[282] Diols are converted into alkenes stereospecifically by heating with trialkyl orthoformates and a catalytic amount of a carboxylic acid.[283] Elimination (extrusion) of sulfur dioxide in the Ramberg–Bäcklund reaction is another powerful method for the synthesis of alkenes that have a broad range of substitution patterns, including tetrasubstituted alkenes, cyclobutenes, and polyenes.[284]

Alkenation of Carbonyl Compounds

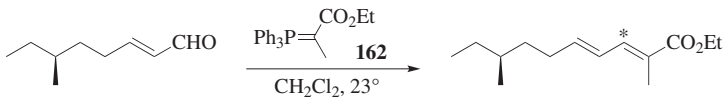
Carbonyl olefination reactions are site-selective and enable the formation of the double bond with no ambiguity as to the position of the resulting alkene. One drawback of this process is a low level of atom economy: commonly used reagents lead to phosphorus-, silicon-, sulfur-, or titanium-containing byproducts in equimolar quantities.

The Wittig reaction[285] couples aldehydes and ketones (often containing other functional groups such as alcohols, ethers, arenes, nitro, and ester groups) with phosphine ylides to provide mono-, di-, and trisubstituted alkenes, typically in good yields. Synthesis of tetrasubstituted alkenes is best performed by means other than the Wittig reaction (for example by McMurry reaction between two carbonyl compounds and low-valent titanium).[286,287] Because simple phosphoranes are very reactive and sensitive to moisture and oxygen, they are usually prepared in a dry solvent (typically THF) under an atmosphere of either nitrogen or argon, and the carbonyl compound is added immediately after the phosphorane has been formed. Phosphoranes containing groups that can stabilize a negative charge are more stable and much easier to handle. Simple, nonstabilized phosphonium ylides (e.g., **161**, **163**) mainly provide the thermodynamically less stable (*Z*)-isomers (Scheme 88).[288] (*E*)-Alkenes can be obtained either by using a stabilized ylide (e.g., **162**) (Scheme 89)[289] or by employing the Schlosser modification of the Wittig reaction with a nonstabilized ylide (Scheme 90).[290]



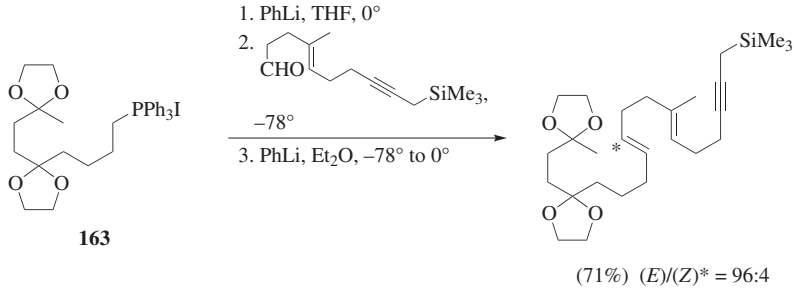
(99%) (*Z*)-isomer only

Scheme 88



(85%) (*E*)/(*Z*)* = 92:8

Scheme 89

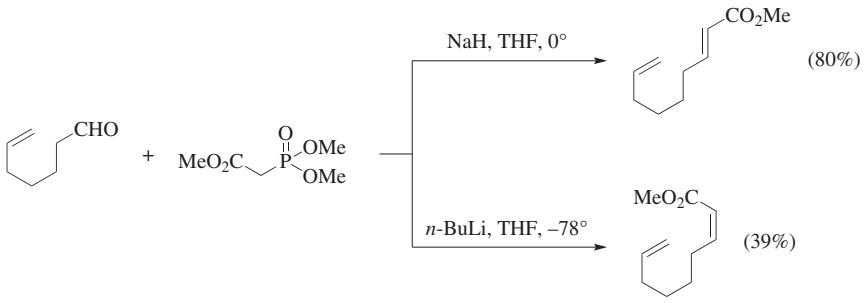


163

(71%) (*E*)/(*Z*)* = 96:4

Scheme 90

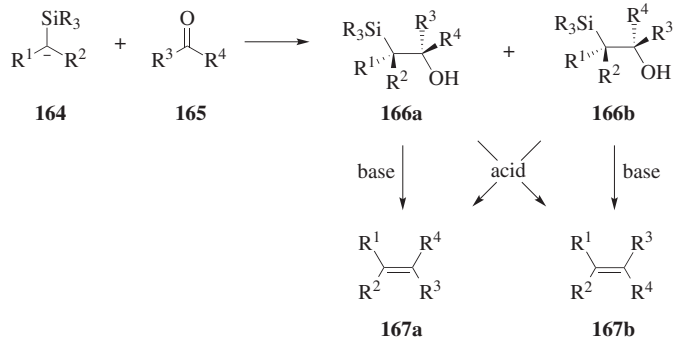
The Horner–Wadsworth–Emmons (HWE)[291] reaction is a modification of the Wittig reaction that employs phosphonate-stabilized carbanions. A particular advantage of this reaction is the broad substrate scope. For example, α,β-unsaturated ketones and sterically hindered ketones can be employed as substrates. Furthermore, purifications of HWE reactions are easier than those of Wittig reactions because the dialkylphosphate byproduct is readily soluble in water. As in the Wittig reaction, careful selection of the olefination conditions and reagents allows the synthesis of (*E*)- and (*Z*)-alkenes with a high degree of stereoselectivity.[292] (*Z*)-Isomers of alkenes are favored under conditions of kinetic control and in the presence of phosphonates with electron-withdrawing groups (e.g., trifluoroethyl phosphonates),[293] whereas more stable (*E*)-isomers of alkenes are favored under thermodynamic conditions (Scheme 91).[294]



Scheme 91

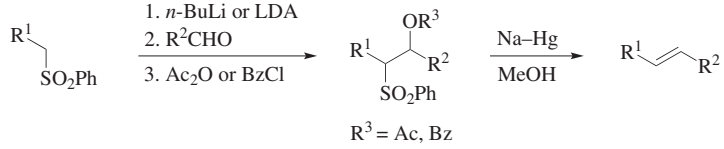
The Peterson reaction[295–297] employs α-silylcarbanions, usually generated in situ, for the synthesis of alkenes from aldehydes and ketones via the intermediate β-hydroxysilanes (Scheme 92). The Peterson reaction is characterized by simpler workup and purification procedures than the Wittig reaction. In addition, because the reagents are both more basic and more nucleophilic, as well as less sterically hindered, they are more reactive than phosphorus ylides. However, the Peterson process does have some drawbacks: α-silylcarbanion formation can be difficult, and a mixture of (*E*)- and (*Z*)-alkene isomers is often obtained. Thus, the addition of α-silylcarbanions **164** to carbonyl compounds **165** usually leads to a diastereomeric mixture of β-hydroxysilanes **166a/b** which, depending on the substituents, may

be difficult to separate. Each diastereoisomer **166a/b** undergoes stereospecific decomposition to afford either the (*E*)- or (*Z*)-isomer (alkene **167a** and **167b**), depending on the elimination conditions.

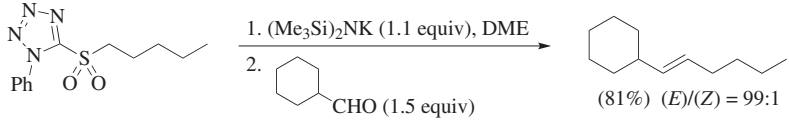


Scheme 92

Another method for alkenation of carbonyl compounds is the Julia reaction,[298] which involves the reaction of an aldehyde or ketone with a phenyl sulfone and yields an alkene after reductive elimination with sodium amalgam (Scheme 93). The reaction consists of multiple steps: (1) generation of a sulfonyl carbanion, (2) formation of a β-hydroxy sulfone, (3) transformation of the hydroxyl group into a good leaving group (e.g., acetate, benzoate, 4-toluenesulfonate), and (4) reduction of the hydroxy sulfone derivative with sodium amalgam. This last step limits the scope of the process to substrates containing functional groups resistant to reduction. As an alternative to sodium amalgam, reducing agents such as samarium diiodide or magnesium diiodide can be utilized.[299] The use of heteroaryl sulfones like benzothiazol-2-yl sulfones,[300] or 1-phenyl-1*H*-tetrazol-5-yl sulfones[301] (Julia–Kocienski olefination) enables the synthesis of alkenes in a one-step procedure, usually with good (*E*)-selectivity, and also circumvents the need for a reductive elimination step (Scheme 94).

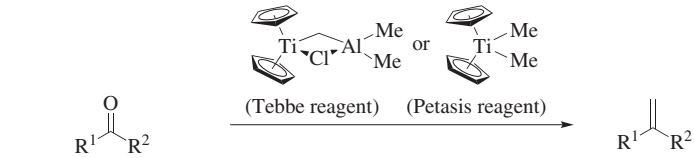


Scheme 93



Scheme 94

Tebbe and Petasis olefinations use titanium alkylidene complexes to methylenate a variety of carbonyl compounds (Scheme 95).[302−304] The method is useful not only for aldehydes and ketones but also for carboxylic acid derivatives, such as esters and amides. Thus, vinyl ethers[305] and enamines[306] can be obtained by this process. The Tebbe olefination can be applied to the synthesis of 1,1-disubstituted alkenes containing bulky substituents, but the reaction can be problematic in systems with high steric hindrance. Whereas this approach is applicable primarily for methylenations, some analogues of the Tebbe and Petasis reagents bearing alkyl chains have been developed to produce trisubstituted alkenes,[307] albeit low stereoselectivity can be a problem. Because the titanium carbenoids require rigorously air-free conditions, an alternative approach relies on generating the titanium carbenoids in situ with a CH_2X_2–TiX_4–Mg reagent.[308]



R^1 = alkyl, aryl
R^2 = H, OR^1, $N(R^1)_2$, alkyl

Scheme 95

Transition-Metal-Catalyzed Cross-Coupling Reactions

Transition-metal-promoted couplings arguably constitute the most powerful means to generate carbon–carbon, carbon–nitrogen, carbon–oxygen, and carbon–sulfur bonds. In contrast to the previously described methods for creating a double bond, the transition-metal-catalyzed reactions described in this section involve bond formation to a double bond already present in one of the reacting partners. Although the carbon–carbon double bond is introduced indirectly, the enormous power of these transformations in organic synthesis warrants their inclusion.

The Heck reaction[309,310] involves insertion of an alkene into a carbon–palladium bond, which is formed from an aryl halide, vinyl halide, or related derivative (Scheme 96). The Heck reaction has a broad functional-group tolerance and, like cross-metathesis, usually proceeds with high (*E*)-selectivity. The regioselectivity of the process is affected by the electronic properties of the alkenes used, the nature of the group into which palladium inserts, the ligands,[311,312] and the additives used. A significant limitation to this approach is that it is not applicable to halide substrates containing a β-hydrogen atom, although some exceptions have been reported.[313,314]

The coupling of an organometaloid or organometallic compound with a halide or pseudohalide is one of the most general and reliable methods for the formation of carbon–carbon bonds (Scheme 97). The main limitation of this methodology is



R^1 = aryl, alkyl
R^2 = aryl, vinyl
Y = halide, OTf

Scheme 96

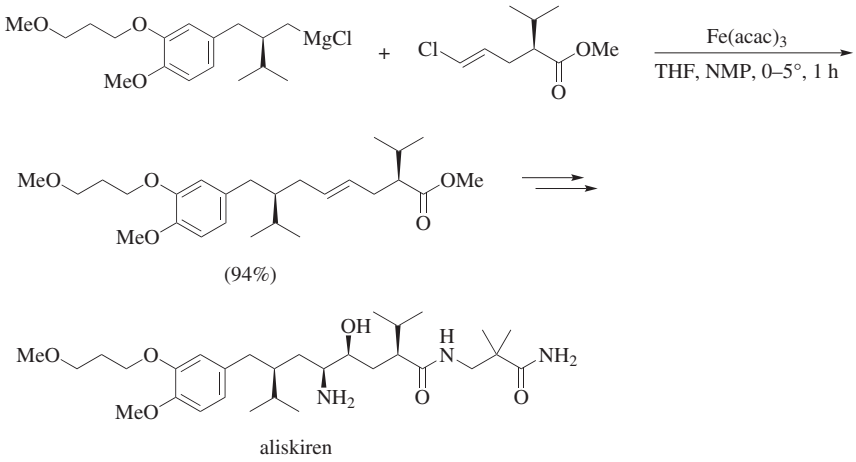


M = MgX (Kumada coupling)
M = SnR_3 (Stille coupling)
M = BR_2 or $B(OR)_2$ (Suzuki–Miyaura coupling)
M = SiR_3 (Hiyama–Denmark coupling)
M = ZnX (Negishi coupling)

Scheme 97

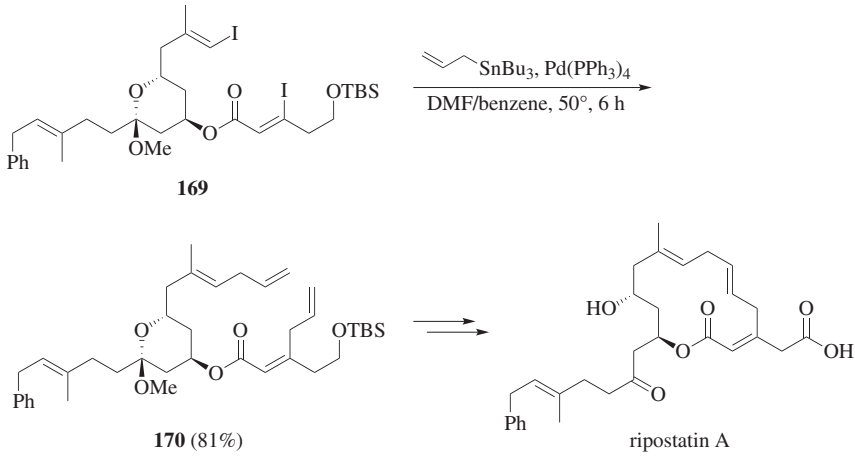
the production of an equimolar amount of MX byproducts that are often difficult to remove and, in some cases, may be toxic.

The Kumada coupling[315,316] employs Grignard reagents that are often commercially available or readily prepared from the corresponding halides. The reaction can be performed at room temperature or below in the presence of relatively inexpensive nickel complexes. However, the applicability of this reaction is limited owing to the reactivity of Grignard reagents with a wide range of functional groups. Nevertheless, the Kumada reaction can be conducted both on small and large scales, including industrial scales, as exemplified in the preparation of the hypertension drug aliskiren (Scheme 98).[317]



Scheme 98

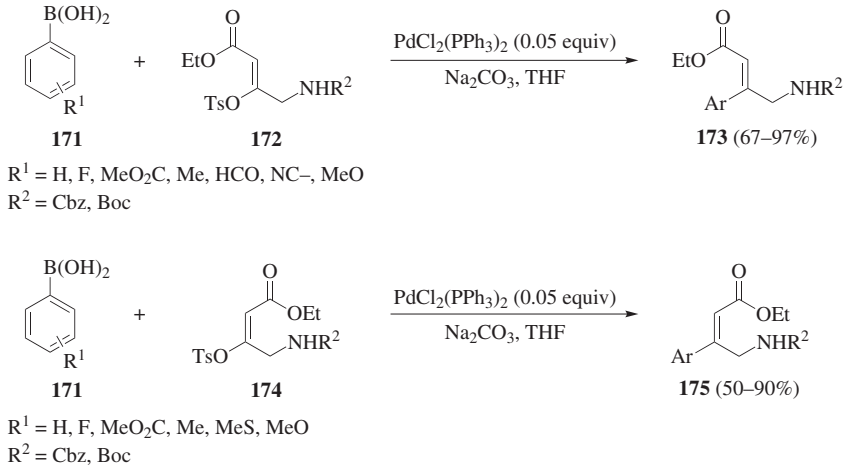
The Stille reaction[318] couples an organostannane with a variety of organic electrophiles. The air and moisture stability of organotin compounds, combined with their ready availability, make the Stille reaction one of the most extensively used coupling reactions. Moreover, because of the low reactivity of organotin reagents and their good functional group compatibility, this method is ideal for the synthesis of complex molecules. The configuration of the alkene is typically retained in the process, except when forcing reaction conditions are employed. One major drawback of the organotin-based reagents is their high toxicity. The synthesis of ripostatin A, a bacterial RNA-polymerase inhibitor, utilizes a double Stille cross-coupling sequence of diiodide **169** for the construction of a macrolactone ring precursor **170** (Scheme 99).[319]



Scheme 99

The key advantages of the Suzuki–Miyaura reaction[123,320] are high functional group tolerance and the relatively high stability of the boron reagents. These factors, combined with the low toxicity of the boron-containing compounds and straightforward removal of the boron byproducts (compared to the tin counterparts formed in the Stille coupling), often make this the reaction of choice. Since neutral boron compounds do not participate in coupling reactions, the use of Lewis bases is essential to generate an active boronate species. The Suzuki–Miyaura coupling also occurs with retention of the electrophile double-bond geometry. Thus, the stereospecific cross-coupling of (*E*)- and (*Z*)-tosylates **172** and **174** with aryl boronic acids **171** give the corresponding trisubstituted (*E*)- and (*Z*)-α,β-unsaturated esters **173** and **175**, respectively, in moderate-to-high yields (Scheme 100).[321]

Scheme 101 depicts a synthesis of synechoxanthin that involves a sequence of four Suzuki–Miyaura couplings, beginning with the reaction of aryl iodide **176** and functionalized building block **177**, in which the *N*-methyliminodiacetic acid (MIDA) boronate motif serves as a masked electrophile.[322] MIDA boronate **178** is

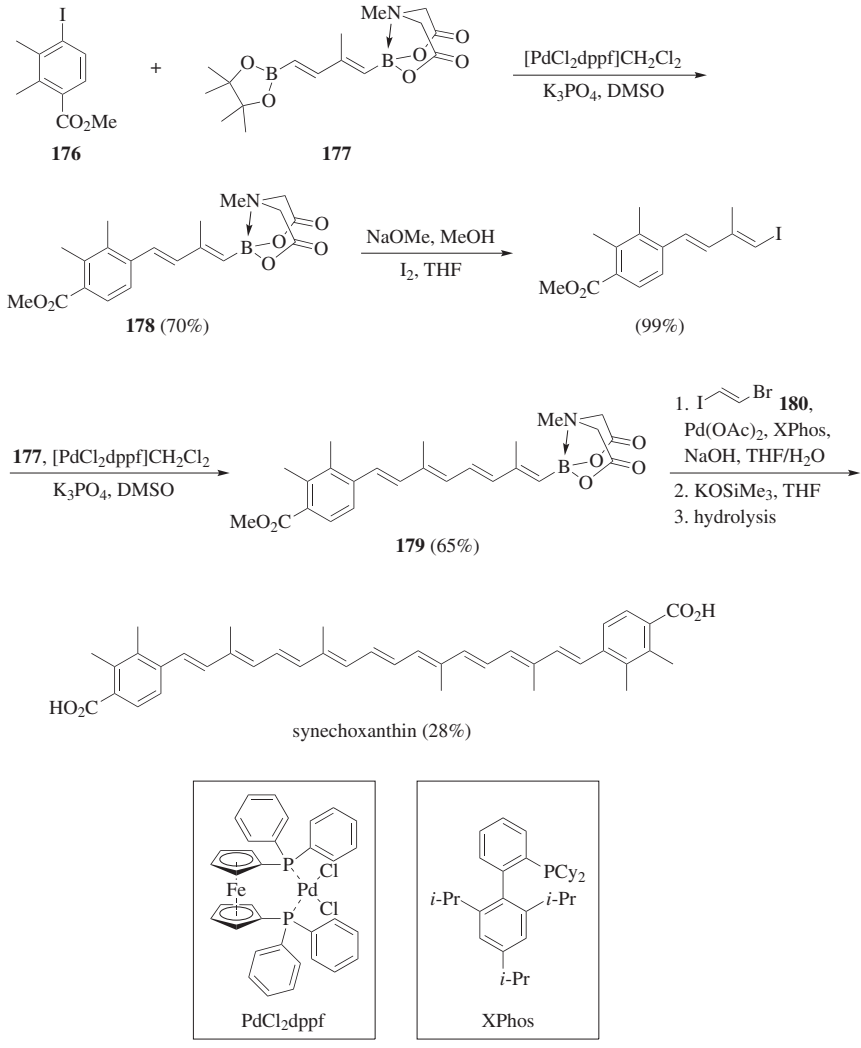


Scheme 100

then halodeborylated and subjected to a second cross-coupling reaction with another molecule of **177**. To complete the polyene framework of synechoxanthin, an in situ MIDA boronate hydrolysis/two-directional double cross-coupling sequence of **179** and **180** yields synechoxanthin bismethyl ester; hydrolysis of the methyl esters affords the natural product.

The Hiyama–Denmark coupling involves the palladium-mediated reaction of organosilanes with organic halides.[323] Organosilanes are often inexpensive, and the silicon-containing byproducts are almost completely nontoxic. Interestingly, the Hiyama–Denmark reaction is less frequently employed than other coupling reactions because of the rather harsh conditions originally required. Inclusion of either a Lewis base (often a fluoride source due to its high affinity for silicon) or the use of an organosilane with an electronegative atom (such as fluoride or oxygen) is required because neutral silanes exhibit low reactivity towards transmetalation with palladium. A fluoride-free variant of the Hiyama–Denmark coupling has been introduced, and the reaction is now compatible with substrates bearing silyl protecting groups.[324,325]

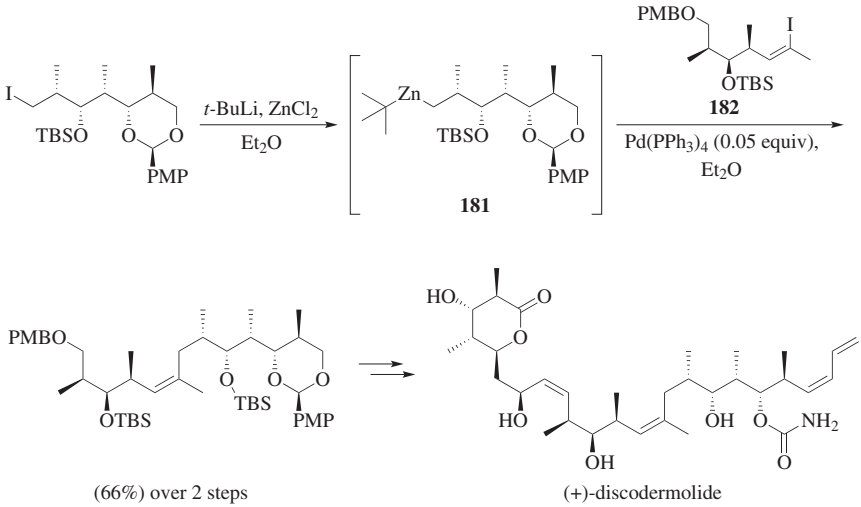
In the Negishi reaction,[326] organozinc compounds are coupled with organic halides in the presence of palladium or nickel complexes to give alkenes. Organozinc compounds are moisture- and air-sensitive, and therefore these reactions must be performed in an oxygen- and water-free environment. However, the high functional-group tolerance and increased reactivity relative to other cross-coupling reactions make the Negishi coupling ideal for combining complex intermediates in the synthesis of natural products. This method has been employed for a gram-scale synthesis of the clinically relevant microtubule-stabilizing agent (+)-discodermolide (Scheme 102).[327,328] In this approach, in situ prepared organozinc **181** is coupled with the vinyl iodide **182** to forge the C14–C15 bond of the target product.



Scheme 101

EXPERIMENTAL CONDITIONS

Cross-metathesis reactions are typically performed under experimentally simple conditions in various solvents (including dichloromethane, 1,2-dichloroethane, benzene, toluene, ethyl acetate, alkyl carbonates, 2-methyltetrahydrofuran, and neat) and at a wide range of temperatures depending on the reactivity of the reactants and catalysts. Most of the reactions proceed best in oven-dried glassware, in moisture- and oxygen-free solvents, and under an inert atmosphere of either N_2 or Ar. Because of the increased activity and stability of metathesis complexes, a growing number of examples of metathesis processes are carried out in technical-grade solvents, as



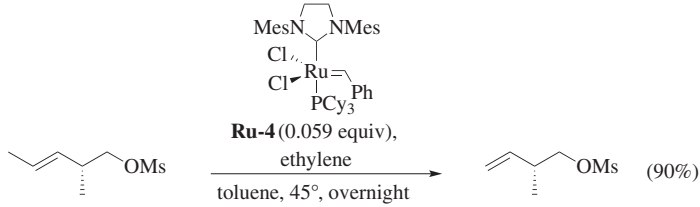
Scheme 102

well as in aqueous media. The olefin metathesis catalysts are usually stable in solid form, but their storage at reduced temperature in a refrigerator and/or in an inert gas atmosphere is strongly recommended. Owing to the large variety of metathesis catalysts used, it is difficult to provide general conditions for their handling, and instructions given by suppliers should be followed. Additives, such as Lewis acids (e.g., $Ti(O\textit{i}\text{-}Pr)_4$, $B(OPh)_3$, CuCl), phenols, or quinones can sometimes be used to increase the yield in the case of problematic CM reactions.

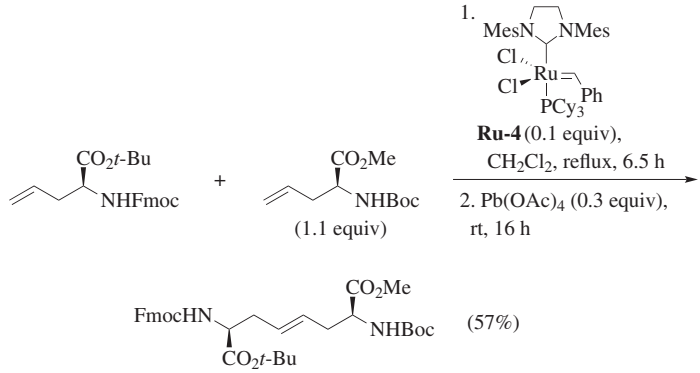
CAUTION: If a cross-metathesis reaction that leads to a volatile alkene byproduct (e.g., ethylene) is done on a large scale, it is important that appropriate precautions are taken to deal with the large volume of the flammable gas that is evolved.

The work-up for CM reactions usually involves either distillation or simple filtration through a short silica gel pad. In most cases, the reaction mixture is treated with ethyl vinyl ether or other scavengers before purification to deactivate the catalyst residues; self-scavenging complexes that are easily removable by filtration have gained in popularity.[329]

EXPERIMENTAL PROCEDURES

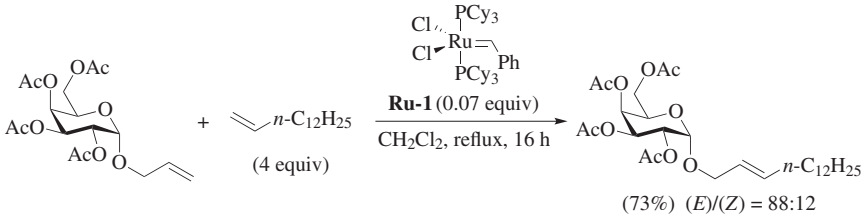


(*R*)-2-Methylbut-3-enyl Methanesulfonate [Ethenolysis of a Mesylate (Type I Alkene)].[330] A solution of (*R*)-2-methylpent-3-enyl methanesulfonate (40 mg, 0.22 mmol) in toluene (3.5 mL) was saturated with ethylene by bubbling ethylene gas through the solution for 10 min. The system was then heated to 45°, and a continuous ethylene flow was maintained. Into the solution was added a solution of catalyst **Ru-4** (11.5 mg, 0.013 mmol, 0.059 equiv) in toluene (1.5 mL) in three portions over an interval of 2 h. The mixture was stirred at 45° overnight while maintaining the ethylene flow. Upon completion of the reaction, the solvent was removed under reduced pressure, and the residue was purified by column chromatography on silica gel (hexane/EtOAc, 9:1) to give (*R*)-2-methylbut-3-enyl methanesulfonate as a colorless oil (33 mg, 90%): $[\alpha]^{22}_{D}$ + 5.0 (*c* 0.6, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.74 (ddd, *J* = 17.4, 10.4, 7.0 Hz, 1H), 5.15 (dd, *J* = 17.3, 1.3 Hz, 2H), 4.12 (dd, *J* = 9.7, 6.6 Hz, 1H), 4.05 (dd, *J* = 9.6, 6.6 Hz, 1H), 2.99 (s, 3H), 2.64–2.57 (m, 1H), 1.09 (d, *J* = 6.84, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 138.3, 116.2, 73.3, 37.3, 37.2, 16.0; IR 3085, 1350, 1171, 957 cm^{-1}; LRMS (*m/z*): $[M + Na]^+$ 187, $[M + H]^+$ 165, 117, 102; HRMS (*m/z*): $[M + H]^+$ calcd for $C_6H_{13}O_3S$, 165.0585; found, 165.0581.



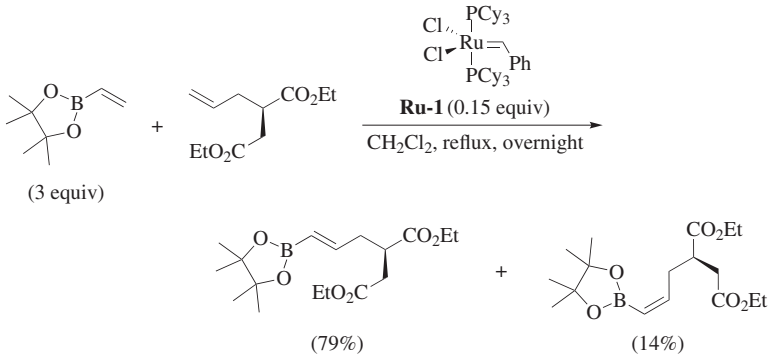
(2*S*,7*S*,*E*)-*tert*-Butyl 7-(*tert*-Butoxycarbonylamino)-2-(9*H*-fluoren-9-ylmethoxycarbonylamino)-7-(methoxycarbonyl)hept-4-enoate [Cross-Metathesis of Two Type I Alkenes].[331] *tert*-Butyl (*S*)-2-((((9*H*-fluoren-9-yl)methoxy)carbonyl) amino)pent-4-enoate (335 mg, 0.852 mmol) and methyl (*S*)-2-((*tert*-butoxycarbonyl)

amino)pent-4-enoate (216 mg, 0.942 mmol, 1.1 equiv) were added to an oven-dried, round-bottomed flask under Ar. Dichloromethane (8.5 mL) and catalyst **Ru-4** (73 mg, 0.085 mmol, 0.1 equiv) were added, and the reaction mixture was heated at reflux for 6.5 h under Ar. The reaction mixture was cooled to rt, and $Pb(OAc)_4$ (112 mg, 0.252 mmol, 0.3 equiv) was added. The mixture was stirred for 16 h at rt. The mixture was diluted with CH_2Cl_2 (ca. 15 mL) and filtered through a pad of Celite/silica gel (1:1), washing with CH_2Cl_2 (ca. 100 mL). The filtrate was evaporated under vacuum, and the crude product was purified via column chromatography on silica gel (toluene/diethyl ether, 9:1) to yield the title product (287 mg, 57%) as a colorless oil: $[\alpha]_D$ + 1.2 (*c* 0.5, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.76 (d, J = 7.4 Hz, 2H), 7.63 (d, J = 7.3 Hz, 2H), 7.40 (app t, J = 7.4 Hz, 2H), 7.31 (app td, J = 7.3, 1.1 Hz, 2H), 5.52–5.35 (m, 3H), 5.18 (d, J = 9.5 Hz, 1H), 4.50–4.18 (m, 5H), 3.72 (s, 3H), 2.57–2.37 (m, 4H), 1.47 (s, 9H), 1.44 (s, 9H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 172.7, 170.9, 155.9, 155.4, 144.1, 141.5, 128.8, 128.6, 127.9, 127.3, 125.4, 120.2, 82.5, 80.2, 67.2, 54.0, 53.3, 52.5, 47.4, 35.83, 35.78, 28.5, 28.3; IR (KBr) 3354 (br), 3065, 3041, 2978, 2934, 1716, 1508, 1451, 1367, 1352, 1249, 1221, 1161, 1081, 972, 847, 760, 740, 703 cm^{-1}; LRMS–EI (*m/z*): M^+ 594 (20), 550 (35), 494 (40), 465 (40), 393 (100), 351 (45). Anal. Calcd for $C_{33}H_{42}N_2O_8 \bullet 1.2\ H_2O$: C, 64.31; H, 7.26; N, 4.55. Found: C, 64.13; H, 7.33; N, 4.38.



2,3,4,5-Tetra-*O*-acetyl-α-pentadec-2-enyl D-Galactoside [Cross-Metathesis of an Allylic Ether (Type I Alkene)].[332] 2,3,4,5-Tetra-*O*-acetyl-α-allyl D-galactoside (388.7 mg, 1 mmol) was dissolved in 5 mL of dry CH_2Cl_2 in an oven-dried flask. A solution of 1-tetradecene (785.5 mg, 4 mmol, 4 equiv) and catalyst **Ru-1** (57.6 mg, 0.07 mmol, 0.07 equiv) in dry CH_2Cl_2 (5 mL) was added via syringe, and the reaction mixture was heated at reflux for about 16 h. Conversion of the starting material was monitored by TLC or by ^{1}H NMR spectroscopic analysis of an aliquot of the reaction mixture (e.g., using APT spectra). When complete consumption of the starting material had occurred, the solution was concentrated under vacuum and then directly chromatographed on a silica gel column (hexane, then hexane/EtOAc) to provide the title product (406.4 mg, 73%, (*E*)/(*Z*) = 88:12): ^{1}H NMR (CD_3OD, 400 MHz) δ 5.61 (dt, J = 15.0, 7.0 Hz, 1H), 5.38 (m, 1H), 5.35 (dd, J = 3.3, 1.0 Hz, 1H), 5.26 (m, 1H), 5.05–5.00 (m, 2H), 4.15 (t, J = 6.6 Hz, 1H), 4.07–3.94 (m, 3H), 3.85 (dd, J = 12.2, 6.9 Hz, 1H), 2.03 (s, 3H), 1.99–1.92 (m, 2H),

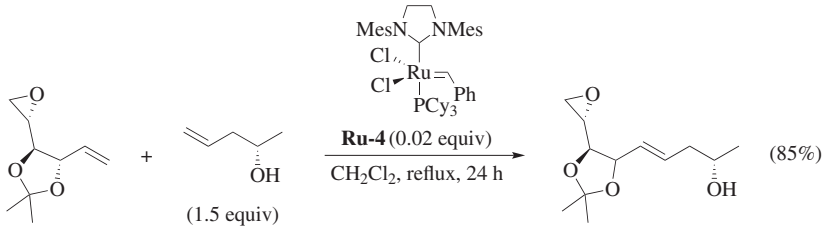
1.97 (s, 3H), 1.94 (s, 3H), 1.87 (s, 3H), 1.26 (m, 2H), 1.21–1.11 (m, 18H), 0.77 (t, $J = 6.5$ Hz, 3H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 170.0, 170.0, 169.9, 169.6, 135.9, 124.5, 94.7, 68.4, 67.9, 67.9, 67.5, 66.1, 61.5, 32.1, 31.7, 29.4, 29.4, 29.4, 29.3, 29.1, 30.0, 28.8, 22.5, 20.5, 20.4, 20.3, 13.9; MALDI–FTMS (*m/z*): $[M + Na]^+$ calcd for $C_{29}H_{48}O_{10}Na$, 579.3139; found, 579.3143.



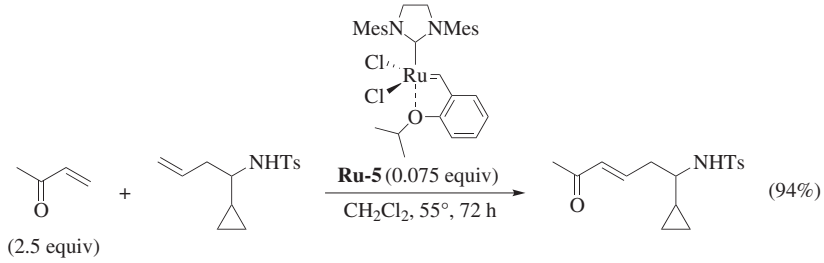
Diethyl 2-(*R*)-(3-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)allyl)succinate [Cross-Metathesis of a Vinyl Boronic Ester (Type II Alkene)].[333] To a solution of diethyl (*R*)-2-allyl succinate (500 mg, 2.34 mmol) in CH_2Cl_2 (23 mL) under Ar was added pinacol vinylboronate (1.17 mL, 6.9 mmol, 3 equiv) and catalyst **Ru-1** (287 mg, 0.35 mmol, 0.15 equiv). The mixture was stirred at reflux overnight and then was cooled to ambient temperature, diluted with CH_2Cl_2, and filtered through a Celite pad. Concentration of the filtrate and purification of the residue by column chromatography on silica gel (heptane/EtOAc, 9:1 to 8:2) provided pure (*E*)-isomer (633 mg, 79%) and (*Z*)-isomer (111 mg, 14%) as white amorphous solids:

(*E*)-Isomer: ^{1}H NMR (300 MHz, $CDCl_3$) δ 6.51 (dt, $J = 18.0$, 13.0 Hz, 1H), 5.50 (d, $J = 18.0$ Hz, 1H), 4.15 (m, 4H), 2.97 (m, 1H), 2.69 (dd, $J = 16.0$, 9.5 Hz, 1H), 2.51 (m, 1H), 2.47 (dd, $J = 16.0$, 6.0 Hz, 1H), 2.38 (m, 1H), 1.26 (m, 18H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 174.3, 172.1, 149.9, 83.4, 83.1, 60.6, 60.5, 41.0, 35.1, 34.1, 24.9, 24.8, 24.7, 14.2, 14.1; LRMS–ESI (*m/z*): $[M + Na]^+$ 363.

(*Z*)-Isomer: ^{1}H NMR (300 MHz, $CDCl_3$) δ 6.36 (dt, $J = 14.5$, 13.5 Hz, 1H), 5.48 (d, $J = 13.5$ Hz, 1H), 4.15 (m, 4H), 2.94 (m, 1H), 2.73 (m, 3H), 2.45 (dd, $J = 16.0$, 4.0 Hz, 1H), 1.27 (m, 18H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 174.5, 172.3, 150.1, 83.6, 83.3, 60.8, 60.7, 41.2, 35.3, 34.3, 25.0, 24.9, 24.8, 14.4, 4.3; LRMS–ESI (*m/z*): $[M + Na]^+$ 363.

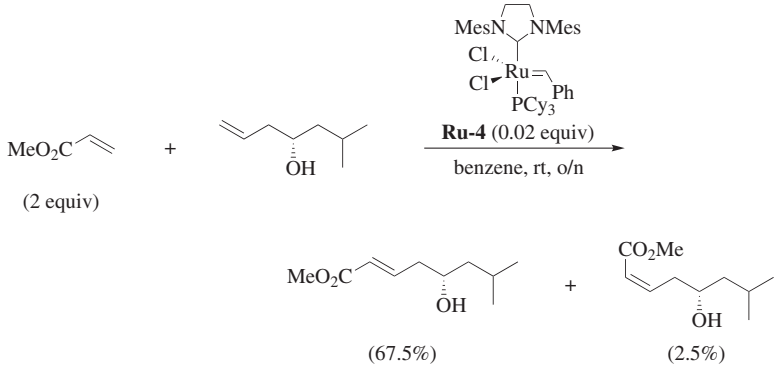


(*S*,*E*)-5-((4*S*,5*R*)-2,2-Dimethyl-5-((*S*)-oxiran-2-yl)-1,3-dioxolan-4-yl)pent-4-en-2-ol [Cross-Metathesis of an Acetal (Type II Alkene)].[334] To a stirred solution of (4*R*,5*S*)-2,2-dimethyl-4-((*S*)-oxiran-2-yl)-5-vinyl-1,3-dioxolane (1.10 g, 6.9 mmol) and (*S*)-pent-4-en-2-ol (885 mg, 10.3 mmol, 1.5 equiv) in dry CH_2Cl_2 (2 mL) was added catalyst **Ru-4** (117.16 mg, 0.138 mmol, 0.02 equiv) under an N_2 atmosphere. The reaction mixture was heated to reflux and stirred at that temperature for 24 h. The reaction mixture was concentrated under reduced pressure, and the residue was purified by column chromatography on silica gel (petroleum ether/EtOAc, 6:1) to give the title product as a colorless oil (1.33 g, 85%): $[\alpha]_D$ + 64.7 (*c* 1.3, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.93–5.85 (m, 1H), 5.62–5.56 (m, 1H), 4.37 (t, J = 8.0 Hz, 1H), 3.91–3.83 (m, 1H), 3.51 (dd, J = 8.4, 5.6 Hz, 1H), 3.06 (ddd, J = 6.4, 3.6, 2.4 Hz, 1H), 2.82 (dd, J = 4.8, 4.0 Hz, 1H), 2.70 (dd, J = 4.8, 2.4 Hz, 1H), 2.25–2.23 (m, 2H), 1.67 (br s, 1H), 1.44 (s, 3H), 1.43 (s, 3H), 1.21 (d, J = 6.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 132.8, 129.8, 109.8, 80.3, 80.2, 67.2, 51.3, 44.9, 42.2, 27.1, 26.8, 23.0; IR 3433, 2985, 2921, 1597, 1454, 1376, 1219, 1160, 1112, 1058 cm^{-1}; HRMS–ESI (*m*/*z*): $[M + Na]^+$ calcd for $C_{12}H_{20}O_4Na$, 251.1253; found 251.1264.



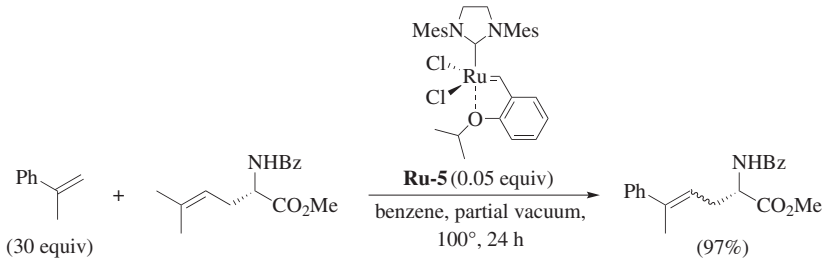
(*E*)-*N*-(1-Cyclopropyl-5-oxohex-3-en-1-yl)-4-methylbenzenesulfonamide [Cross-Metathesis of an α,β-Unsaturated Ketone (Type II Alkene)].[335] A resealable reaction tube was fitted with a magnetic stir bar and then charged with catalyst **Ru-5** (70.9 mg, 0.113 mmol, 0.075 equiv). The tube was then sealed with a rubber septum and purged with Ar. Argon-sparged CH_2Cl_2 (0.25 M with respect

to the homoallylic sulfonamide employed), *N*-(1-cyclopropylbut-3-en-1-yl)-4-methylbenzenesulfonamide (400 mg, 1.51 mmol), and methyl vinyl ketone (0.31 mL, 3.77 mmol, 2.5 equiv) were then added sequentially via syringe. The rubber septum was replaced with a screw cap, and the tube was heated at 55° (oil-bath temperature) for 72 h. After cooling to rt, the reaction mixture was concentrated in vacuo, and the crude material was purified directly by column chromatography on silica gel (petroleum ether/EtOAc, 4:1) to afford the title product as a brown oil (436 mg, 94%): ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.62 (d, J = 8.0 Hz, 2H), 7.17 (d, J = 8.0 Hz, 2H), 6.61 (q, J = 7.5 Hz, 1H), 5.88 (d, J = 16.0 Hz, 1H), 5.18–5.05 (m, 1H), 2.58–2.26 (m, 6H), 2.05 (s, 3H), 0.74–0.60 (m, 1H), 0.43–0.31 (m, 1H), 0.26–0.18 (m, 1H), 0.23–0.14 (m, 1H), 0.07–0.04 (m, 1H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 198.4, 143.4, 143.2, 137.8, 133.8, 129.6, 127.0, 58.2, 38.8, 26.7, 21.5, 16.1, 4.1, 3.6; IR 1670, 1361, 1326, 1156, 1093, 981, 816, 665 cm^{-1}; HRMS–ESI (*m*/*z*): [M + Na]$^+$ calcd for $C_{16}H_{21}NNaO_3SNa$, 330.1134; found, 330.1141.

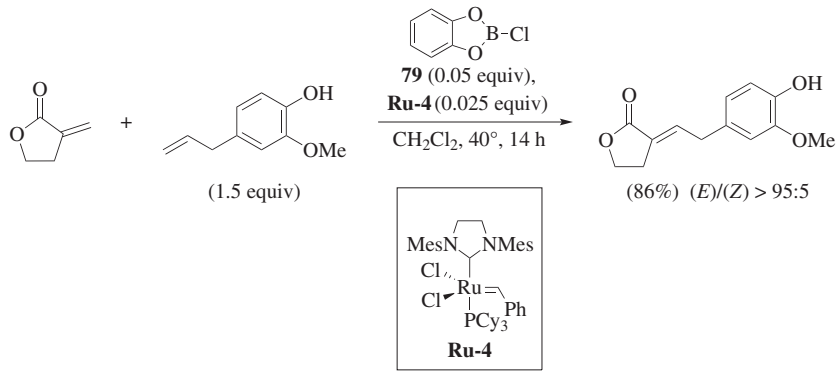


(5*R*)-5-Hydroxy-7-methyl-oct-2-enoic Acid Methyl Ester [Cross-Metathesis of Methyl Acrylate (Type II Alkene)].[336] 6-Methylhept-1-en-4-ol (200 mg, 1.56 mmol) was dissolved in benzene (7.8 mL) under N_2, and methyl acrylate (0.28 mL, 3.1 mmol, 2 equiv) was added, followed by catalyst **Ru-4** (26.5 mg, 31.2 μmol, 0.02 equiv). The reaction was stirred at rt overnight, and then was quenched by exposure to air. The solvent was removed under reduced pressure, and the crude product was purified by column chromatography on silica gel (hexane/EtOAc, 9:1 to 8:2) to give the (*E*)-product (196 mg) and the (*Z*)-product (7 mg) (203.4 mg, total yield 70%): R_f (hexane/EtOAc, 8:2) 0.36; ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.94 (dddd, J = 16.0, 7.0, 7.0, 1.5 Hz, 1H), 5.85 (dd, J = 16.0, 1.5 Hz, 1H), 3.80–3.75 (m, 1H), 3.67 (s, 3H), 2.36–2.23 (m, 2H), 2.07 (br s, 1H), 1.76–1.67 (m, 1H), 1.37 (dddd, J = 15.5, 7.5, 5.5, 1.5 Hz, 1H), 1.19 (dddd, J = 15.0, 7.5, 4.5, 1.5 Hz, 1H), 0.87 (dd, J = 7.0, 1.5 Hz, 3H), 0.85 (dd, J = 7.0, 1.5 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 166.9, 145.8, 123.3, 68.5, 51.5, 46.2, 40.7, 24.5, 23.3, 21.9; IR (thin film) 3465, 2954, 2870, 1726, 1657, 1436, 1323, 1273, 1210, 1168, 1040, 986 cm^{-1}; HRMS–CI

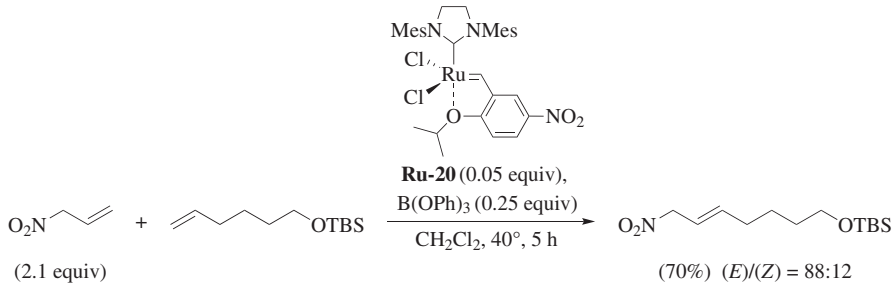
(*m*/*z*): $[M + H]^+$ calcd for $C_{10}H_{19}O_3$, 187.1334; found, 187.332; $[M + NH_4]^+$ calcd for $C_{10}H_{18}O_3$, 204.1600; found, 204.1595.



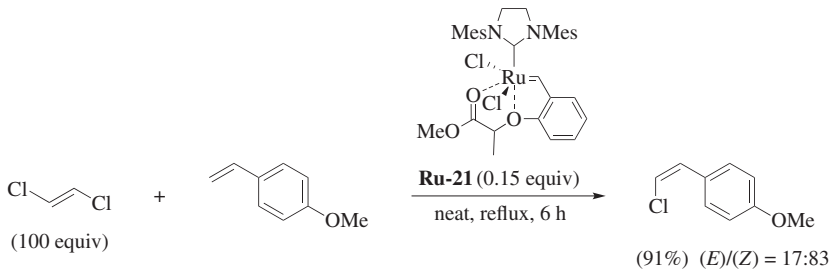
Methyl (*S*)-2-Benzamido-5-phenylhex-4-enoate [Cross-Metathesis of α-Methylstyrene (Type III Alkene)].[337] Methyl (*S*)-2-benzamido-5-methylhex-4-enoate (50.0 mg, 0.191 mmol), α-methylstyrene (677 mg, 5.74 mmol, 30 equiv), and benzene (1 mL) were added to an oven-dried Schlenk vessel equipped with a magnetic stir bar. The vessel was sealed and subjected to a freeze–pump–thaw cycle to remove traces of oxygen. Catalyst **Ru-5** (6.0 mg, 0.0096 mmol, 0.05 equiv) was then added under a flow of N_2. The reaction vessel was placed under a partial vacuum until the solvent began to bubble. The tube was then sealed and heated to 100° for 24 h. The reaction mixture was cooled to rt, and then was distilled (0.2 mm Hg) with a water or liquid N_2 condenser to recover excess α-methylstyrene. The residue was purified by column chromatography on silica gel (hexane/EtOAc, 5:1 to 3:1) to afford the title product as a colorless oil (59.9 mg, 97%): ^{1}H NMR (400 MHz, $CDCl_3$, mixture of isomers) δ 7.80–7.78 (m, 2H), 7.51 (tt, J = 7.2, 1.6 Hz, 1H), 7.46–7.41 (m, 2H), 7.36–7.22 (m, 5H), 6.80 (d, J = 7.6 Hz, 1H), 5.70 (tq, J = 7.6, 1.2 Hz, 1H), 4.99 (dt, J = 7.6, 5.8 Hz, 1H), 3.80 (s, 3H), 2.99–2.77 (m, 2H), 2.04 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$, mixture of isomers) δ 172.6, 167.1, 143.4, 139.4, 134.1, 131.9, 128.7, 128.4, 127.2, 127.1, 125.9, 121.2, 60.5, 52.7, 52.6, 31.7, 16.3; IR (neat) 3345, 1739, 1646, 1602, 1533, 1489, 1436, 1266, 1217, 1179 cm^{-1}; HRMS–ESI (*m*/*z*): $[M + Na]^+$ calcd for $C_{20}H_{21}NO_3Na$, 346.1414; found, 346.1417.



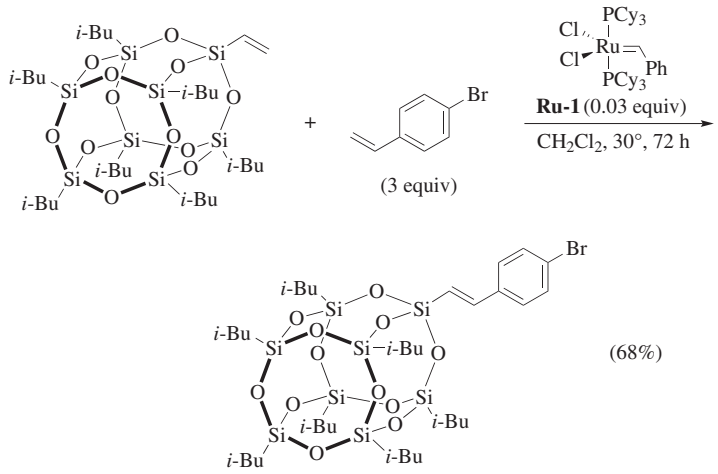
Dihydro-3-(2-(4-hydroxy-3-methoxyphenyl)ethylidene)furan-2(*3H*)-one [Cross-Metathesis of a Lactone with an Exocyclic Double Bond (Type III Alkene)].[173] To a stirred solution of α-methylene-γ-butyrolactone (0.5 mmol, 44 μL) and 4-allyl-2-methoxyphenol (0.75 mmol, 123 mg, 1.5 equiv) in CH_2Cl_2 (1.2 mL) was added B-chlorocatecholborane (**79**) (3.86 mg, 0.025 mmol, 0.05 equiv) and catalyst **Ru-4** (10.19 mg, 0.012 mmol, 0.025 equiv). The reaction mixture was heated at 40° under N_2 for 14 h. The solvent was then removed under reduced pressure, and the residue was purified by column chromatography on silica gel (hexane/EtOAc, 20:1, changing to EtOAc/MeOH, 4:1) to provide the title product as a colorless oil (100.7 mg, 86%, (*E*)/(*Z*) > 95:5): ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.82 (m, 1H), 6.76 (d, J = 8.5 Hz, 1H), 6.62–6.57 (m, 2H), 5.66 (br s, 1H, OH), 4.31 (app t, J = 7.5 Hz, 2H), 3.78 (s, 3H), 3.38 (d, J = 7.5 Hz, 2H), 2.84–2.80 (m, 2H); ^{13}C NMR (400 MHz, $CDCl_3$) δ 171.3 (s), 146.8 (s), 144.5 (s), 138.9 (d), 129.4 (s), 125.8 (s), 121.1 (d), 114.5 (d), 111.0 (d), 65.5 (t), 56.0 (q), 35.9 (t), 25.1 (t); IR 3396, 2920, 1742, 1676, 1601, 1513, 1430, 1379, 1268, 1205, 1177, 1150, 1122, 1027 cm^{-1}; LCMS–EI (*m*/*z*): M^+ 234 (100), 189 (60), 175 (14), 157 (20), 129 (21), 115 (18); HRMS–EI (*m*/*z*): $[M + H]^+$ calcd for $C_{13}H_{15}O_4$, 235.09649; found, 235.09674.



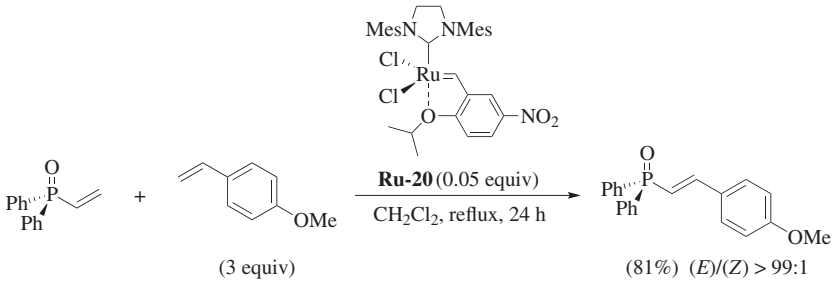
***tert*-Butyldimethyl((7-nitrohept-5-en-1-yl)oxy)silane [Cross-Metathesis of an Allylic Nitro Compound (Type III Alkene)].[179]** To a solution of 5-hexenyl *tert*-butyldimethylsilyl ether (236.1 mg, 1.10 mmol) and 3-nitropropene (199.4 mg, 2.29 mmol, 2.1 equiv) in CH_2Cl_2 (4.5 mL) was added triphenyl borate (80.2 mg, 0.28 mmol, 0.25 equiv). Catalyst **Ru-20** was then added in one portion (37.3 mg, 0.06 mmol, 0.05 equiv). The resulting mixture was heated at 40° for 5 h under an Ar atmosphere. After cooling the reaction mixture to rt, the solvent was removed under reduced pressure. The crude product was purified by preparative TLC (cyclohexane/EtOAc, 20:1), and the title product was obtained as a yellow oil (210.8 mg, 70%, (*E*)/(*Z*) = 88:12) that solidified in a refrigerator: ^{1}H NMR ($CDCl_3$, 400 MHz, (*E*)-isomer) δ 5.92 (dtt, *J* = 15.2, 6.7, 1.0 Hz, 1H), 5.75 (dtt, *J* = 15.3, 7.2, 1.4 Hz, 1H), 4.88 (dd, *J* = 7.2, 0.9 Hz, 2H), 3.61 (t, *J* = 6.1 Hz, 2H), 2.18–2.13 (m, 2H), 1.58–1.40 (m, 4H), 0.89 (s, 9H), 0.47 (s, 6H); ^{13}C NMR ($CDCl_3$, 100 MHz, (*E*)-isomer) δ 141.6, 118.7, 77.6, 62.8, 32.2, 32.0, 25.9, 24.8, 18.4, 5.3; IR (film) 2952, 2931, 2897, 2858, 1608, 1557, 1519, 1483, 1472, 1463, 1429, 1375, 1361, 1341, 1271, 1256, 1137, 1104, 1006, 972, 952, 911, 836, 813, 799, 776, 742, 661, 653 cm^{-1}; LRMS–ESI (*m/z*): $[M + Na]^+$ 296; HRMS–ESI (*m/z*): $[M + Na]^+$ calcd for $C_{13}H_{27}NO_3SiNa$, 296.1652; found, 296.1651.



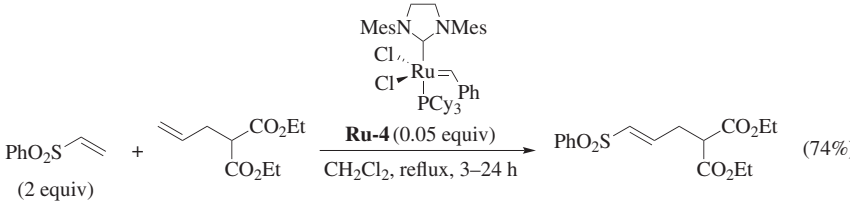
1-[(*E,Z*)-2-Chloroethenyl]-4-methoxybenzene [Cross-Metathesis of a Vinyl Halide (Type III Alkene)].[105] To a solution of 4-methoxystyrene (80.5 mg, 0.60 mmol) in (*E*)-1,2-dichloroethene (5.8 g, 4.6 mL, 60 mmol, 100 equiv) was added catalyst **Ru-21** (60.3 mg, 0.09 mmol, 0.15 equiv). The resulting mixture was stirred at reflux for 6 h, cooled to rt, and (*E*)-1,2-dichloroethene was removed under reduced pressure. The crude product was purified by preparative TLC (cyclohexane/EtOAc, 20:1) to give the title product as a colorless oil (92 mg, 91%, (*E*)/(*Z*) = 17:83): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68–7.64 (m, 2H), 7.25–7.21 (m, 2H), 6.93–6.89 (m, 2H), 6.88–6.84 (m, 2H), 6.78 (d, J = 13.7 Hz, 1H), 6.57 (d, J = 8.1 Hz, 1H), 6.51 (d, J = 13.7 Hz, 1H), 6.16 (d, J = 8.1 Hz, 1H), 3.83 (s, 3H), 3.81 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.5, 159.3, 132.7, 130.7, 128.6, 127.6, 127.3, 126.9, 116.4, 115.4, 114.2, 113.6, 55.2; IR (film) 3079, 3005, 2957, 2837, 1606, 1574, 1510, 1462, 1345, 1304, 1257, 1174, 1033, 833, 787, 691, 536 cm^{-1}; LRMS–EI (*m*/*z*): M^+ 168 (100), 153 (56), 125 (40), 89 (33), 63 (21); HRMS–EI (*m*/*z*): M^+ calcd for C_9H_9ClO, 168.0342; found, 168.0347. Anal. Calcd for C_9H_9ClO: C, 64.11; H, 5.38; Cl, 21.02. Found: C, 64.25; H, 5.39; Cl, 20.84.



(*E*)-2-(4-Bromophenyl)vinylheptaisobutyl-T8-silsesquioxane [Cross-Metathesis of a Vinyl Siloxane (Type III Alkene)].[338] Vinylhepta-isobutyl-T8-silsesquioxane (3.5 g, 4.15 mmol) and catalyst **Ru-1** (0.068 g, 0.083 mmol, 0.02 equiv) were placed in a Schlenk flask at rt under N_2. Dry CH_2Cl_2 (4.9 mL) and 4-bromostyrene (2.27 g, 1.63 mL, 12.4 mmol, 3 equiv) were added to the flask by syringe, and the mixture was magnetically stirred at 30°. After 48 h, an additional portion of catalyst **Ru-1** (0.034 g, 0.041 mmol, 0.01 equiv) was added, and the mixture was further stirred at 30° for 24 h. After cooling to rt, the reaction solution was poured into MeOH (100 mL), and the crude product was collected by filtration, washed with MeOH, and purified by column chromatography on silica gel (*n*-hexane) to provide the title product (68%). The product was determined to be the (*E*)-isomer by ^{1}H NMR spectroscopic analysis: ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.47 (d, J = 8.4 Hz, 2H), 7.30 (d, J = 8.4 Hz, 2H), 7.10 (d, J = 19.1 Hz, 1H), 6.12 (d, J = 19.1 Hz, 1H), 1.88 (m, 7H), 0.97 (d, J = 6.6 Hz, 18H), 0.96 (d, J = 6.6 Hz, 24H), 0.65 (d, J = 7.0 Hz, 6H), 0.62 (d, J = 7.1 Hz, 8H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 146.66, 136.56, 131.69, 128.27, 122.61, 119.67, 25.71, 23.88, 23.86, 22.50, 22.43; ^{29}Si NMR ($CDCl_3$, 80 MHz) δ –67.39, –67.83, –80.17; FTIR (KBr) 2954, 2926, 2906, 2870, 1610, 1486, 1464, 1400, 1383, 1367, 1332, 1230, 1105, 1039, 1010, 989, 952, 839, 782, 742 cm^{-1}; HRMS–FAB (*m/z*): $[M + H]^+$ calcd for $C_{36}H_{70}BrO_{12}Si_8$, 997.2205; found, 997.2209.

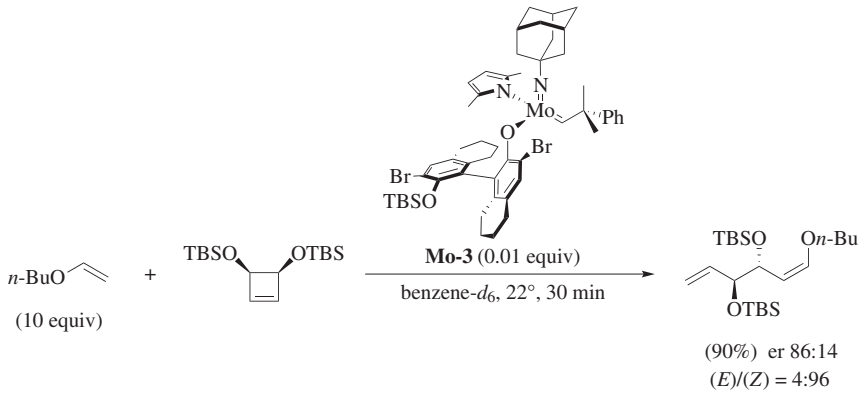


(*E*)-[2-(4-Methoxyphenyl)vinyl]diphenylphosphine Oxide [Cross-Metathesis of a Vinyl Phosphine Oxide (Type III Alkene)].[215] To a mixture of the vinylphosphine oxide (62 mg, 0.27 mmol) and catalyst **Ru-20** (9.1 mg, 0.014 mmol, 0.05 equiv) in CH_2Cl_2 (13 mL) was added 4-methoxystyrene (108.7 mg, 0.11 mL, 0.81 mmol, 3 equiv) via syringe. The resulting mixture was stirred at reflux for 24 h, and then the solvent was removed under reduced pressure. The crude product was purified by column chromatography on silica gel (EtOAc, then EtOAc/methanol, 10:1 to 5:1) to afford the title product as a colorless solid (73 mg, 81%, (*E*)/(*Z*) > 99:1): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79–7.72 (m, 4H), 7.57–7.51 (m, 2H), 7.51–7.45 (m, 6H), 7.45–7.38 (m, 1H), 6.94–6.86 (m, 2H), 6.67 (dd, J = 22.3, 17.3 Hz, 1H), 3.84 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 161.2 (s), 147.2 (d, J = 4.2 Hz), 133.1 (d, J = 106.0 Hz), 131.8 (d, J = 2.6 Hz), 131.4 (d, J = 10.3 Hz), 129.4 (s), 128.5 (d, J = 12.1 Hz), 127.9 (d, J = 17.7 Hz), 116.0 (d, J = 106.0 Hz), 114.2 (s), 55.4 (s); ^{31}P NMR (162 MHz, $CDCl_3$) δ 24.9; LRMS–EI (*m/z*): M^+ 334 (100), 319 (11.81), 257 (9.83), 202 (50.93), 198 (13), 183 (11.37), 155 (20.90), 77 (10.11), 47 (11.35); HRMS–EI (*m/z*): M^+ calcd for $C_{21}H_{19}O_2P$, 334.1122; found, 334.1116. Anal. Calcd for $C_{21}H_{19}O_2P$: C, 75.45; H, 5.68. Found: C, 75.51; H, 5.69.



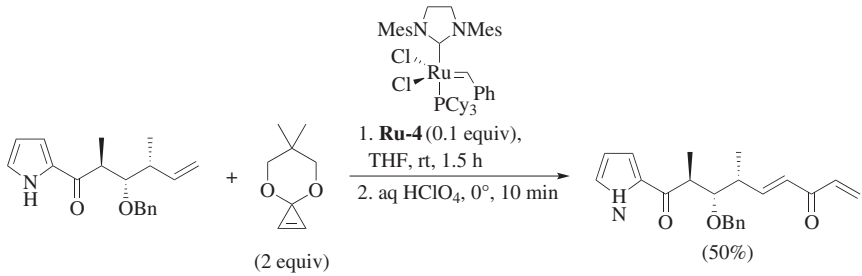
Diethyl 2-[(*E*)-3-(Phenylsulfonyl)-2-propenyl]malonate [Cross-Metathesis of a Vinyl Sulfone (Type III Alkene)].[228] To a mixture of diethyl 2-allylmalonate (50.1 mg, 0.25 mmol) and vinyl sulfone (84.1 mg, 0.50 mmol, 2 equiv) in CH_2Cl_2 (15 mL) was added a solution of Grubbs second-generation catalyst **Ru-4** (10.6 mg, 0.0125 mmol, 0.05 equiv) in CH_2Cl_2 (5 mL). The resulting mixture was stirred at reflux for 3–24 h, and the solvent was removed under reduced pressure. The crude

product was purified by column chromatography on silica gel (cyclohexane/EtOAc) to give the title compound as a colorless oil (63 mg, 74%): ^{1}H NMR (200 MHz, $CDCl_3$) δ 7.78–7.14 (m, 5H), 6.48 (dt, J = 15.8, 1.2 Hz, 1H), 6.15 (dt, J = 15.8, 7.0 Hz, 1H), 4.21 (q, J = 7.1 Hz, 4H), 3.48 (t, J = 7.4 Hz, 1H), 2.80 (td, J = 7.4, 1.2 Hz, 2H), 1.23 (t, J = 7.1 Hz, 6H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 168.9, 137.1, 132.8, 128.5, 127.4, 126.2, 125.6, 77.5, 77.3, 76.7, 61.5, 52.0, 32.2, 14.1; IR (film) 2984, 2938, 1731, 1447, 1321, 1308, 1148, 1087, 821, 596 cm^{-1}; LRMS–EI (*m*/*z*): 276 (23), 202 (36), 157 (16), 130 (16), 129 (100), 128 (31), 117 (34), 115 (20), 91 (11); HRMS–LSI (*m*/*z*): [M + H]$^+$ calcd for $C_{16}H_{21}O_6S$, 341.1059; found, 341.1040.

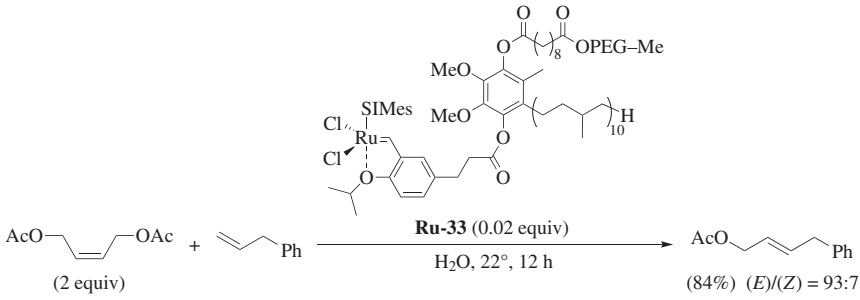


(5*R*,6*S*)-5-((*Z*)-2-Butoxyvinyl)-2,2,3,3,8,8,9,9-octamethyl-6-vinyl-4,7-dioxa-3,8-disiladecane [AROCM of a Vinyl Ether (Type III Alkene)].[339] In a N_2-filled glovebox, an oven-dried 4-mL vial equipped with a magnetic stir bar was charged with the catalyst **Mo-3** (16 μL, 0.02 M in benzene, 0.32 μmol) and *n*-butyl vinyl ether (32.0 mg, 0.320 mmol, 10 equiv). The resulting mixture was stirred for 5 min and then was added by syringe to a solution of 3,4-bis(*tert*-butyldimethylsilyloxy)-*cis*-cyclobutene (10.0 mg, 31.8 μmol) in benzene-d_6 in a 4-mL vial, and the resulting solution was stirred for 30 min at 22°. When the starting material had been consumed, the reaction was quenched by exposure to air or by addition of wet diethyl ether, and then the mixture was concentrated under vacuum (conversion was determined by ^{1}H NMR spectroscopic analysis). The resulting brown oil was purified by column chromatography on silica gel (hexane/Et_2O, 9:1) to afford the desired product as a colorless oil (11.1 mg, 90% yield, (*E*)/(*Z*) = 4:96, er 86:14): $[\alpha]_D^{20}$ – 19.2 (*c* 0.500, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.90 (dd, J = 6.3, 1.0 Hz, 1H), 5.83 (ddd, J = 17.2, 10.4, 6.1 Hz, 1H), 5.14 (ddd, J = 17.4, 3.5, 2.2 Hz, 1H), 5.10 (ddd, J = 10.5, 3.0, 2.1 Hz, 1H), 4.52 (ddd, J = 8.9, 4.1, 1.1 Hz, 1H), 4.33 (dd, J = 9.3, 6.4 Hz, 1H), 4.00 (ddd, J = 7.4, 6.1, 2.8 Hz, 1H), 3.70 (ddd, J = 13.2, 7.0, 4.0 Hz, 2H), 1.60–1.52 (m, 2H), 1.40 (ddd, J = 22.1, 14.5, 7.5 Hz, 2H), 0.90 (t, J = 7.2 Hz, 3H), 0.87 (s, 9H),

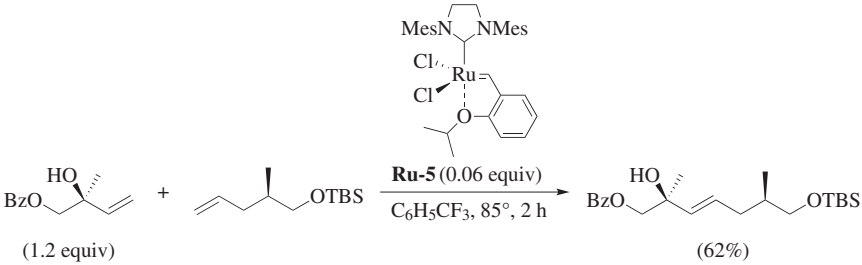
0.85 (s, 9H), 0.034 (s, 3H), 0.03 (s, 3H), 0.01 (s, 3H), 0.005 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.0, 139.1, 115.2, 108.0, 78.2, 72.4, 71.0, 32.1, 26.3, 26.2, 19.3, 18.7, 18.5, 14.0, –4.2, –4.3, –4.6; IR (neat) 2956, 2929, 2857, 1663, 1472, 1463, 1405, 1377, 1251, 1217, 1112, 1083, 1005, 940, 919, 834, 776, 671 cm^{-1}; HRMS–ESI (*m*/*z*): $[M + Na]^+$ calcd for $C_{22}H_{46}O_3Si_2$, 437.2899; found, 437.2907. The enantiomeric ratio was determined by HPLC analysis of the corresponding alcohol (after removal of the silyl group) by comparison with racemic material (t_R (major) 17.34 min, t_R (minor) = 16.43 min; OJ column, hexane/*i*-PrOH, 98/2, 1.0 mL/min, 220 nm).



3-Benzyloxy-2,4-dimethyl-1-(1*H*-pyrrol-2-yl)nona-5,8-diene-1,7-dione [Tandem ROCM of a Cyclopropenone Ketal (Type II Alkene)].[340] Catalyst **Ru-4** (25 mg, 0.030 mmol, 0.1 equiv) was dissolved in anhydrous THF (2 mL) and treated dropwise over 30 min with a solution of 3-benzyloxy-2,4-dimethyl-1-(1*H*-pyrrol-2-yl) -hex-5-en-1-one (90 mg, 0.30 mmol) and the cyclopropenone ketal (84 mg, 0.60 mmol, 2 equiv) in THF (3 mL) at rt. After 1.5 h, the reaction mixture was cooled to 0°, treated with $HClO_4$ (0.050 mL, 30% aqueous solution), and stirred at 0° for 10 min, at which point TLC analysis indicated complete consumption of the starting material. The reaction mixture was quenched with saturated $NaHCO_3$ solution and then diluted with EtOAc/hexane, and the biphasic mixture was washed with brine. The organic layer was dried over $MgSO_4$, filtered, and concentrated. The residue was purified by column chromatography on silica gel (hexane/EtOAc, 5:1 to 3:1) to provide the title compound as a pale-brown oil (53 mg, 50%): $[\alpha]^{26}_D$ – 31.2 (*c* 1.0, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.33 (br s, 1H), 7.22–7.16 (m, 3H), 7.08 (dd, *J* = 16.0, 7.0 Hz, 1H), 7.08–7.04 (m, 1H), 7.02–6.97 (m, 3H), 6.58 (dd, *J* = 17.5, 11.0 Hz, 1H), 6.43 (dd, *J* = 16.0, 1.0 Hz, 1H), 6.31 (dd, *J* = 4.5, 3.0 Hz, 1H), 6.29 (dd, *J* = 17.5, 1.0 Hz, 1H), 5.83 (dd, *J* = 11.0, 1.0 Hz, 1H), 4.38 (d, *J* = 11.0 Hz, 1H), 4.34 (d, *J* = 11.0 Hz, 1H), 3.95 (dd, *J* = 9.5, 3.0 Hz, 1H), 3.50 (dq, *J* = 9.5, 7.0 Hz, 1H), 2.76–2.68 (m, 1H), 1.22 (d, *J* = 7.0 Hz, 3H), 1.18 (d, *J* = 7.0 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 192.9 (s), 189.6 (s), 151.7 (d), 138.0 (s), 134.7 (d), 132.1 (s), 128.4 (t), 128.0 (d), 127.5 (d), 127.3 (d), 127.2 (d), 125.5 (d), 117.2 (d), 110.6 (d), 83.9 (d), 74.6 (t), 44.2 (d), 38.6 (d), 14.8 (q), 11.9 (q); LRMS–APCI (*m*/*z*): $[M + H]^+$ 352.

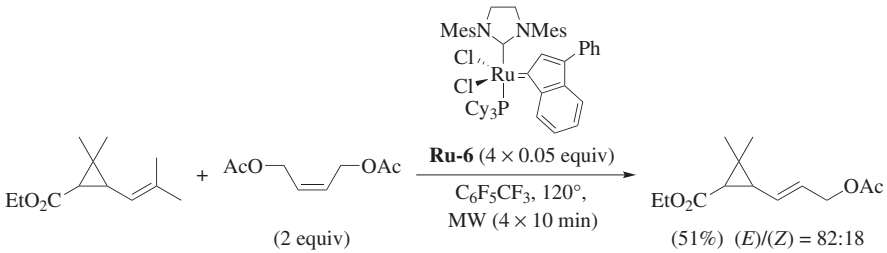


4-Phenyl-2-butenyl Acetate [Cross-Metathesis in Water].[32,341] Allylbenzene (31 mg, 0.26 mmol), (*Z*)-but-2-ene-1,4-diyl diacetate (92 mg, 0.53 mmol, 2 equiv), and the catalyst **Ru-33** (19 mg, 0.005 mmol, 0.02 equiv) were sequentially added to a Biotage 2–5 mL microwave reactor vial containing a Teflon-coated stir bar at rt. The vial was sealed with a septum, and H_2O (0.5 mL) was added via syringe. The resulting solution was stirred at 22° for 12 h. The homogeneous reaction mixture was then diluted with EtOAc (5 mL), filtered through a pad of silica gel layered over a pad of Celite, and the pad was washed with EtOAc (3 × 10 mL). The resulting solution was concentrated in vacuo, and the crude product was purified by column chromatography on silica gel (hexane/EtOAc, 96:4) to afford the title product as a colorless oil (42 mg, 84%, (*E*)/(*Z*) = 93:7): ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.34–7.17 (m, 5H), 5.92 (m, 1H), 5.65 (m, 1H), 4.54 (m, 2H), 3.41 (d, J = 3.3 Hz, 2H), 2.06 (br s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.4, 135.1, 134.0, 129.2, 129.1, 126.8, 125.8, 65.5, 60.8, 39.2, 21.6; HRMS–EI (*m*/*z*): [M – H]$^-$ calcd for $C_{12}H_{13}O_2$, 189.0916; found, 189.0916.

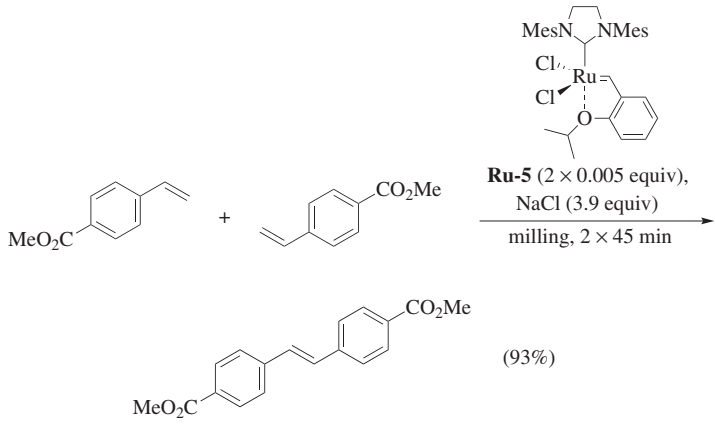


(2*S*,6*R*,*E*)-7-(*tert*-Butyldimethylsilyloxy)-2-hydroxy-2,6-dimethylhept-3-enyl Benzoate [Cross-Metathesis in a Fluorinated Solvent].[342] Catalyst **Ru-5** (37.6 mg, 0.06 mmol, 0.06 equiv) was added to a mixture of (*R*)-*tert*-butyldimethyl(2-methylpent-4-enyloxy)silane (0.21 g, 1.0 mmol) and (*S*)-2-hydroxy-2-methylbut-3-enyl benzoate (0.25 g, 1.2 mmol, 1.2 equiv) in $C_6H_5CF_3$ (10 mL) under an N_2 atmosphere at rt. The mixture was heated to 85° and stirred at that temperature for 2 h. The reaction mixture was allowed to cool to rt and then was concentrated under

vacuum. The residual crude product was purified by column chromatography on silica gel (hexane/EtOAc, 10:1) to afford the title product as colorless oil (0.24 g, 62%): $[\alpha]_D$ + 4.4 (*c* 1.10, $CHCl_3$); ^1H NMR (300 MHz, $CDCl_3$) δ 8.11–7.99 (m, 2H), 7.63–7.36 (m, 3H), 5.90–5.70 (m, 1H), 5.60 (d, *J* = 15.55 Hz, 1H), 4.25 (q, *J* = 11.12 Hz, 2H), 3.39 (d, *J* = 6.06 Hz, 1H), 2.20 (m, 1H), 1.96–1.58 (m, 2H), 1.39 (s, 3H), 0.88 (s, 9H), 0.82 (d, *J* = 6.70 Hz, 3H), 0.02 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 166.5, 134.5, 133.1, 129.9, 129.6, 129.0, 128.4, 72.1, 71.5, 67.6, 36.0, 35.9, 25.9, 25.1, 18.3, 16.3, –5.4; IR (neat) 3447, 2956, 2857, 1723, 1603, 1452, 1274, 1114, 836, 711 cm^{-1}; HRMS–ESI (*m*/*z*): $[M + Na]^+$ calcd for $C_{22}H_{36}O_4SiNa$, 415.2281; found, 415.2267.



(*E*/*Z*)-Ethyl 3-(3-Acetoxyprop-1-enyl)-2,2-dimethylcyclopropanecarboxylate [Cross-Metathesis Assisted by Microwave Irradiation].[40] To a microwave vial charged with *cis*-1,4-diacetoxy-2-butene (172.2 mg, 1 mmol, 2 equiv), ethyl chrysanthemate (98 mg, 0.5 mmol), and $C_6H_5CF_3$ (2 mL) was added the catalyst **Ru-6** (23.7 mg, 0.025 mmol, 0.05 equiv). The vial was flushed with Ar, placed in a microwave reactor, and heated at 120° for 10 min. Progress of the reaction was monitored by TLC and ^1H NMR spectroscopic analysis. Three additional portions of **Ru-6** (23.7 mg, 0.025 mmol, 0.05 equiv) were added; each addition was followed by heating in the microwave reactor at 120° for 10 min. The vial contents were transferred to a round-bottomed flask, and the solvent was removed under vacuum. The crude residue was purified by column chromatography on silica gel (cyclohexane/EtOAc, 20:1) to provide the title compound as a brownish oil (61.3 mg, 51%, (*E*)/(*Z*) = 82:18): ^1H NMR (500 MHz, $CDCl_3$) δ 5.75 (td, *J* = 15.3, 6.5 Hz, 1H), 5.53 (dd, *J* = 15.3, 8.7 Hz, 1H), 4.53 (d, *J* = 6.5 Hz, 2H), 4.18–4.07 (m, 2H), 2.06 (s, 3H), 1.57 (d, *J* = 5.3 Hz, 1H), 1.29–1.24 (m, 7H), 1.17 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 171.7, 170.8, 133.1, 125.9, 64.8, 60.4, 35.3, 34.2, 28.7, 22.1, 21.0, 20.2, 14.3; IR (film) 2981, 2953, 2876, 1741, 1726, 1668, 1459, 1448, 1430, 1380, 1341, 1277, 1231, 1177, 1148, 1115, 1096, 1075, 1057, 1026, 967, 844, 607 cm^{-1}; HRMS–ESI (*m*/*z*): $[M + Na]^+$ calcd for $C_{13}H_{20}O_4Na$, 263.1254; found, 263.1264. Anal. Calcd for $C_{13}H_{20}O_4$: C, 64.98; H, 8.39. Found: C, 64.99; H, 8.24.



Dimethyl 4,4′-Stilbenedicarboxylate [Mechanochemically Induced Cross-Metathesis].[343] Methyl 4-vinylbenzoate (324.4 mg, 2 mmol) was added to a 10-mL Teflon jar charged with a single stainless steel ball bearing. Sodium chloride (450 mg, 150 wt %, 3.9 equiv) and catalyst **Ru-5** (6.0 mg, 0.01 mmol, 0.005 equiv) were added to the jar. The reaction mixture was then milled in a Retsch MM400 mill for 45 min. Another portion of catalyst **Ru-5** (6.0 mg, 0.01 mmol, 0.005 equiv) was added to the reaction mixture, which was then milled for an additional 45 min. The catalyst and salt were then removed from the purple mixture by adding diethylene glycol vinyl ether (a catalyst quenching agent) (500 ppm) and deionized water (3–4 mL) to the crude reaction mixture. After milling at 30 Hz for an additional 15–60 minutes (depending on the quenching agent used), the solid was collected by filtration and washed with deionized water. Any remaining purple residues and salt were removed by washing with cold EtOAc and water, and the resulting white solid was dried in air to afford the product as a white powder (275.4 mg, 93%): ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.05 (d, J = 7.95 Hz, 4H), 7.59 (d, J = 7.62 Hz, 4H), 7.23 (s, 2H), 3.93 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 166.8, 141.2, 130.1, 130.0, 129.5, 126.6, 52.2; HRMS (*m*/*z*): $[M]^+$ calcd for $C_{18}H_{17}O_4$, 297.1121; found, 297.1124.

TABULAR SURVEY

Efforts were made to include all cross-metathesis (CM) reactions that appeared in the literature through the beginning of 2020. Tables are organized according to the classification presented in the Scope and Limitations section.

It is difficult to systematize examples of the cross metathesis since in each reaction two alkene substrates are used. To facilitate the positioning of a given reaction, the tables are arranged according to the CM alkene type. The alkenes are assigned to one of three types according to the classification of Grubbs (Type I: alkenes that undergo rapid homodimerization; Type II: alkenes that undergo slow homodimerization; Type III: alkenes that do not undergo homodimerization). As Type IV alkenes do not undergo CM or homodimerization, they are not included. The first table contains CM reactions of ethylene and of alkenes of Type I that do not possess functional groups in an allylic or vinylic position. It is assumed, in most cases, that functional groups that are more remote from the reacting C–C double bond do not affect the metathesis reactions. The second table shows CM of allylic boronates. The third table shows CM of protected and unprotected allylic amines, etc. Table 33 contains examples of CM with vinylic organosulfur compounds—challenging partners of Type III in Grubbs' classification. The titles of the individual tables are listed in the Table of Contents.

To find a given CM reaction, locate each of the two CM partners using the table of contents, and then examine the table of the higher number. For example, if the first of the CM partners of a given reaction is a primary allylic alcohol (Type I, Table 4) and the second CM partner is a 4-substituted styrene (Type II, Table 10), this CM reaction is placed in Table 10. Similarly, a CM reaction between ethyl acrylate (Type II, Table 20A) and an allyl boronic ester (Type I, Table 2) is placed in Table 20A. Therefore, any given CM reaction is set in the Tabular Survey according to its more senior CM partner.

A consequence of the classification system used is that the same alkene may be found in several different tables. The only exception from the rules given above are ethenolysis reactions (i.e., CM with ethylene), which are all included in Table 1 for simplicity.

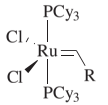
Within each table the individual entries are arranged by increasing carbon count of the alkene which appears in the first column. For alkenes with the same core structure, the cross partners are arranged by increasing carbon count. The carbon count does not include protecting groups, nor heteroatom substituents when their omission allows a better comparison of similar core structures. Compounds within the same carbon count are grouped based on structural similarities. The yields for the reactions are given in parentheses, followed by the ratio of (*E*)/(*Z*) isomers or enantiomers where applicable. Unspecified yields are denoted by (—).

The Charts preceding the Tables contain the structures of the bold-numbered catalysts; the numbers in the Tables do not correspond to those in the text. In addition to the abbreviations listed in "*The Journal of Organic Chemistry* Standard Abbreviations and Acronyms" the following are used in the Tables:

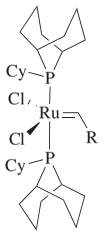
ADMET	acyclic diene metathesis polymerization
Ad	adamantyl
BHT	butylated hydroxytoluene, dibutylhydroxytoluene
BMI	bismaleimide
BMIM	1-butyl-3-methylimidazolium ion
BOM	benzyloxymethyl
B(pin)	boronic acid pinacol ester
BQ	1,4-benzoquinone
Brij30	polyoxyethylene(4)lauryl ether (surfactant)
CAM	carbamoylmethyl
ClBcat	B-chlorocatecholborane
2-Cl-BQ	2-chloro-1,4-benzoquinone
2,6-Cl_2-BQ	2,6-dichloro-1,4-benzoquinone
CM	cross-metathesis
CSA	camphorsulfonic acid
DB24C8	dibenzo-24-crown-8
DCB	dichlorobenzene
Dipp	2,6-diisopropylphenyl
DMC	dimethylcarbonate
DMP	Dess–Martin periodinane
2,2-DMP	2,2-dimethoxypropane
DVB	divinylbenzene
FAH	fluorinated aromatic hydrocarbon
F_4-BQ	2,3,5,6-tetrafluoro-1,4-benzoquinone
Fc	ferrocene
IC	incomplete conversion
IMes	1,3-bis(2,4,6-trimethylphenyl)imidazolium
IPr	1,3-bis-(2,6-diisopropylphenyl)imidazole-2-ylidene
MAP	monoalkoxidepyrrolide
MIDA	*N*-methyliminodiacetic acid
Mipp	2-methyl-6-isopropylphenyl
MS	molecular sieves
MW	microwave irradiation
Naph	naphthyl
NB	2-nitrobenzyl
o-NBSH	2-nitrobenzenesulfonyl hydrazine
NMM	*N*-methylmorpholine
p-NOS	4-nitrobenzensulfonyl (nosyl)
o-Ns	2-nitrobenzensulfonyl
PAC	phenacyl

PBB	polybrominated biphenyl
Pbf	pentamethyl-2,3-dihydrobenzofuran-5-sulfonyl
PC	propylene carbonate
Phoban	9-phosphabicyclo-[3.3.1]-nonane
Phth	phthaloyl
PMP	4-methoxyphenyl
PNB	4-nitrobenzoate
n-Pn	*n*-pentyl
PNP	4-nitrophenyl
PPTS	pyridinium *p*-toluenesulfonate
PSS	polyoxyethanyl β-sitosterol sebacate (surfactant)
PTS	polyoxyethanyl α-tocopheryl sebacate (surfactant)
RCM	ring-closing cross-metathesis
ROMP	ring-opening metathesis polymerization
rr	regioisomer ratio
SAMP	(*S*)-*N*-amino-2-(methoxymethyl)pyrrolidyl
SDS	sodium dodecyl sulfate (surfactant)
SES	2-(trimethylsilyl)ethylsulfonyl
SIMes	1,3-bis(2,4,6-trimethylphenyl)-4,5-dihydroimidazol-2-ylidene
TBDPS	*tert*-butyldiphenylsilyl
TDS	(dimethyl)thexylsilyl
TIS	triisopropylsilane
TPGS	*D*-α-tocopherol polyethylene glycol succinate (surfactant)
TPS	tripropylsilyl
Trip	2,4,6-triisopropylphenyl
Troc	trichloroethyloxycarbonyl
Trt	trityl
TxDMS	thexyldimethylsilyl

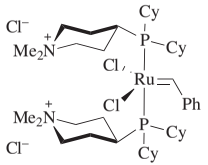
CHART 1. RUTHENIUM CATALYSTS USED IN THE TABLES



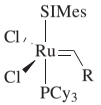
	R
Gr I	Ph
Ru cat **1**	Me_2C=CH
Ru cat **2**	Ph_2C=CH
Ru cat **3**	2-thiophene
Ru cat **4**	poly-DVB



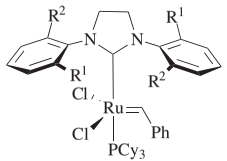
	R
Ru cat **5**	Ph
Ru cat **6**	Me_2C=CH



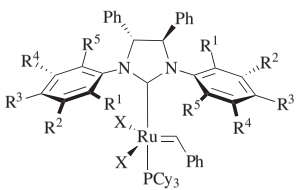
Ru cat **7**



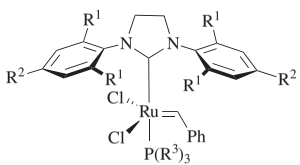
	R
Gr II	Ph
Ru cat **8**	Ph (on SABA-15)
Ru cat **9**	Ph (on SiO_2)
Ru cat **10**	PhS
Ru cat **11**	Me_2C=CH
Ru cat **12**	poly-DVB



	R^1	R^2
Ru cat **13**	Me	H
Ru cat **14**	F	F
Ru cat **15**	*i*-Pr	*i*-Pr

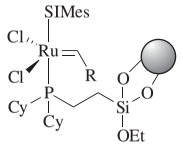


	R^1	R^2	R^3	R^4	R^5	X
Ru cat **16**	*i*-Pr	H	H	H	H	Cl
Ru cat **17**	*i*-Pr	H	H	H	H	I
Ru cat **18**	*i*-Pr	*i*-Pr	H	H	H	Cl
Ru cat **19**	*i*-Pr	*i*-Pr	H	H	H	I
Ru cat **20**	*i*-Pr	H	H	*i*-Pr	H	Cl
Ru cat **21**	*i*-Pr	H	H	*i*-Pr	H	I
Ru cat **22**	*i*-Pr	H	MeO	Me	H	Cl
Ru cat **23**	*i*-Pr	H	MeO	Me	H	I
Ru cat **24**	*i*-Pr	H	MeO	*t*-Bu	H	Cl
Ru cat **25**	*i*-Pr	H	MeO	*t*-Bu	H	I
Ru cat **26**	Me	H	Me	H	Me	I

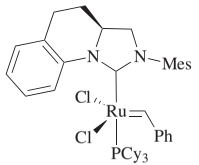


	R^1	R^2	R^3
Ru cat **27**	Me	Me	*i*-PrO
Ru cat **28**	Me	Me	EtO
Ru cat **29**	Me	Me	Ph
Ru cat **30**	Me	H	Ph

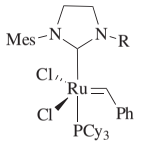
CHART 1. RUTHENIUM CATALYSTS USED IN THE TABLES (*Continued*)



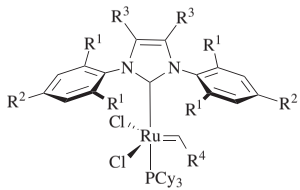
Ru cat **31**



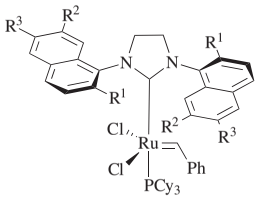
Ru cat **32**



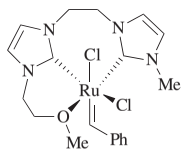
	R
Ru cat **33**	Me
Ru cat **34**	*n*-Bu



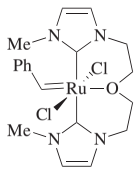
	R^1	R^2	R^3	R^4
Ru cat **35**	Me	Me	H	Ph
Ru cat **36**	Me	Me	H	Me_2C=C
Ru cat **37**	Me	Me	H	poly–DVB
Ru cat **38**	*i*-Pr	H	H	Ph
Ru cat **39**	Me	Me	H	2-thienyl
Ru cat **40**	Me	Me	Me	2-thienyl



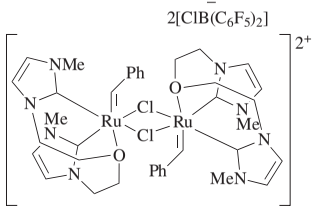
	R^1	R^2	R^3
Ru cat **41**	Me	Me	H
Ru cat **42**	*i*-Pr	H	H
Ru cat **43**	*i*-Pr	H	*i*-Pr
Ru cat **44**	*i*-Pr	*i*-Pr	H
Ru cat **45**	Cy	H	H



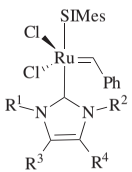
Ru cat **46**



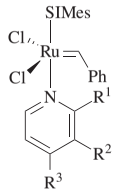
Ru cat **47**



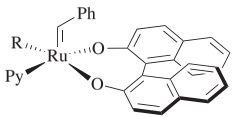
Ru cat **48**



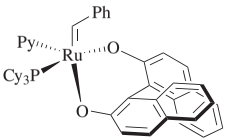
	R^1	R^2	R^3	R^4
Ru cat **49**	Me	Me	H	O_2N
Ru cat **50**	Me	Me	Cl	Cl
Ru cat **51**	Me	*i*-Pr	Cl	Cl
Ru cat **52**	*i*-Pr	*i*-Pr	Cl	Cl
Ru cat **53**	Mes	Mes	H	H



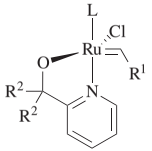
	R^1	R^2	R^3
Ru cat **54**	H	H	H
Ru cat **55**	H	Br	H
Ru cat **56**	Me	H	H
Ru cat **57**	Me	H	Me



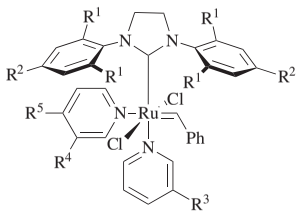
	R
Ru cat **58**	IMes
Ru cat **59**	SIMes



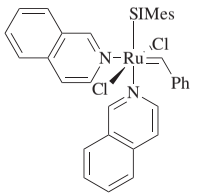
Ru cat **60**



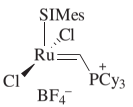
	L	R^1	R^2
Ru cat **61**	PCy_3	Ph	Me
Ru cat **62**	SIMes	Ph	Me
Ru cat **63**	SIMes	Ph	Ph
Ru cat **64**	SIMes	PhS	Me



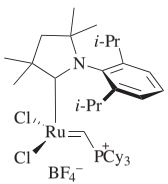
	R^1	R^2	R^3	R^4	R^5
Ru cat **65**	Me	H	H	H	H
Ru cat **66**	Me	Me	H	H	H
Ru cat **67**	Me	Me	Br	Br	H
Ru cat **68**	Me	Me	Br	H	polyvinyl
Ru cat **69**	*i*-Pr	H	H	H	H



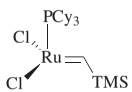
Ru cat **70**



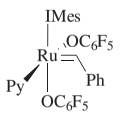
Ru cat **71**



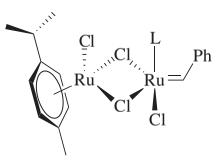
Ru cat **72**



Ru cat **73**

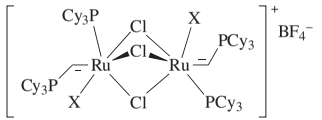


Ru cat **74**

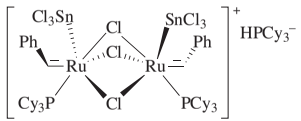


	L
Ru cat **75**	Cy_3P
Ru cat **76**	IPr

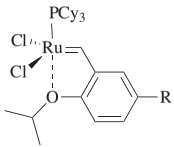
CHART 1. RUTHENIUM CATALYSTS USED IN THE TABLES (*Continued*)



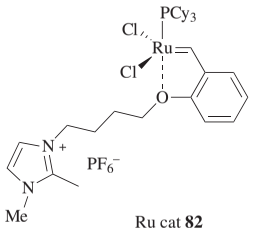
	X
Ru cat **77**	Cl
Ru cat **78**	Br



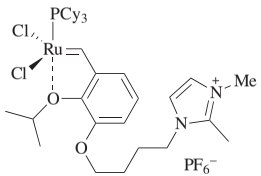
Ru cat **79**



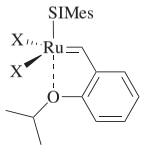
	R
Hov I	H
Ru cat **80**	$Me_2(O_2N)S$
Ru cat **81**	n-$C_8F_{17}(CH_2)_3$



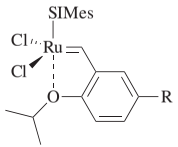
Ru cat **82**



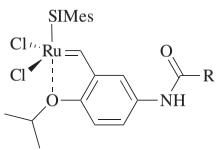
Ru cat **83**



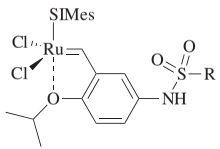
	X
Hov II	Cl
Ru cat **84**	Br
Ru cat **85**	I



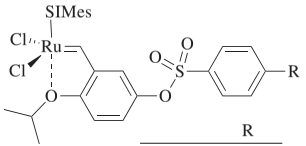
	R
Ru cat **86**	Cl
Ru cat **87**	Br
Ru cat **88**	O_2N
Ru cat **89**	$Me_2(O_2N)S$
Ru cat **90**	$Me_2(O_2N)S$ on SABA-15
Ru cat **91**	n-$C_8F_{17}(CH_2)_2$



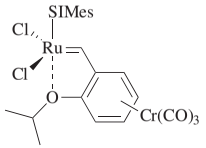
	R
Ru cat **92**	Me
Ru cat **93**	CF_3
Ru cat **94**	i-BuO
Ru cat **95**	EtO_2C
Ru cat **96**	C_6F_5
Ru cat **97**	Ad



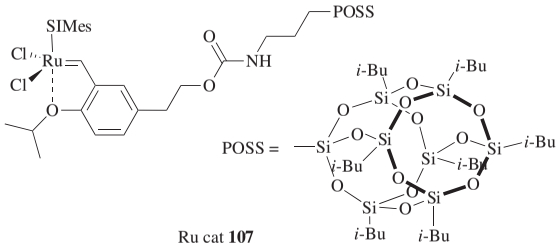
	R
Ru cat **98**	CF_3
Ru cat **99**	4-$O_2NC_6H_4$
Ru cat **100**	2-$O_2NC_6H_4$
Ru cat **101**	2,4-$(O_2N)_2C_6H_3$
Ru cat **102**	C_6F_5



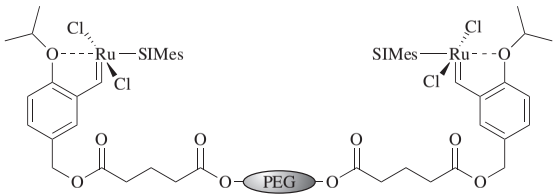
	R
Ru cat **103**	H
Ru cat **104**	MeO
Ru cat **105**	O_2N



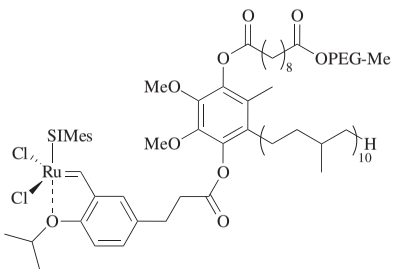
Ru cat **106**



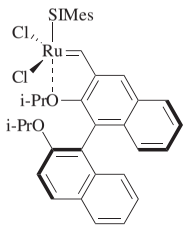
Ru cat **107**



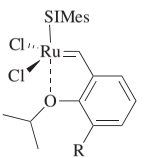
Ru cat **108**



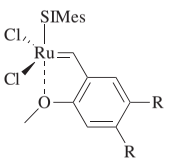
Ru cat **109**



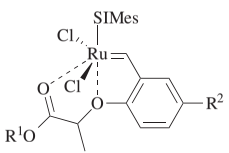
Ru cat **110**



	R
Ru cat **111**	MeO
Ru cat **112**	Ph

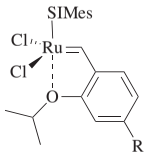


	R
Ru cat **113**	H
Ru cat **114**	MeO

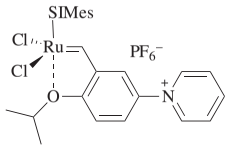


	R^1	R^2
Ru cat **115**	Me	H
Ru cat **116**	Me	O_2N
Ru cat **117**	Me	Ac
Ru cat **118**	Et	H
Ru cat **119**	Et	Me
Ru cat **120**	Et	MeO
Ru cat **121**	Et	O_2N

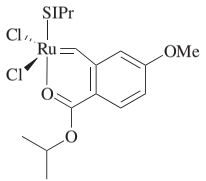
CHART 1. RUTHENIUM CATALYSTS USED IN THE TABLES (*Continued*)



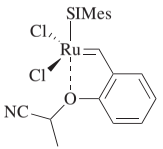
	R
Ru cat **122**	O_2N
Ru cat **123**	$Et_2HN^+TsO^-$
Ru cat **124**	$Et_2MeN^+Cl^-$
Ru cat **125**	$Et_2MeN^+poly\text{-}O_3S^-$
Ru cat **126**	$Et_2MeN^+I^-$
Ru cat **127**	$Et_2MeN^+PF_6^-$



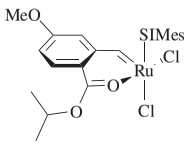
Ru cat **128**



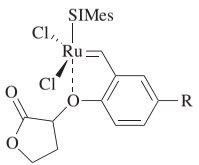
Ru cat **129**



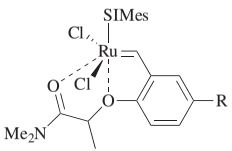
Ru cat **130**



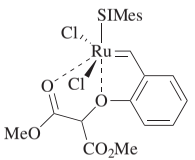
Ru cat **131**



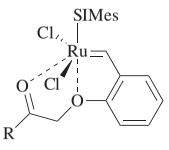
	R
Ru cat **132**	H
Ru cat **133**	MeO



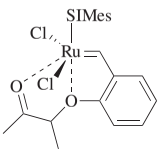
	R
Ru cat **134**	H
Ru cat **135**	MeO



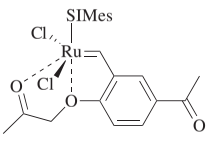
Ru cat **136**



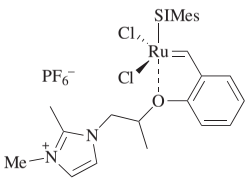
	R
Ru cat **137**	Me
Ru cat **138**	Et



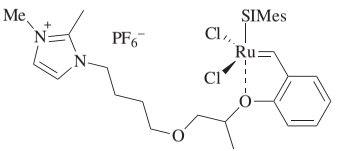
Ru cat **139**



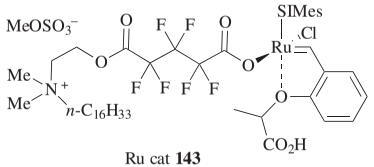
Ru cat **140**



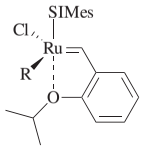
Ru cat **141**



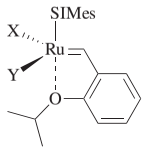
Ru cat **142**



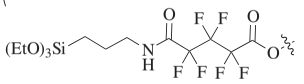
Ru cat **143**



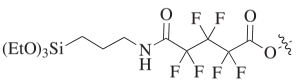
	R
Ru cat **144**	Cl_3Sn
Ru cat **145**	$MesSO_3$
Ru cat **146**	$NapSO_3$
Ru cat **147**	$(PhO)_2PO_2$

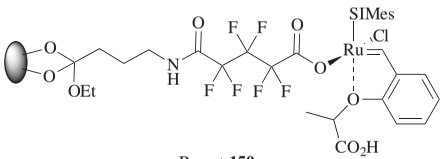


Ru cat **148**, X = Y =

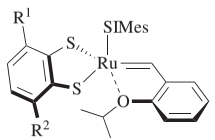


Ru cat **149**, X = Cl, Y =

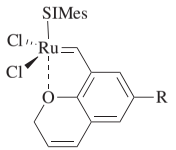




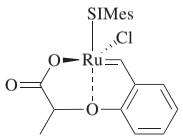
Ru cat **150**



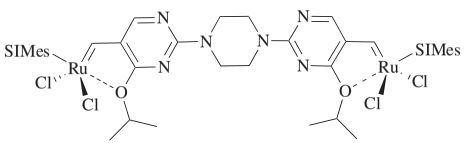
	R^1	R^2
Ru cat **151**	H	H
Ru cat **152**	Cl	Cl
Ru cat **153**	Br	Cl



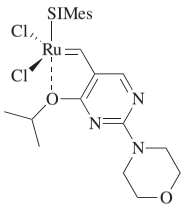
	R
Ru cat **154**	Me
Ru cat **155**	O_2N



Ru cat **156**

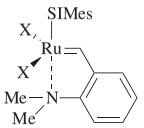


Ru cat **157**

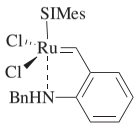


Ru cat **158**

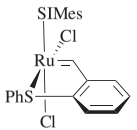
CHART 1. RUTHENIUM CATALYSTS USED IN THE TABLES (*Continued*)



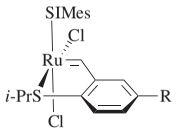
	X
Ru cat **159**	Cl
Ru cat **160**	Br
Ru cat **160**	I



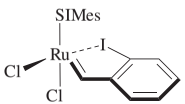
Ru cat **162**



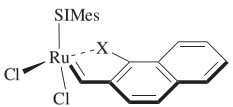
Ru cat **163**



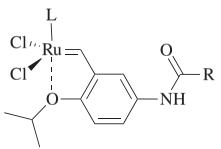
	R
Ru cat **164**	H
Ru cat **165**	O_2N



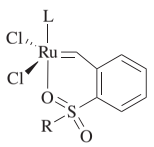
Ru cat **166**



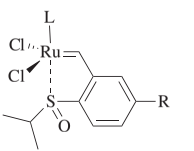
	X
Ru cat **167**	Br
Ru cat **168**	I



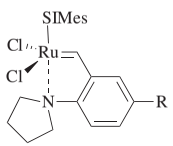
	L	R
Ru cat **169**	IMes	CF_3
Ru cat **170**	SIPr	CF_3
Ru cat **171**	IPr	CF_3
Ru cat **172**	SIPr	*i*-BuO
Ru cat **173**	SIPr	EtO_2C



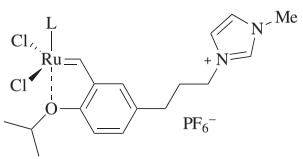
	L	R
Ru cat **174**	SIMes	*t*-Bu
Ru cat **175**	SIPr	*t*-Bu
Ru cat **176**	SIPr	Ph
Ru cat **177**	SIPr	Me_2N
Ru cat **178**	IMes	*t*-Bu



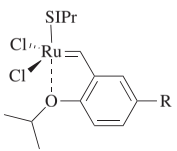
	L	R
Ru cat **179**	SIMes	H
Ru cat **180**	SIMes	O_2N
Ru cat **181**	IMes	H



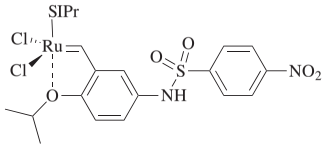
	R
Ru cat **182**	H
Ru cat **183**	MeO
Ru cat **184**	O_2N



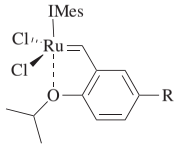
	L
Ru cat **185**	SIMes
Ru cat **186**	IMes



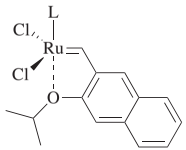
	R
Ru cat **187**	H
Ru cat **188**	O_2N



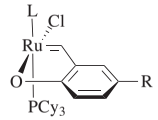
Ru cat **189**



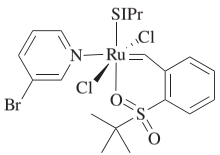
	R
Ru cat **190**	H
Ru cat **191**	poly-CH_2O



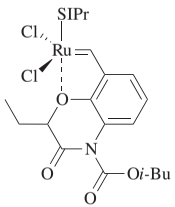
	L
Ru cat **192**	IMes
Ru cat **193**	Me_2IMes



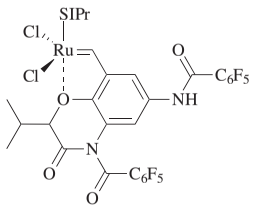
	L	R
Ru cat **194**	SIMes	H
Ru cat **195**	SIMes	O_2N
Ru cat **196**	Me_2IMes	H



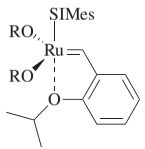
Ru cat **197**



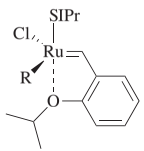
Ru cat **198**



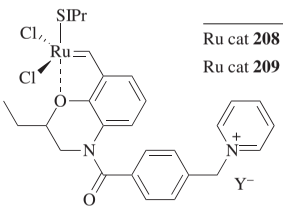
Ru cat **199**



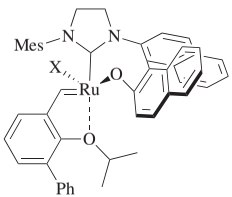
	R
Ru cat **200**	TBS
Ru cat **201**	TMS
Ru cat **202**	TIPS



	R
Ru cat **203**	$MesSO_3$
Ru cat **204**	$TripSO_3$
Ru cat **205**	*p*-$TolSO_3$
Ru cat **206**	$CamSO_3$
Ru cat **207**	$BINAPPO_4$

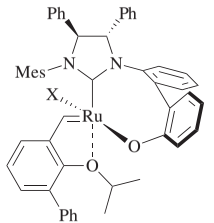


	Y
Ru cat **208**	PF_6
Ru cat **209**	[Si]-$CH_2C_6H_4SO_3$

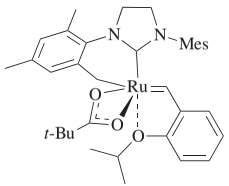


	X
Ru cat **210**	Cl
Ru cat **211**	I

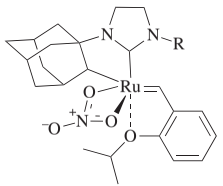
CHART 1. RUTHENIUM CATALYSTS USED IN THE TABLES (*Continued*)



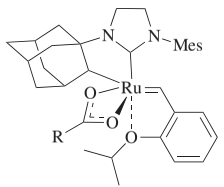
	X
Ru cat **212**	Cl
Ru cat **213**	I



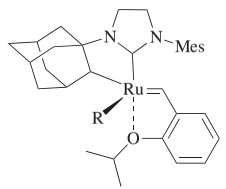
Ru cat **214**



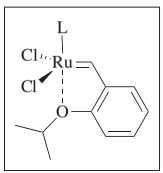
	R
Ru cat **215**	Mes
Ru cat **216**	Dipp



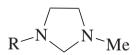
	R
Ru cat **217**	*t*-Bu
Ru cat **218**	Cy_2CH
Ru cat **219**	Me
Ru cat **220**	$(MeO)_2(CH_3)CH$



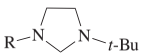
	R
Ru cat **221**	I
Ru cat **222**	DippO



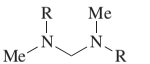
L =



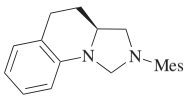
	R
Ru cat **223**	Mes
Ru cat **224**	Dipp



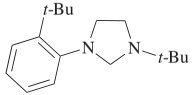
	R
Ru cat **225**	Mes
Ru cat **226**	Dipp



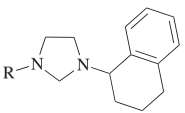
	R
Ru cat **227**	Mes
Ru cat **228**	Dipp



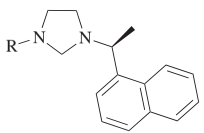
Ru cat **229**



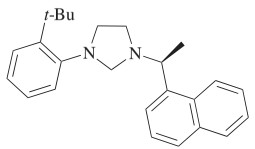
Ru cat **230**



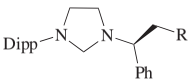
	R
Ru cat **231**	Mes
Ru cat **232**	Dipp



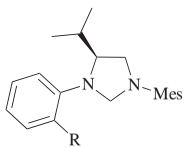
	R
Ru cat **233**	Mes
Ru cat **234**	Dipp



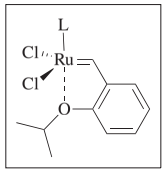
Ru cat **235**



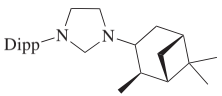
	R
Ru cat **236**	Me
Ru cat **237**	Et



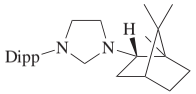
	R
Ru cat **238**	*i*-Pr
Ru cat **239**	Br
Ru cat **240**	Ph



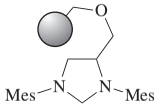
L =



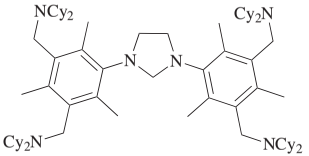
Ru cat **241**



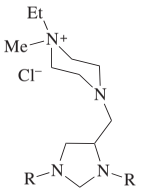
Ru cat **242**



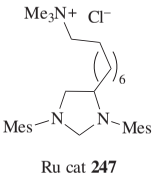
Ru cat **243**



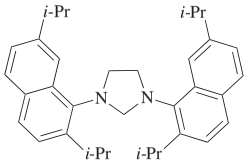
Ru cat **244**



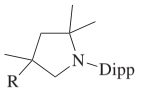
	R
Ru cat **245** on SABA 15	Mes
Ru cat **246** on SABA 15	Dipp



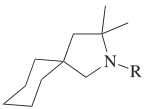
Ru cat **247**



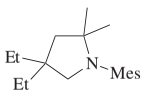
Ru cat **248**



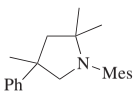
	R
Ru cat **249**	Me
Ru cat **250**	*n*-Pr
Ru cat **251**	Ph



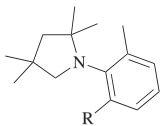
	R
Ru cat **252**	Mes
Ru cat **253**	Dipp



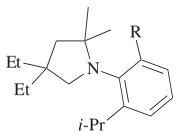
Ru cat **254**



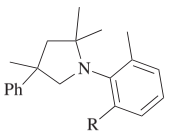
Ru cat **255**



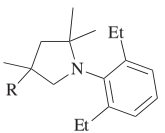
	R
Ru cat **256**	Et
Ru cat **257**	*i*-Pr
Ru cat **258**	*t*-Bu



	R
Ru cat **259**	H
Ru cat **260**	Me

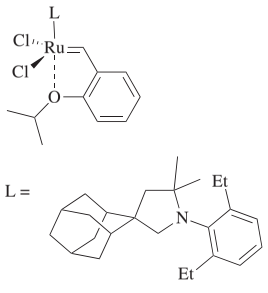


	R
Ru cat **261**	Et
Ru cat **262**	*i*-Pr

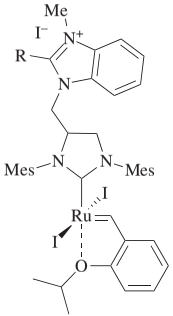


	R
Ru cat **263**	Me
Ru cat **264**	Ph

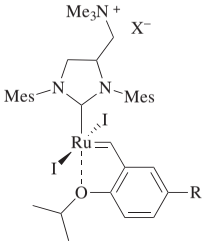
CHART 1. RUTHENIUM CATALYSTS USED IN THE TABLES (*Continued*)



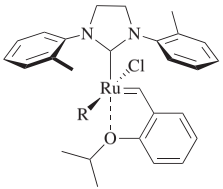
Ru cat **265**



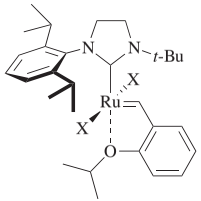
	R
Ru cat **266**	Me
Ru cat **267**	Ph



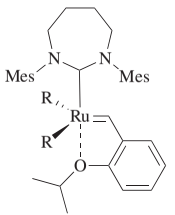
	R	X
Ru cat **268**	H	I
Ru cat **269**	O_2N	I
Ru cat **270**	O_2N	Cl



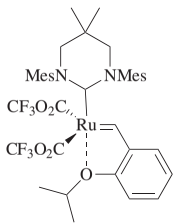
	R
Ru cat **271**	Cl
Ru cat **272**	$MesSO_3$
Ru cat **273**	$TripSO_3$
Ru cat **274**	BINOL-phosphate



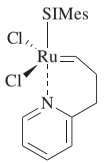
	R
Ru cat **275**	Cl
Ru cat **276**	I



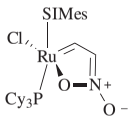
	R
Ru cat **277**	Cl
Ru cat **278**	CF_3O_2C



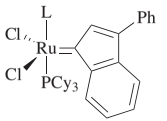
Ru cat **279**



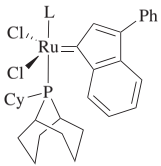
Ru cat **280**



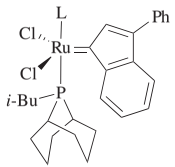
Ru cat **281**



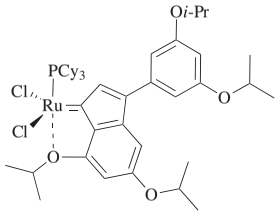
	L
Ind I	PCy_3
Ind II	SIMes
Ru cat **282**	IMes
Ru cat **283**	Me_2IMes
Ru cat **284**	Cl_2IMes
Ru cat **285**	SIPr
Ru cat **286**	IPr



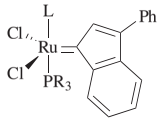
	L
Ru cat **287**	phoban
Ru cat **288**	SIMes
Ru cat **289**	IMes



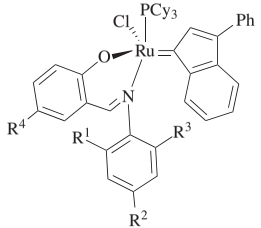
	L
Ru cat **290**	phoban
Ru cat **291**	SIMes
Ru cat **292**	IMes



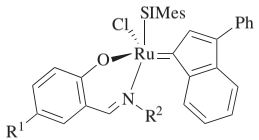
Ru cat **293**



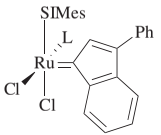
	L	R
Ru cat **294**	SIMes	Ph
Ru cat **295**	SIMes	4-$MeOC_6H_4$
Ru cat **296**	SIMes	4-FC_6H_4
Ru cat **297**	SIPr	Ph
Ru cat **298**	IPr	Ph



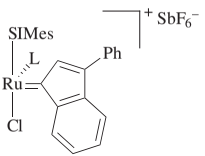
	R^1	R^2	R^3	R^4
Ru cat **299**	Me	H	H	H
Ru cat **300**	Me	Me	Me	H
Ru cat **301**	Me	H	Me	O_2N
Ru cat **302**	Cl	H	H	O_2N
Ru cat **303**	Me	Me	Me	O_2N
Ru cat **304**	*i*-Pr	H	*i*-Pr	O_2N
Ru cat **305**	H	Me	H	O_2N
Ru cat **306**	H	Me	H	H
Ru cat **307**	*i*-Pr	H	*i*-Pr	H



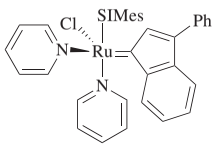
	R^1	R^2
Ru cat **308**	H	Ph
Ru cat **309**	H	2-MeC_6H_4
Ru cat **310**	H	4-MeC_6H_4
Ru cat **311**	O_2N	2-MeC_6H_4
Ru cat **312**	O_2N	4-MeC_6H_4
Ru cat **313**	O_2N	Cy



	L
Ru cat **314**	$(MeO)_3P$
Ru cat **315**	$(EtO)_3P$
Ru cat **316**	$(i\text{-}PrO)_3P$
Ru cat **317**	$(PhO)_3P$

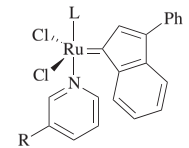


	L
Ru cat **318**	$(i\text{-}PrO)_3P$

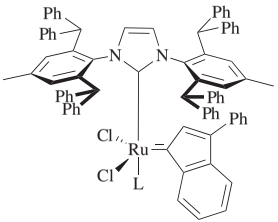


Ru cat **319**

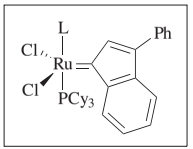
CHART 1. RUTHENIUM CATALYSTS USED IN THE TABLES (*Continued*)



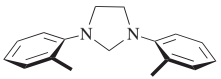
	L	R
Ru cat **320**	SIMes	H
Ru cat **321**	SIPr	H
Ru cat **322**	SIPr	Br
Ru cat **323**	IPr	H



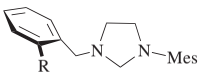
	L
Ru cat **324**	PPh_3
Ru cat **325**	Py



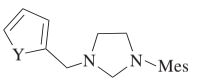
L =



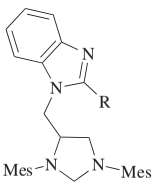
Ru cat **326**



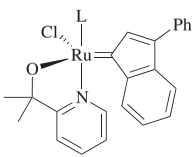
	R
Ru cat **327**	MeO
Ru cat **328**	Me_2N



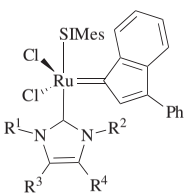
	Y
Ru cat **329**	O
Ru cat **330**	S



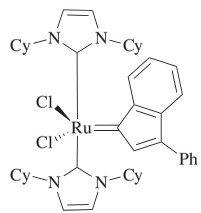
	R
Ru cat **331**	Me
Ru cat **332**	Ph



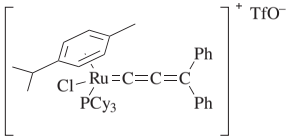
	L
Ru cat **333**	SIMes
Ru cat **334**	IMes



	R^1	R^2	R^3	R^4
Ru cat **335**	Me	Me	H	H
Ru cat **336**	Me	Me	H	O_2N
Ru cat **337**	Me	Me	Cl	Cl
Ru cat **338**	Me	Me	NC–	NC–
Ru cat **339**	Me	Me	Me	Me
Ru cat **340**	Me	*i*-Pr	Cl	Cl
Ru cat **341**	Et	Et	Cl	Cl
Ru cat **342**	*i*-Pr	*i*-Pr	Me	Me
Ru cat **343**	Cy	Cy	H	H



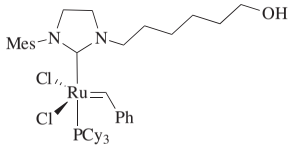
Ru cat **344**



Ru cat **345**

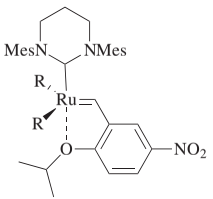
$[RuCl_2(p\text{-cymene})]_2 + IMesH_2Cl + CsCO_2$

Ru cat **346**

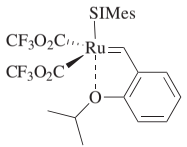


Ru cat **347**

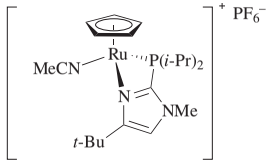
Ru cat **348** = Ru cat **347** immobilized



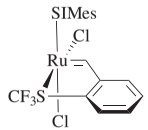
	R
Ru cat **349**	Cl
Ru cat **350**	CF_3O_2C



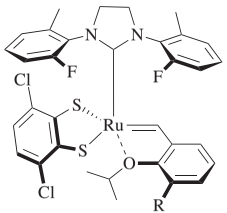
Ru cat **351**



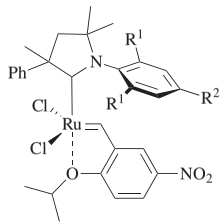
Ru cat **352**



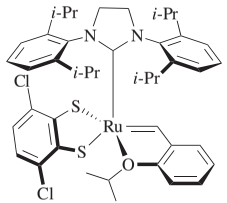
Ru cat **353**



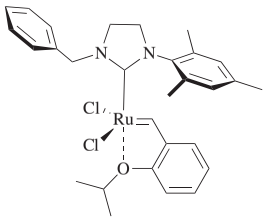
	R
Ru cat **354**	H
Ru cat **355**	Ph



	R^1	R^2
Ru cat **356**	Me	Me
Ru cat **357**	Et	H

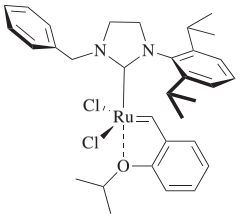


Ru cat **358**

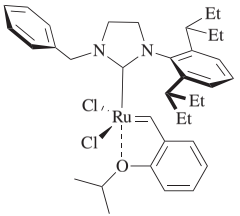


Ru cat **359**

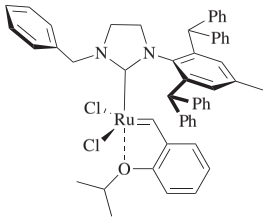
CHART 1. RUTHENIUM CATALYSTS USED IN THE TABLES (*Continued*)



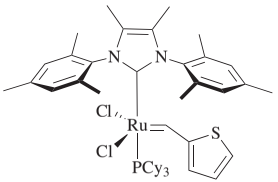
Ru cat **360**



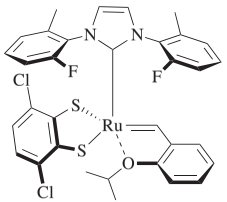
Ru cat **361**



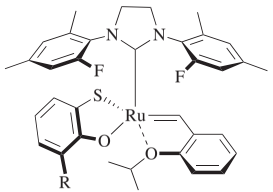
Ru cat **362**



Ru cat **363**

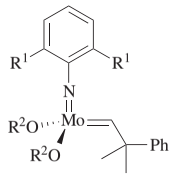


Ru cat **364**

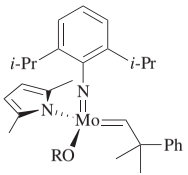


	R
Ru cat **365**	Me
Ru cat **366**	*i*-Pr
Ru cat **367**	*t*-Bu

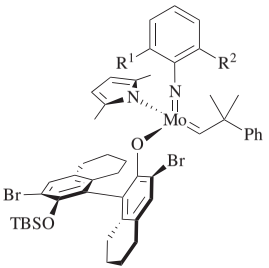
CHART 2. MOLYBDENUM CATALYSTS USED IN THE TABLES



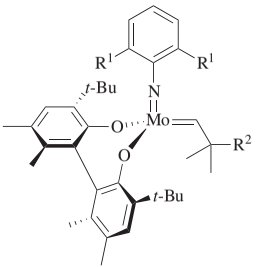
	R^1	R^2
Mo cat **1**	*i*-Pr	$(CF_3)_2MeC$
Mo cat **2**	Me	CF_3Me_2C



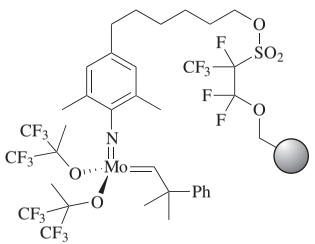
	R
Mo cat **3**	$(CF_3)_2MeC$
Mo cat **4**	Ph_3Si



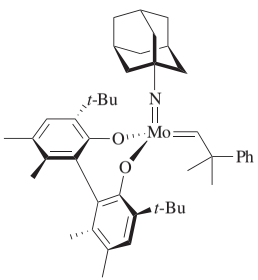
	R^1	R^2
Mo cat **5**	Me	Me
Mo cat **6**	*i*-Pr	*i*-Pr
Mo cat **7**	CF_3	H



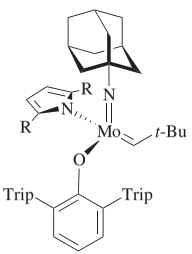
	R^1	R^2
Mo cat **8**	*i*-Pr	Ph
Mo cat **9**	Me	Ph
Mo cat **10** (as THF complex)	Cl	Me



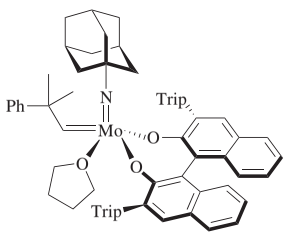
Mo cat **11**



Mo cat **12**

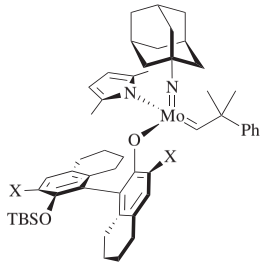


	R
Mo cat **13**	H
Mo cat **14**	Me

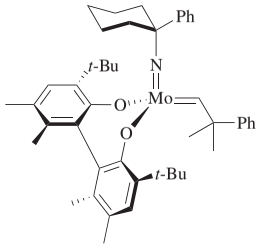


Mo cat **15**

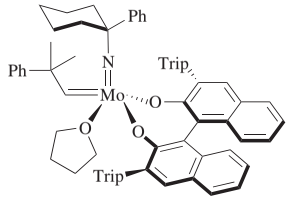
CHART 2. MOLYBDENUM CATALYSTS USED IN THE TABLES (*Continued*)



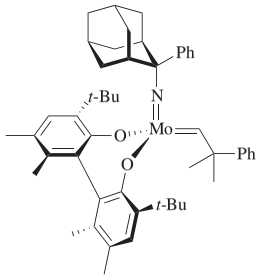
	X
Mo cat **16**	F
Mo cat **17**	Cl
Mo cat **18**	Br
Mo cat **19**	I



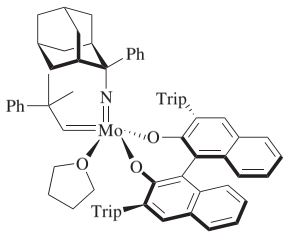
Mo cat **20**



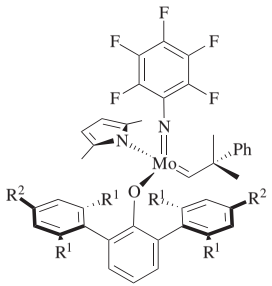
Mo cat **21**



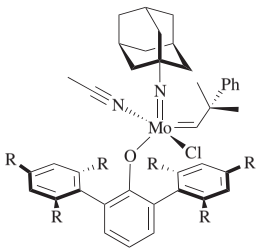
Mo cat **22**



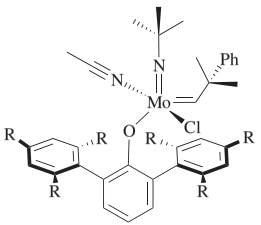
Mo cat **23**



	R^1	R^2
Mo cat **24**	Me	H
Mo cat **25**	*i*-Pr	H
Mo cat **26**	Et	H
Mo cat **27**	Et	Et

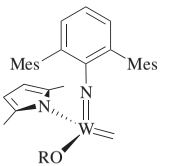


	R
Mo cat **28**	Me
Mo cat **29**	*i*-Pr

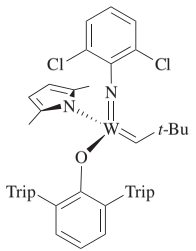


	R
Mo cat **30**	Me
Mo cat **31**	*i*-Pr

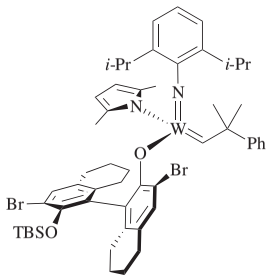
CHART 3. TUNGSTEN CATALYSTS USED IN THE TABLES



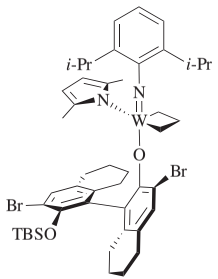
	R
W cat **1**	Ph_3Si
W cat **2**	2,6-$Me_2C_6H_3$



W cat **3**



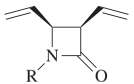
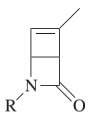
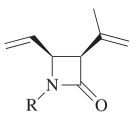
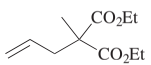
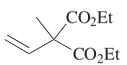
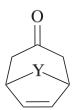
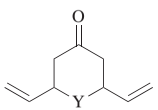
W cat **4**



W cat **5**

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND

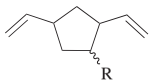
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 excess		Gr I (0.1 eq), DCM, rt	 R: H (50); TMS (—); TBDPS (60); TBS (89)	119
excess		Gr I (0.1 eq), DCM, rt	 R: H (28); TMS (—); TBDPS (53); TBS (90)	119
1 bar		Hov II (0.1 eq), $Pd_2Br_2[P(t\text{-}Bu)_3]_2$ (0.005 eq), toluene, 100°, 12 h	 (77)	344
		Gr I (0.01 eq), DCM, rt, 26 h	 Y: O (43); CH_2 (50)	345



x bar



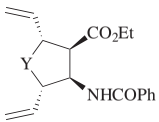
Catalyst (*y* eq),
toluene, rt



R	*x*	Catalyst	*y*	Time (h)		
$(EtO)_3Si$	4	Ru cat **73**	0.00025	24	(99)	346
Me_3SiOMe_2Si	4	Ru cat **73**	0.001	24	(99)	346
$(EtO)_3Si$	3	Gr I	0.00025	24	(97)	347
CH_2=$CHCH_2$	2	Gr I	0.0014	24	(88)	347
Ac	2	Gr I	0.001	48	(92)	347



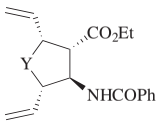
Catalyst (0.05 eq),
DCM, 20°, 2 h



Y	Catalyst		
O	Hov I	(79)	
CH_2	Gr I	(37)	348
CH_2	Gr II	(33)	
CH_2	Hov I	(38)	
CH_2	Hov II	(41)	



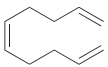
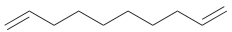
Catalyst (0.05 eq),
DCM, 20°, 2 h



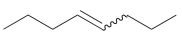
Y	Catalyst		
O	Hov I	(68)	
CH_2	Gr I	(46)	348
CH_2	Gr II	(20)	
CH_2	Hov I	(80)	
CH_2	Hov II	(28)	

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 25 atm		1. $MoCl_5/SiO_2$ (0.06 eq), 24 h 2. $SnMe_4$ (8 eq), 24 h	 (68) $(Z)/(E)$ = 99:1	349
x bar		Mo cat **6** (*y* eq), neat, rt		350

x	*y*	Time (h)	Conv. (%)[a]	
10	0.0002	16	98	(90)
10	0.0001	20	98	(80)
20	0.0001	20	93	(93)
20	0.00005	16	88	(88)
20	0.000033	20	75	(75)

x atm	 (*E*)/(*Z*) mixture	Mo cat **6** (*y* eq)		351

x	*y*	Time (h)		(*E*)/(*Z*)
4	0.004	0.25	(79)	>98:2
4	0.001	1	(76)	91:9
20	0.001	1	(77)	97:3
20	0.002	1	(71)	89:11
20	0.0005	4	(62)	>98:2
20	0.0002	18	(77)	>98:2

20 atm



(*Z*)/(*E*) = 80:20

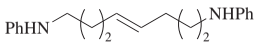
Mo cat **6** (0.0002 eq), 18 h



(20) (*E*)/(*Z*) = 98:2

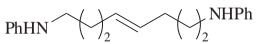
351

x atm



I

Ru cat **215** (*y* eq), THF, 35°

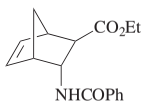


II (—)

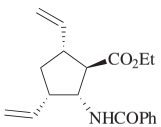
352

x	(*E*)/(*Z*) **I**	*y*	Time (h)	(*E*)/(*Z*) **II**
1	80:20	0.005	4	92:8
5	80:20	0.01	4	>95:5
5	60:40	0.01	6	86:14





Catalyst (0.05 eq), DCM, 20°, 2 h

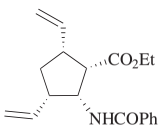


Catalyst	
Gr I	(68)
Gr II	(29)
Hov I	(45)
Hov II	(16)

348

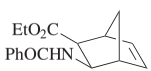


Catalyst (0.05 eq), DCM, 20°, 2 h

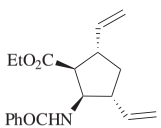


Catalyst	
Gr I	(6)
Gr II	(26)
Hov I	(29)
Hov II	(31)

348



Hov I (0.05 eq), DCM, 20°, 2 h

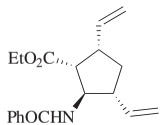
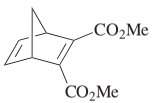
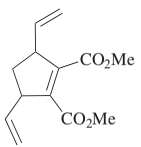


(39)

348

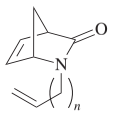
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

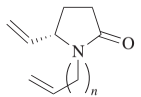
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
		Hov I (0.05 eq), DCM, 20°, 2 h	 (64)	348
x bar		Catalyst (0.01 eq), benzene		353

x	Catalyst	Temp (°)	Time (h)	
1	W cat **1**	20	16	(22)
3.7	W cat **1**	20	16	(24)
20	W cat **1**	20	16	(3)
1	W cat **2**	20	16	(25)
3.7	W cat **2**	20	16	(41)
3.7	W cat **2**	20	22	(47)
3.7	W cat **2**	20	48	(53)
20	W cat **2**	20	16	(24)
1	W cat **2**	20	22	(45)
1	W cat **2**	20	24	(63)
1	W cat **2**	60	21	(85)
1	W cat **2**	60	48	(70)
1	W cat **2**	60	93	(>98)
1	W cat **2**	80	21	(52)

1 atm

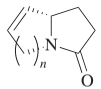


Catalyst (x eq), DCM, rt, 24 h



I

+

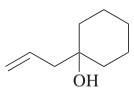


II

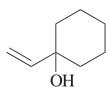
354

n	Catalyst	x	Conv. (%)[b]	**I**	**II**
1	Gr I	0.05	20	(10)	(—)
1	Gr I	0.1	50	(25)	(—)
1	Ru cat **35**	0.05	20	(5)	(—)
2	Gr I	0.05	70	(7)	(60)
2	Gr I	0.1	70	(5)	(65)
2	Ru cat **35**	0.05	80	(35)	(55)
3	Gr I	0.1	80	(10)	(60)
4	Gr I	0.05	80	(30)	(—)
4	Gr I	0.1	80	(60)	(—)

1 bar



Hov II (0.03 eq), $Pd_2Br_2[P(t\text{-}Bu)_3]_2$ (0.005 eq), toluene, 100°, 12 h

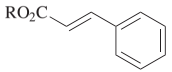
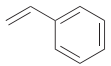


(86)

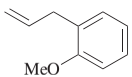
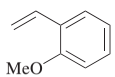
344

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

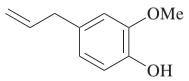
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 *x* eq		Hov II (*y* eq), DCM, 40°	 + 	356

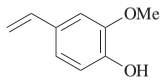
x	R	*y*	Time (h)	Conv. (%)[a]
0.5	H	0.125	48	29
1	H	0.125	24	23
1	Et	0.05	24	16
1	Bu	0.125	24	38
5	Bu	0.05	24	29

10 bar		Hov II (0.03 eq), $Pd_2Br_2[P(t\text{-}Bu)_3]_2$ (0.005 eq), THF, 60°, 16 h		(87)	344

x bar



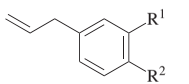
Hov II (*y* eq),
$Pd_2Br_2[P(t\text{-}Bu)_3]_2$
(*z* eq), THF



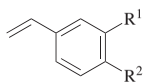
344

x	*y*	*z*	Time (h)	Temp (°)	Conv. (%)[a]	
10	0.03	0.005	16	60	>99	(97)
10	0.03	0.001	16	60	>99	(92)
10	0.01	0.005	16	60	>99	(91)
10	0.03	0.005	4	60	>99	(87)
5	0.03	0.005	16	60	>99	(83)
10	0.03	0.005	0.25	60 (MW)	>99	(90)
10	0.03	—	16	60	44	(33)

10 bar



Hov II (0.03 eq),
$Pd_2Br_2[P(t\text{-}Bu)_3]_2$
(0.005 eq),
THF, 60°, 16 h

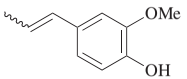
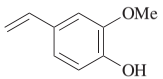


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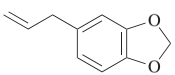
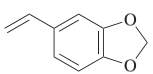
R^1	R^2	
H	MeO	(89)
H	Cl	(92)
H	F	(95)
H	Me	(94)
MeO	HO	(85)
MeO	MeO	(90)
CF_3	H	(95)
n-PrO_2C	MeO	(93)

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

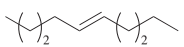
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 10 bar		Catalyst (0.03 eq), solvent, 60°, 16 h		344

Catalyst	Solvent	Conv. (%)[c]	
Gr I	toluene	46	(39)
Hov I	toluene	51	(35)
Gr II	toluene	>99	(44)
Hov II	toluene	>99	(55)
Ru cat **139**	toluene	>99	(47)
Ind I	toluene	30	(26)
Ru cat **320**	toluene	57	(31)
Ru cat **312**	toluene	41	(35)
Hov II	MeOH	82	(—)
Hov II	NMP	62	(62)
Hov II	acetone	82	(80)
Hov II	diglyme	>99	(93)
Hov II	THF	>99	(96)

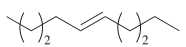
10 bar		Hov II (0.03 eq), $Pd_2Br_2[P(t\text{-}Bu)_3]_2$ (0.005 eq), THF, 60°, 16 h		(92)	344

x atm



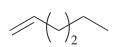
I

Ru cat **215**
(0.005 eq),
THF, 35°, 4 h



II

\+

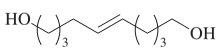


III

352

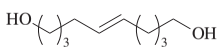
x	(*E*)/(*Z*) **I**	(*E*)/(*Z*) **II**
1	79:21	90:10
5	79:21	>95:5
5	52:48	90:10

x atm



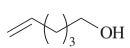
I

Ru cat **215**
(0.005 eq),
THF, 35°, 6 h



II

\+

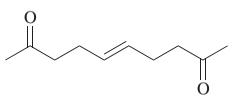


III

352

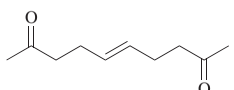
x	(*E*)/(*Z*) **I**	(*E*)/(*Z*) **II**
1	82:18	92:8
5	82:18	>95:5
5	68:32	90:10

x atm



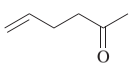
(*E*)/(*Z*) = 72:28

Ru cat **215**
(0.005 eq),
THF, 35°, 4 h



I

\+



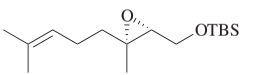
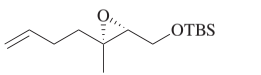
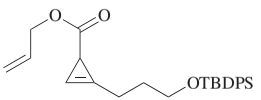
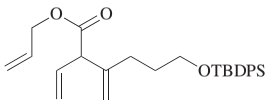
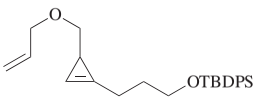
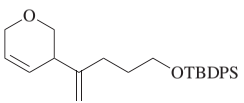
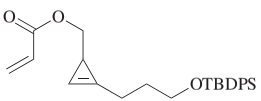
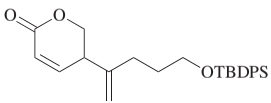
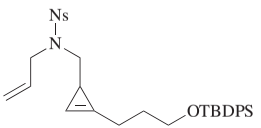
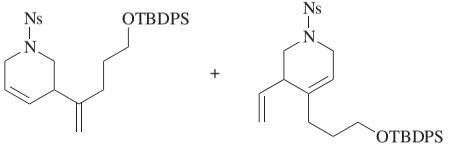
II

352

x	**I** + **II**	(*E*)/(*Z*) **I**
1	(85)	90:10
5	(85)	>95:5

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
		1. Gr II (0.03 eq), DCM, 40°, 24 h 2. *m*-CPBA (2 eq), DCM, 0.5 h	 (54)	355
1 atm		Gr II (0.025 eq), toluene, reflux	 (43)	357
1 atm		Gr II (0.025 eq), DCM, reflux	 (57)	357
1 atm		Gr II (0.025 eq), benzene, reflux	 (64)	357
1 atm		Gr II (0.025 eq), benzene, reflux	 **I** (68) **I/II** = 87:13 **II**	357

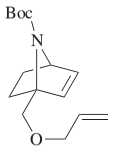
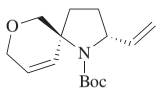
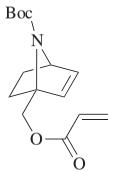
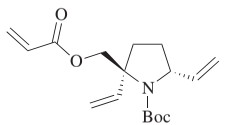
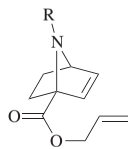
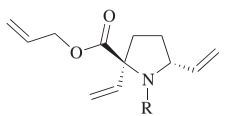
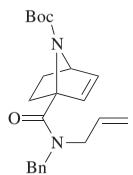
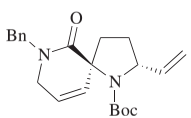
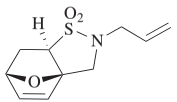
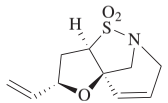
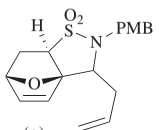
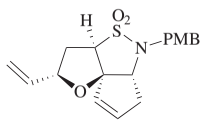
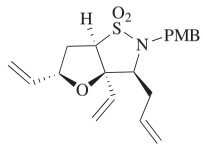
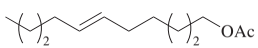
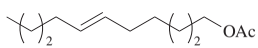
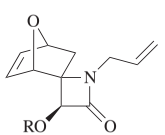
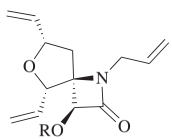
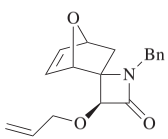
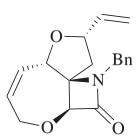
1 atm		Gr II (0.05 eq), toluene, 80°, 8 h		(91)	358
1 atm		Gr II (0.05 eq), toluene, 80°, 14 h		(79)	358
1 atm		Gr II (0.05 eq), toluene, 80°, 14 h		R Boc (88) Ac (73)	358
1 atm		Gr II (0.05 eq), toluene, 80°, 14 h		(91)	358

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 1 atm	 (±)	Gr II (0.05 eq), DCM, 45°, 3h	 (±) (74)	359
1 atm	 (±)	Gr II (0.1 eq), DCM, 45°, 3h	 (±) (54) +  (±) (16)	359
4 atm	 (*E*)/(*Z*) = 83:17	Mo cat **6** (0.001 eq), 0.25 h	 (75) (*E*)/(*Z*) > 98:2	351
1 atm		Gr I (0.1 eq), DCM, rt, 12 h	 R: Ph (85), Bn (85)	360
1 atm		Gr I (0.1 eq), DCM, rt, 12 h	 (98)	360

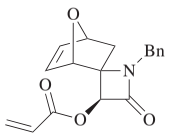
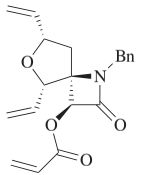
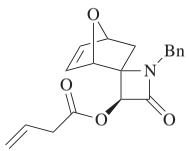
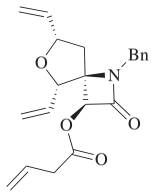
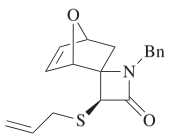
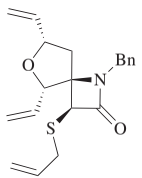
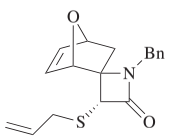
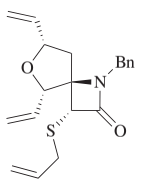
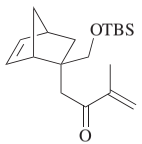
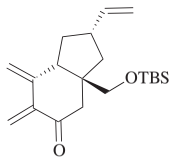
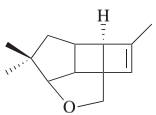
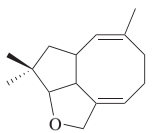
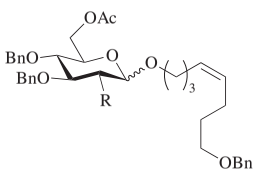
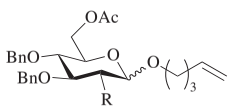
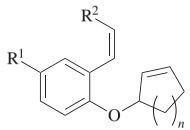
1 atm		Gr II (0.1 eq), DCM, rt, 12 h		(70)	360
1 atm		Gr II (0.1 eq), DCM, rt, 12 h		(70)	360
1 atm		Gr II (0.1 eq), DCM, rt, 12 h		(50)	360
1 atm		Gr II (0.1 eq), DCM, rt, 12 h		(70)	360

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

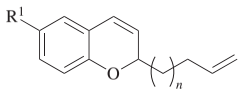
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
		Gr I (0.025 eq), DCM, rt, 6 h	 (99)	361
1 atm		Gr II (0.05 eq), benzene, 50–80°, 6 + 10 h	 (74)	269
		Catalyst (0.1 eq), solvent, 48 h		178

R	Catalyst	Solvent	Temp (°)	
BnO	Gr I	DCM	rt	(90)
BnO	Gr II	DCM	40	(50)
BnO	Ru cat **66**	DCE	80	(tr)
N_3	Gr II	DCM	rt	(0)
N_3	Ru cat **66**	DCE	80	(tr)
AcHN	Gr I	DCM	rt	(92)



1 atm

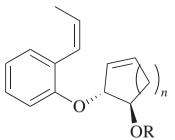
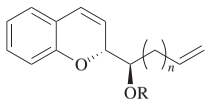
Catalyst (*x* eq),
DCM, 22°



R^1	R^2	*n*	Catalyst	*x*	Time (h)		
H	H	1	Gr I	0.05	16	(0)	363
H	H	2	Gr I	0.05	16	(35)	363
H	H	3	Gr I	0.05	10–14	(92)	363
H	H	4	Gr I	0.05	10–14	(90)	363
MeO	H	3	Gr I	0.05	10–14	(100)	363
F	H	3	Gr I	0.05	10–14	(86)	363
O_2N	H	4	Gr I	0.05	10–14	(84)	363
H	H	1	Gr I	0.1	—	(<5)	364
H	Me	1	Gr I	0.1	50	(78)	364
MeO	H	3	Ru cat **2**	0.05	14	(99)	364
MeO	H	4	Ru cat **2**	0.05	14	(90)	364
O_2N	H	3	Ru cat **2**	0.05	14	(91)	364

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 1 atm		Catalyst (*x* eq), solvent, 22°		364

R	*n*	Catalyst	*x*	Solvent	Time (h)	
Bn	1	Gr I	0.09	DCM	36	(35)
TBS	1	Gr I	0.09	DCM	36	(12)
Bn	2	Gr I	0.09	DCM	36	(36)
TBS	2	Gr I	0.09	DCM	36	(32)
H	3	Gr I	0.09	DCM	36	(54)
Bn	3	Gr I	0.09	DCM	36	(82)
TBS	3	Gr I	0.09	DCM	36	(88)
Bn	1	Mo cat **1**	0.1	benzene	24	(91)
TBS	1	Mo cat **1**	0.1	benzene	24	(93)
Bn	2	Mo cat **1**	0.1	benzene	24	(79)
TBS	2	Mo cat **1**	0.1	benzene	24	(90)
H	3	Mo cat **1**	0.1	benzene	24	(<5)
Bn	3	Mo cat **1**	0.1	benzene	24	(75)
TBS	3	Mo cat **1**	0.1	benzene	24	(97)

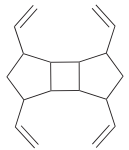
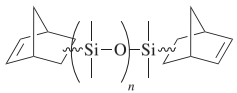
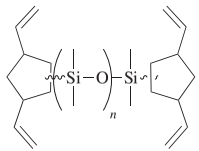
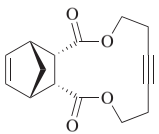
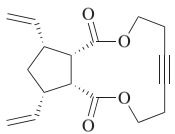
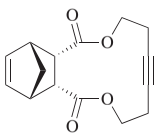
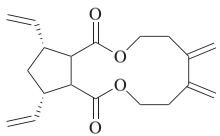
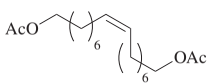
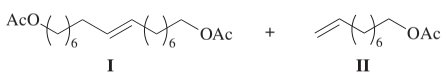
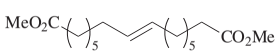
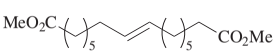
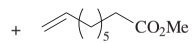
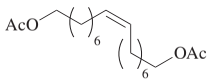
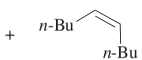
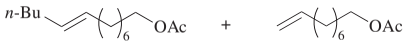
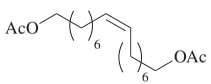
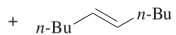
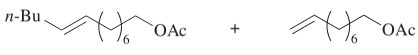
3 bar		Gr I (0.0003 eq), toluene, rt, 24 h		(99)	347
4 bar		Gr I (*x* eq), toluene, rt, 24 h		*n* *x* 1 0.0005 (99); 12 0.0007 (99); 13 0.0007 (99)	347
		Gr I (0.05 eq), rt, 20 h		(76)	385
		Gr II (0.05 eq), 60°, 20 h		(100)	385
x atm	 (*E*)/(*Z*) = 78:22	Ru cat **215** (0.005 eq), THF, 35°, 4 h	 **I** + **II**	*x* (*E*)/(*Z*) **I**: 1 93:7; 5 >95:5	352

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

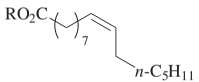
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 *x* atm	 (*E*)/(*Z*) = 80:20	Ru cat **215** (0.005 eq), THF, 35°, 6 h	 **I** +  **II**	*x* 1: 88:12; 5: >95:5	352
x atm	 (*Z*)/(*E*) = 75:25 + 	Catalyst (*y* eq), THF, 35°	 **I** + **II**		352

x	Catalyst	*y*	Time (h)	**I**	(*E*)/(*Z*) **I**	**II**
0	Ru cat **215**	0.01	24	(<1)	—	(<1)
1	Ru cat **215**	0.01	4.5	(21)	5:95	(8)
0	Ru cat **217**	0.025	2	(37)	69:31	(<1)

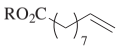
x atm	 (*Z*)/(*E*) = 75:25 + 	Catalyst (*y* eq), THF, 35°	 **I** + **II**		352

x	Catalyst	*y*	Time (h)	**I**	(*E*)/(*Z*) **I**	**II**
0	Ru cat **215**	0.01	24	(<1)	—	(<1)
1	Ru cat **215**	0.01	24	(<1)	—	(2)
0	Ru cat **217**	0.025	2	(30)	69:31	(<1)

8 bar



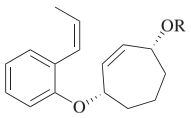
Ind II (0.0005 eq),
DCM, 20°, 6 h



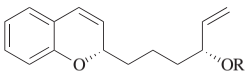
R	Conv. (%)[c]
Me	47
4-HOC_6H_4	7

365

1 atm



Catalyst (x eq),
solvent, 22°



R	Catalyst	x	Solvent	Time (h)	
H	Gr I	0.09	DCM	36	(10)
Bn	Gr I	0.09	DCM	36	(65)
TBS	Gr I	0.09	DCM	36	(55)
H	Mo cat **1**	0.1	benzene	24	(<5)
Bn	Mo cat **1**	0.1	benzene	24	(98)
TBS	Mo cat **1**	0.1	benzene	24	(95)

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TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

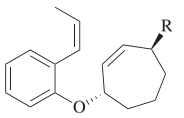
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

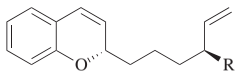
C_2



1 atm



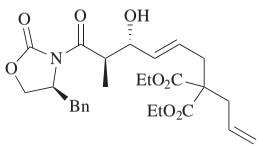
Catalyst (*x* eq), solvent, 22°



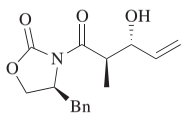
364

R	Catalyst	*x*	Solvent	Time (h)	
H	Ru cat **2**	0.1	DCM	24	(81)
BnO	Gr I	0.09	DCM	36	(25)
TBSO	Gr I	0.09	DCM	36	(29)
BnO	Mo cat **1**	0.1	benzene	24	(88)
TBSO	Mo cat **1**	0.1	benzene	24	(92)

x atm

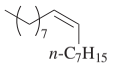


Catalyst (0.05 eq), solvent



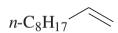
366

x	Catalyst	Solvent	Temp (°)	Time (h)	
1	Gr II	DCE	40	12	(56)
—	Gr II	DCE	40	12	(61)
—	Gr II	DCE	60	12	(10)
1	Gr II	DCE	60	12	(7)
1	Hov II	DCE	40	12	(69)
1	Hov II	DCE	60	12	(62)
—	Hov II	DCE	60	12	(12)
1	Hov II	Toluene	60	12	(83)
—	Hov II	Toluene	60	12	(46)
1	Hov II	Toluene	60	3	(77)
1	Hov II	Toluene	60	6	(74)



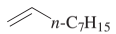
x bar

Catalyst (*y* eq), solvent



I

+

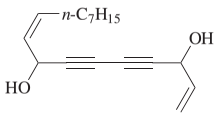
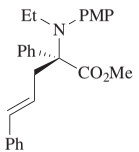
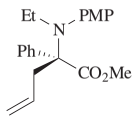
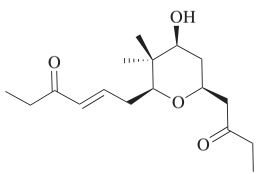
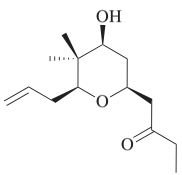


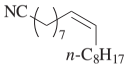
II

x	Catalyst	*y*	Solvent	Temp (°)	Time (h)	Conv. (%)[d]	**I + II**
1	Gr I	0.049	DCM	40	20	94	(41)
1	Hov I	0.049	DCM	40	20	96	(59)
1	Hov II	0.034	DCM	40	20	97	(61)
10	Hov II	0.034	DCM	40	20	98	(73)
5	Hov II	0.037	DCM	40	20	99	(80)
5	Hov II	0.035	MeOH	40	20	94	(0)
5	Hov II	0.035	toluene	40	20	99	(71)
5	Hov II	0.035	hexane	40	20	99	(91)
5	Hov II	0.035	acetic acid	40	20	95	(32)
5	Hov II	0.034	ethyl acetate	40	20	95	(10)
5	Hov II	0.035	dimethyl carbonate	40	20	98	(21)
5	Hov II	0.034	hexane	40	1	99	(81)
5	Hov II	0.034	hexane	40	3	99	(84)
5	Hov II	0.01	hexane	40	1	98	(66)
5	Hov II	0.01	hexane	40	20	99	(87)
5	Hov II	0.001	hexane	40	1	96	(30)
5	Hov II	0.036	hexane	RT	1	93	(39)
5	Hov II	0.034	hexane	RT	3	95	(32)
10	Hov II	0.034	hexane	RT	20	98	(78)
5	Hov II	0.034	hexane	RT	20	100	(96)
1	Hov II	0.034	hexane	RT	20	99	(79)
1	Hov II	0.034	hexane	40	20	98	(69)
5	Hov II	0.001	—	40	20	94	(25)

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
		Gr II (0.1 eq), DCM, rt, 16 h	 (81)	117
		Hov II (0.2 eq), toluene, 90° (MW), 0.5 h	 (24)	368
1 atm		Hov II (0.1 eq), toluene, 60°	 (70)	369



x	Catalyst	*y*	Solvent	Temp (°)	Time (h)	Conv. (%)[c]	**I**	**II**
1	Gr I	0.025	toluene	rt	3	45	(—)	(—)
1	Hov I	0.025	toluene	rt	3	80	(—)	(—)
1	Ind I	0.025	toluene	rt	3	45	(—)	(—)
1	Ru cat **293**	0.025	toluene	rt	3	82	(—)	(—)
1	Gr II	0.025	toluene	rt	3	82	(—)	(—)
1	Hov II	0.025	toluene	rt	3	91	(—)	(—)
1	Ru cat **89**	0.025	toluene	rt	3	91	(—)	(—)
1	Ind II	0.025	toluene	rt	3	83	(—)	(—)
1	Ru cat **139**	0.025	toluene	rt	3	85	(—)	(—)
1	Ru cat **137**	0.025	toluene	rt	3	40	(—)	(—)
1	Hov I	0.01	toluene	rt	3	70	(64)	(66)
1	Ru cat **293**	0.01	toluene	rt	3	73	(66)	(70)
1	Hov II	0.01	toluene	rt	3	82	(69)	(77)
1	Hov II	0.01	pentane	rt	3	43	(—)	(—)
1	Hov II	0.01	cyclohexane	rt	3	36	(—)	(—)
1	Hov II	0.01	dibuthyl ether	rt	3	52	(—)	(—)
1	Hov II	0.01	CPME	rt	3	63	(—)	(—)
1	Hov II	0.01	DMC	rt	3	71	(—)	(—)
1	Ru cat **89**	0.01	toluene	rt	3	83	(70)	(76)
1	Ru cat **139**	0.01	toluene	rt	3	83	(79)	(75)
1	Hov II	0.005	toluene	rt	3	79	(61)	(68)
1	Ru cat **89**	0.005	toluene	rt	3	82	(67)	(75)
1	Ru cat **139**	0.005	toluene	rt	3	79	(63)	(70)
20	Gr I	0.0025	toluene	120	16	98	(—)	(—)
20	Gr I	0.00125	toluene	120	16	86	(—)	(—)

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

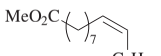
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

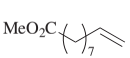
Please refer to the charts preceding the tables for the catalyst structures.

C_2

x bar

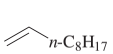


Catalyst (*y* eq),



I

+



II

x	Catalyst	*y*	Solvent	Temp (°)	Time (h)	Conv. (%)[d]	**I**	**II**	**I + II**	
1	Gr I	0.025	toluene	70	3.5	45	(40)	(42)	(—)	371
1	Hov I	0.025	toluene	70	3.5	91	(89)	(88)	(—)	371
1	Ru cat **345**	0.025	toluene	70	3.5	25	(19)	(20)	(—)	371
1	Ru cat **346**	0.025	toluene	70	3.5	97	(17)	(54)	(—)	371
10	Hov I	0.025	toluene	70	3.5	97	(97)	(97)	(—)	371
10	Hov I	0.025	toluene	70	3.5	97	(97)	(85)	(—)	371
1	Hov I	0.025	toluene	70	3.5	93	(93)	(93)	(—)	371
10	Gr I	0.065	[bmim][OTf]	20	2	19	(—)	(—)	(—)	371
10	Gr I	0.065	[bmim][NTf_2]	20	2	79	(—)	(—)	(—)	371
10	Gr I	0.065	[bdmim][NTf_2]	20	2	83	(—)	(—)	(—)	371
10	Ru cat **82**	0.05	[bdmim][NTf_2]	20	2	38	(—)	(—)	(—)	371
10	Ru cat **83**	0.05	[bdmim][NTf_2]	20	2	89	(—)	(—)	(—)	371
10	Gr I	0.0001	—	40	2	58	(—)	(—)	(54)	372
10	Gr I	0.0001	—	60	0.5	54	(—)	(—)	(48)	372
10	Hov I	0.0001	—	40	0.5	51	(—)	(—)	(48)	372
10	Gr II	0.0001	—	40	2	64	(—)	(—)	(28)	372
10	Gr II	0.0001	—	60	<0.25	64	(—)	(—)	(28)	372
10	Hov II	0.0001	—	40	0.5	60	(—)	(—)	(20)	372
10	Hov II	0.0001	—	60	<0.25	68	(—)	(—)	(32)	372
10	Ru cat **15**	0.0001	—	40	1	69	(—)	(—)	(38)	372
10	Ru cat **187**	0.0001	—	60	0.25	79	(—)	(—)	(56)	372
55	Ru cat **187**	0.0001	—	25	6	87	(—)	(—)	(70)	372
10	Ru cat **69**	0.0001	—	40	0.25	62	(—)	(—)	(21)	372
10	Ru cat **66**	0.0001	—	40	0.25	50	(—)	(—)	(3)	372

12	Ru cat **159**	0.0001	—	60	6.5	79	(—)	(—)	(57)	373
12	Ru cat **159**	0.0001	—	80	2	81	(—)	(—)	(54)	373
10	Ru cat **160**	0.0001	—	60	3	78	(—)	(—)	(57)	373
10	Ru cat **161**	0.0001	—	60	4	59	(—)	(—)	(53)	373
10	Ru cat **279**	0.0001	—	60	0.5	35	(—)	(—)	(30)	373
10	Ru cat **71**	0.0001	—	60	4	77	(—)	(—)	(51)	373
10	Ru cat **249**	0.00005	—	40	20	61	(—)	(—)	(57)	373
10	Ru cat **253**	0.0001	—	40	6	46	(—)	(—)	(43)	373
10	Ru cat **263**	0.000035	—	40	1	75	(—)	(—)	(56)	373
10	Ru cat **72**	0.0001	—	40	22	60	(—)	(—)	(54)	373
10	Ru cat **256**	0.0001	—	40	3	37	(—)	(—)	(32)	374
10	Ru cat **263**	0.0001	—	40	3	42	(—)	(—)	(37)	374
10	Ru cat **257**	0.000003	—	40	3	59	(—)	(—)	(54)	374
10	Ru cat **258**	0.000003	—	40	3	18	(—)	(—)	(17)	374
10	Ru cat **249**	0.000003	—	40	3	19	(—)	(—)	(18)	374
10	Ru cat **259**	0.000003	—	40	3	22	(—)	(—)	(14)	374
10	Ru cat **254**	0.000003	—	40	3	26	(—)	(—)	(22)	374
10	Ru cat **260**	0.000003	—	40	3	42	(—)	(—)	(39)	374
10	Ru cat **252**	0.000003	—	40	3	19	(—)	(—)	(14)	374
10	Ru cat **253**	0.000003	—	40	3	13	(—)	(—)	(13)	374
10	Ru cat **250**	0.000003	—	40	3	16	(—)	(—)	(15)	374
10	Ru cat **255**	0.000003	—	40	3	41	(—)	(—)	(34)	374
10	Ru cat **261**	0.000003	—	40	3	46	(—)	(—)	(39)	374
10	Ru cat **264**	0.000003	—	40	3	48	(—)	(—)	(43)	374
10	Ru cat **262**	0.000003	—	40	3	57	(—)	(—)	(54)	374
10	Ru cat **251**	0.000003	—	40	3	47	(—)	(—)	(46)	374
10	Ru cat **249**	0.00005	—	40	20	61	(—)	(—)	(57)	375
10	Ru cat **253**	0.0001	—	40	6	46	(—)	(—)	(43)	375
10	Ru cat **263**	0.000035	—	40	1	75	(—)	(—)	(56)	375

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

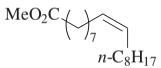
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

C_2



x bar

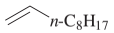


Catalyst (*y* eq),



I

+



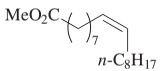
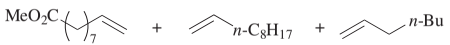
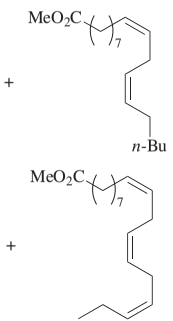
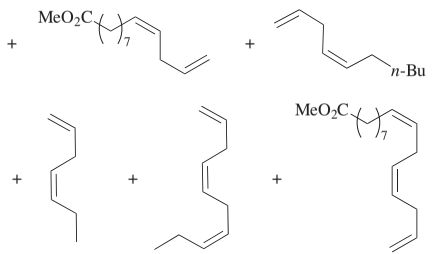
II

x	Catalyst	*y*	Solvent	Temp (°)	Time (h)	Conv. (%)[d]	**I**	**II**	**I + II**	
4	Gr I	0.0003	—	rt	2	65	(—)	(—)	(63)	113
4	Hov I	0.0003	—	rt	2	69	(—)	(—)	(65)	113
4	Ru cat **187**	0.00005	—	rt	1	54	(—)	(—)	(28)	113
4	Ru cat **15**	0.00005	—	rt	0.67	61	(—)	(—)	(35)	113
4	Ru cat **263**	0.00005	—	rt	1	80	(—)	(—)	(70)	376
10	Mo cat **6**	0.002	—	rt	15	95	(—)	(—)	(95)	376
4	Mo cat **18**	0.0002	—	rt	18	96	(—)	(—)	(94)	376
4	W cat **5**	0.002	—	rt	17	48	(—)	(—)	(48)	376
10	Ru cat **5**	0.00003	—	60	2	43	(—)	(—)	(—)	377
10	Ru cat **287**	0.0002	—	50	2	60	(—)	(—)	(—)	376
10	Ru cat **287**	0.0001	—	50	2	70	(—)	(—)	(—)	376
10	Ru cat **287**	0.00005	—	50	2	64	(—)	(—)	(—)	376
4	Gr I	0.0002	—	30	18	75	(—)	(—)	(—)	378
1	Ru cat **75**	0.01	—	80	12	99	(96)	(97)	(—)	379
1	Ru cat **76**	0.01	—	80	12	99	(92)	(92)	(—)	379
10	Ru cat **11**	0.0001	—	60	2	—	(24)	(—)	(—)	380
9	Ru cat **3**	0.00017	—	13	4	61	(—)	(—)	(—)	381
50	Ru cat **3**	0.00002	—	90	4	20	(—)	(—)	(—)	381
9	Ru cat **192**	0.00017	—	12	4	18	(—)	(—)	(—)	381

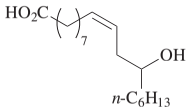
9	Ru cat **193**	0.00017	—	13	4	18	(—)	(—)	(—)	381
50	Ru cat **193**	0.00016	—	25	4	23	(—)	(—)	(—)	381
7	Ru cat **40**	0.005	—	60	0.3	25	(—)	(—)	(—)	382
7	Ru cat **40**	0.005	toluene	60	0.3	32	(—)	(—)	(—)	382
7	Ru cat **40**	0.005	DCM	60	1	46	(—)	(—)	(—)	382
10	Ru cat **234**	0.0001	—	40	6	54	(—)	(—)	(46)	383
10	Ru cat **233**	0.0001	—	40	6	11	(—)	(—)	(9)	383
10	Ru cat **236**	0.0001	—	40	6	52	(—)	(—)	(45)	383
10	Ru cat **237**	0.0001	—	40	6	42	(—)	(—)	(36)	383
10	Ru cat **232**	0.0001	—	40	6	59	(—)	(—)	(51)	383
10	Ru cat **241**	0.0001	—	40	6	52	(—)	(—)	(46)	383
10	Ru cat **242**	0.0001	—	40	6	15	(—)	(—)	(15)	383
10	Ru cat **231**	0.0001	—	40	6	17	(—)	(—)	(11)	383
10	Ru cat **225**	0.0001	—	40	6	40	(—)	(—)	(31)	383
10	Ru cat **242**	0.0005	—	40	6	48	(—)	(—)	(46)	383
10	Ru cat **232**	0.0005	—	40	6	89	(—)	(—)	(78)	383
10	Ru cat **237**	0.0005	—	40	2	83	(—)	(—)	(72)	383
10	Ru cat **225**	0.0005	—	40	4	65	(—)	(—)	(53)	383
10	Ru cat **235**	0.0005	—	40	6	70	(—)	(—)	(41)	383
10	Ru cat **241**	0.0005	—	40	6	86	(—)	(—)	(75)	383
1	Hov I	0.025	DCM	rt	3	88	(—)	(—)	(—)	384
10.3	Ru cat **215**	0.001	DCM	40	1	—	(—)	(—)	(80)	352
10.3	Ru cat **215**	0.0001	DCM	40	1	—	(—)	(—)	(12)	352

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

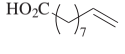
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2		Catalyst (0.01 eq), toluene, 4 h		379
 1 atm				

Catalyst	Temp (°)	Conv. (%)[c]	Select (%)[c]
Gr I	25	82	90
Gr I	50	95	92
Gr I	70	99	93
Ru cat **38**	25	90	60
Ru cat **38**	50	99	55
Ru cat **38**	70	99	50
Ru cat **75**	25	99	96
Ru cat **75**	50	99	90
Ru cat **75**	70	99	80
Ru cat **76**	25	99	90
Ru cat **76**	50	99	88
Ru cat **76**	70	99	74



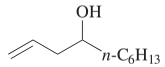
20 bar

Ind II (0.001 eq), toluene, 80°, 3 h



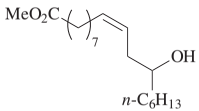
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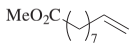
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112



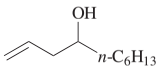
20 bar

Catalyst (0.01 eq), toluene, 50°, 8 h



I

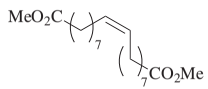
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II

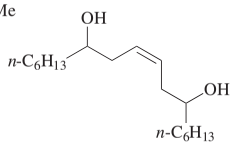
112

+



III

+

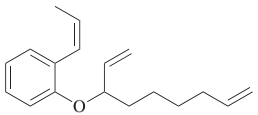
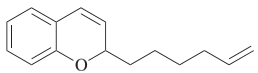
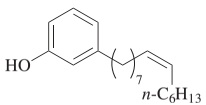
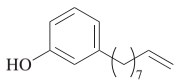


IV

Catalyst	Conv (%)[c]	**I**	**II**	**III**	**IV**
Gr I	26	(16)	(19)	(—)	(1)
Gr II	98	(54)	(76)	(8)	(2)
Ind I	26	(19)	(22)	(—)	(—)
Ind II	98	(63)	(78)	(4)	(1)
Ru cat **319**	98	(33)	(79)	(20)	(2)
Ru cat **290**	42	(30)	(34)	(—)	(—)
Ru cat **320**	99	(36)	(81)	(18)	(1)
Ru cat **292**	84	(52)	(48)	(6)	(10)
Ru cat **39**	93	(66)	(66)	(3)	(7)
Ru cat **40**	91	(62)	(58)	(3)	(8)
Ru cat **139**	89	(36)	(81)	(18)	(1)

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

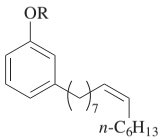
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 1 atm		Gr I (0.05 eq), DCM, 22°		(83) 364
300 kPa		Catalyst (x eq), toluene, 60°, 2 h		387

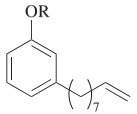
Catalyst	x	Conv. (%)[e]
Gr II	0.02	90
Ru cat **8**	0.02	71
Ru cat **8**	0.01	60
Ru cat **8**	0.004	56
Ru cat **8**	0.002	46
Ru cat **8**	0.001	26
Ru cat **89**	0.02	92
Ru cat **90**	0.02	89
Ru cat **90**	0.01	86
Ru cat **90**	0.004	81
Ru cat **90**	0.002	73
Ru cat **90**	0.001	56



8 bar



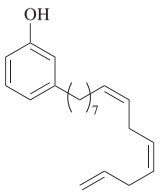
Catalyst
(0.0005 eq),
DCM, 6 h



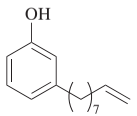
365

R	Catalyst	Temp (°)	Conv. (%)[e]	
H	Ru cat **316**	70	28	(13)
H	Ru cat **139**	70	72	(9)
Me	Ind I	rt	53	(50)
Me	Ru cat **316**	rt	71	(6)
Me	Ru cat **139**	rt	77	(2)

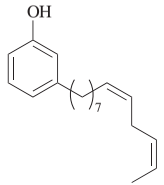
8 bar



Catalyst
(0.0005 eq),
DCM, 6 h



+



365

I **II**

Catalyst	Temp (°)	Conv. (%)[e]	**I**	**II**
Ind I	20	95	(94)	(2)
Gr II	20	90	(91)	(5)
Ind II	70	84	(68)	(12)
Ru cat **294**	40	83	(54)	(20)
Ru cat **320**	70	87	(59)	(22)
Ru cat **316**	90	92	(75)	(12)
Ru cat **139**	20	82	(50)	(12)
Ru cat **137**	40	95	(24)	(10)

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

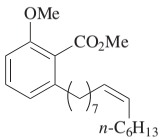
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

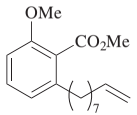
Please refer to the charts preceding the tables for the catalyst structures.

C_2

8 bar



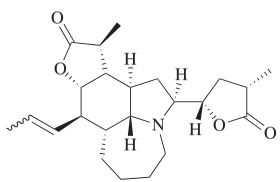
Catalyst (0.01 eq), solvent, 16 h



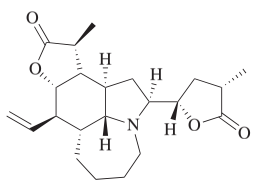
365

Catalyst	Solvent	Temp (°)	Conv. (%)[e]
Hov I	DCM	25	93
Ru cat **320**	DCM	25	17
Ru cat **312**	DCM	25	30
Ru cat **139**	DCM	25	96
Ru cat **95**	DCM	25	90
Hov I	THF	60	74
Ru cat **320**	THF	60	88
Ru cat **312**	THF	60	56
Ru cat **139**	THF	60	44
Ru cat **95**	THF	60	93





Hov II (5 × 0.05 eq), TsOH (1 eq), DCM, reflux, 60 h



(81)

116

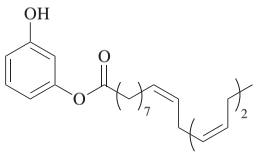
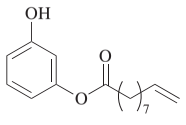
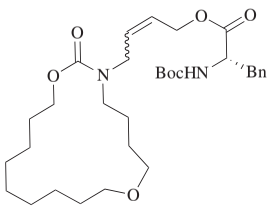
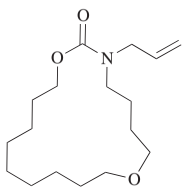
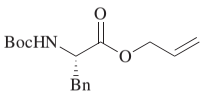
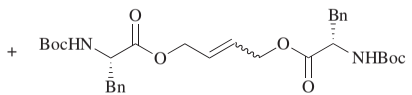
 8 bar		Ind II (0.0005 eq), DCM, 20°, 6 h		36[c]		365
excess		Gr II (0.02 eq), DCM, reflux, 2.5 h	 (36)	+	 (37)	386
			+  (4)			

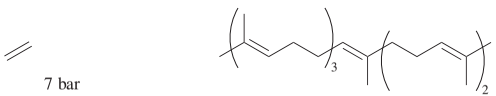
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

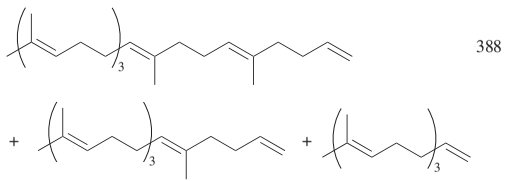
Please refer to the charts preceding the tables for the catalyst structures.

C_2



7 bar

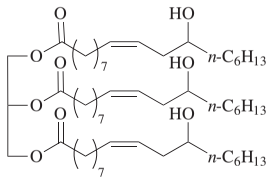
Catalyst (*x* eq), solvent



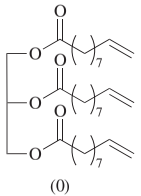
388

Catalyst	*x*	Solvent	Temp (°)	Time (h)	Conv. (%)[c]
Ru cat **341**	0.001	C_6D_6	100	6	99
Ru cat **341**	0.0001	C_6D_6	120	3	65
Ru cat **341**	0.0001	toluene	120	3	65
Ru cat **340**	0.0001	toluene	120	3	33
Ru cat **336**	0.0001	toluene	120	3	75
Ru cat **335**	0.0001	toluene	120	3	48
Ru cat **51**	0.0001	toluene	120	3	33
Ru cat **49**	0.000005	toluene	120	3	6
Ru cat **50**	0.0001	toluene	120	3	55
Ru cat **53**	0.000005	toluene	120	3	3
Gr II	0.0001	toluene	120	3	35
Hov II	0.0001	toluene	120	3	85

20 bar

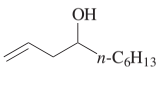


Ind II (0.001eq), toluene, 80°, 3 h



(0)

+



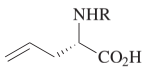
(87)

112

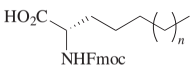
C_{3-4}



5 eq



1. Hov II (0.05 eq), DCM, rt
2. H_2 (60 psi), MeOH



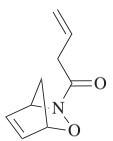
n	R	
0	Fmoc	(93)
0	Boc	(78)
1	Fmoc	(86)

127

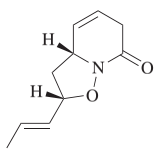
C_4



excess



Gr II (2 × 0.05 eq), toluene, 80°, 2 × 3 h

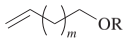
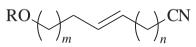
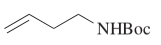
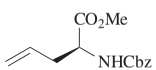
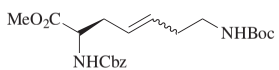
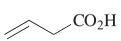
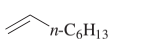
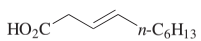
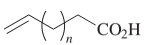
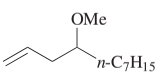
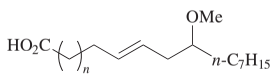


(75)

389

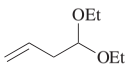
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

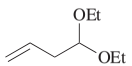
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{4-5}				
 2 eq		Catalyst (0.05 eq), DCM, reflux, 2 h		182
C_4				
 2 eq		Gr I (0.1 eq), DCM, reflux, 16 h	 (69)	390
		Gr II (2 × 0.025 eq), DCM, 40°, 24 h	 (98) (*E*)/(*Z*) = 80:20	391
	 5 eq	Gr II (0.05 eq), DCM, reflux		416

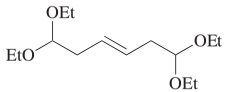
n		(*E*)/(*Z*)
0	(<5)	95:5
1	(84)	95:5

n	R	*m*	Catalyst	Conc (M)		(*E*)/(*Z*)
1	H	2	Gr I	1.2	(2)	78:22
1	H	2	Gr II	0.05	(38)	86:14
1	H	2	Gr II	0.5	(81)	86:14
1	H	2	Hov II	0.05	(72)	67:33
1	H	2	Hov II	0.5	(65)	86:14
1	H	1	Gr II	0.5	(77)	78:22
1	H	7	Gr II	0.5	(16)	71:29
1	Ph_3C	2	Gr II	0.5	(23)	71:29
2	H	2	Gr II	0.5	(72)	83:17
2	H	2	Hov II	0.05	(48)	80:20





Gr I (0.05 eq),
DCM, 45°, 12 h

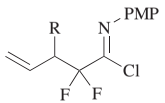


(37) (*E*)/(*Z*) = 52:48

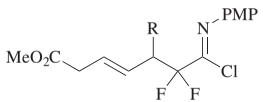
124



2 eq

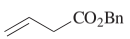


Gr II (0.1 eq),
solvent, reflux



392

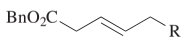
R	Solvent	Time (h)		(*E*)/(*Z*)
H	DCM	4	(60)	91:9
H	DCM	15	(70)	87.5:12.5
H	toluene	15	(—)	—
Me	DCM	15	(75)	86:14



x eq



Catalyst (*y* eq),
DCM, reflux



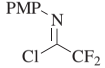
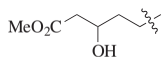
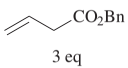
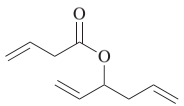
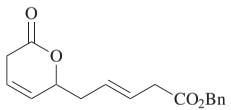
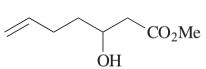
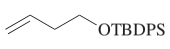
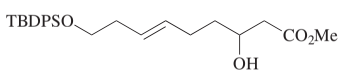
x	R	Catalyst	*y*	Time (h)		(*E*)/(*Z*)	
2		Gr II	0.1	4	(60)	91:9	392
5		Ru cat **35**	0.02	4–12	(69)	85:15	393

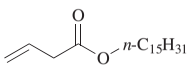
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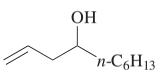
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4  3 eq		Gr II (0.025 eq), DCM, 40°, 16 h	 (60)	394
C_{4-11} 	 3 eq	1. Ru cat **152** (0.01 eq), (*Z*)-butene (20 eq), THF, 22°, time 2. Ru cat **152** (0.04 eq), THF, 100 torr, 22°, 8 h		395

R^1	R^2	Time (h)		(*Z*)/(*E*)
$HO(CH_2)_2$	$BnO_2C(CH_2)_2$	16	(56)	95:5
$BnO_2C(CH_2)_2$	$HO_2C(CH_2)_2$	1	(74)	97:3
$HO(CH_2)_8$	$HO_2C(CH_2)_2$	1	(58)	>98:2
$OHC(CH_2)_8$	$HO_2C(CH_2)_2$	1	(66)	>98:2

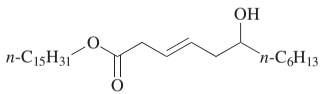
C_4  5 eq		Ru cat **35** (0.02 eq), DCM, reflux, 4–12 h	 (61) (*E*)/(*Z*) = 60:40	393





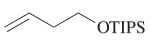
2 eq

Gr II (0.05 eq),
DCM, reflux, 15 h

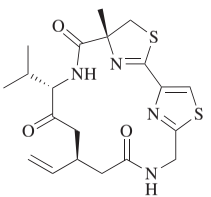


(49) (*E*) only

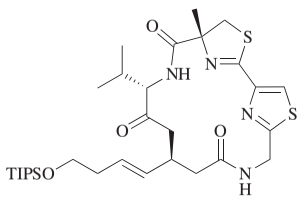
396



1 eq

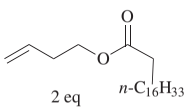


Gr II (0.3 eq),
toluene,
reflux, 3 h

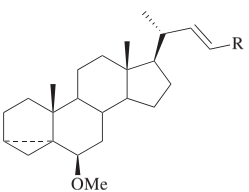


(50) (*E*)/(*Z*) = 90:10

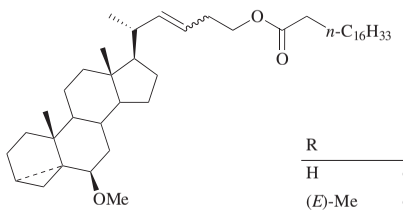
397



2 eq



Hov II (0.2 eq),
toluene, 80°, 48 h

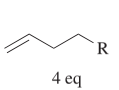
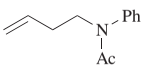
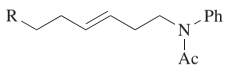
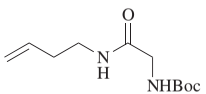
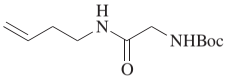
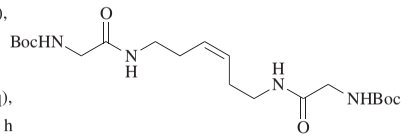
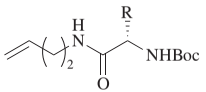
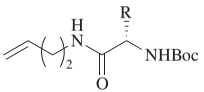
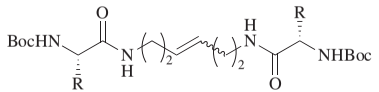
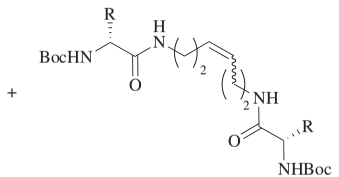


R	
H	(43)
(*E*)-Me	(44)
(*E*)-*i*-Bu	(12)
(*Z*)-*i*-Bu	(13)

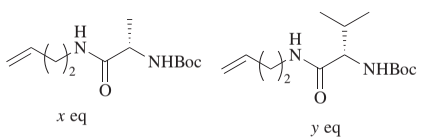
398

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

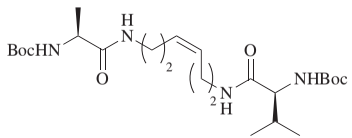
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

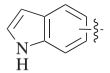
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{4-5}				
 4 eq		Gr II (0.02 eq), 2,6-Cl_2-BQ (0.1 eq), DCM, reflux, 7 d	 R = TBSO (66%) 85:15; BnO (59%) 85:15; MeO (60%) 85:15; $BnOCH_2$ (45%) 80:20; AcPhN (60%) 85:15; HO (71%) 75:25	399
C_4				
		1. Ru cat **152** (0.01 eq), (*Z*)-butene (20 eq), THF, 22°, 4 h 2. Ru cat **152** (0.04 eq), THF, 100 torr, 22°, 1 h	 (88) (*Z*)/(*E*) > 98:2	395
		Gr I (0.1 eq), DCM, rt, 12 h	 **I** +  **II**	400

149



Catalyst (0.075 eq),
THF, 40°, 4 h



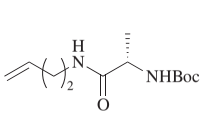
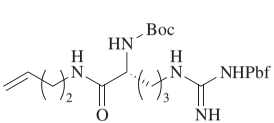
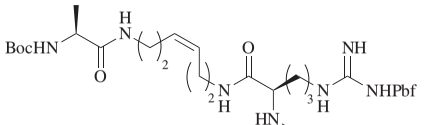
R	I	II
H	(0)	(0)
Bn	(19)	(58)
	(22)	(67)
	(0)	(0)
i-PrCH$_2$	(0)	(0)
2-napthalen-CH$_2$	(35)	(56)
$C_6F_5CH_2$	(0)	(0)
i-Pr	(0)	(0)

x	*y*	Catalyst		(*Z*)/(*E*)
1	1	Ru cat **215**	(41)	90:10
1	2	Ru cat **215**	(44)	86:14
1	4	Ru cat **215**	(48)	91:9
1	6	Ru cat **215**	(58)	88:12
2	1	Ru cat **215**	(44)	90:10
4	1	Ru cat **215**	(52)	91:9
6	1	Ru cat **215**	(51)	87:13
1	1	Ru cat **216**	(47)	93:7
1	2	Ru cat **216**	(48)	91:9
1	4	Ru cat **216**	(41)	90:10
1	6	Ru cat **216**	(60)	90:10
2	1	Ru cat **216**	(58)	93:10
4	1	Ru cat **216**	(57)	91:9
6	1	Ru cat **216**	(60)	90:10

401

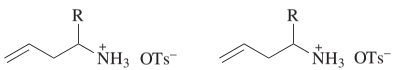
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

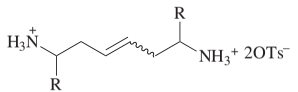
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 *x* eq	 *y* eq	Catalyst (0.075 eq), THF, 40°, 4 h		401

x	*y*	Catalyst		(*Z*)/(*E*)
1	1	Ru cat **215**	(46)	90:10
1	2	Ru cat **215**	(43)	84:16
1	4	Ru cat **215**	(38)	84:16
1	6	Ru cat **215**	(34)	72:28
2	1	Ru cat **215**	(47)	88:12
4	1	Ru cat **215**	(58)	90:10
6	1	Ru cat **215**	(62)	87:13
1	1	Ru cat **216**	(47)	93:7
1	2	Ru cat **216**	(48)	90:10
1	4	Ru cat **216**	(41)	91:9
1	6	Ru cat **216**	(38)	88:12
2	1	Ru cat **216**	(58)	91:9
4	1	Ru cat **216**	(60)	92:8
6	1	Ru cat **216**	(66)	90:10

C_{4-5}



Hov II (0.05 eq),
DCM



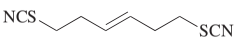
402

R	Temp (°)	Time (h)	Conv. (%)[a]
H	40	24	92
H	100 (MW)	2	95
HO_2C	40	24	0
MeO_2C	40	24	92
HO_2C	100 (MW)	2	0
MeO_2C	100 (MW)	2	90

C_4



Catalyst (x eq),
DCM



403

Catalyst	x	Temp	Time	
Gr II	0.025 + 0.025	reflux	16 h	(5)
Gr II	0.04 + 0.01	rt (MW)	20 + 10 min	(22)
Hov II	0.025 + 0.025	reflux	16 h	(40)
Hov II	0.04 + 0.01	rt (MW)	20 + 10 min	(81)

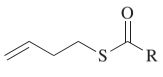
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

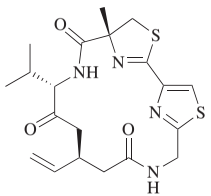
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

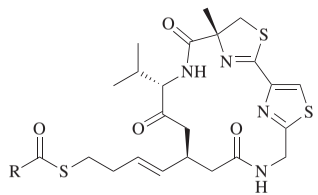
C_4



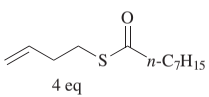
x eq



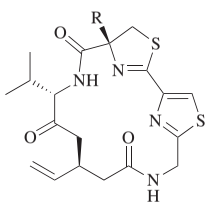
Gr II (*y* eq), toluene



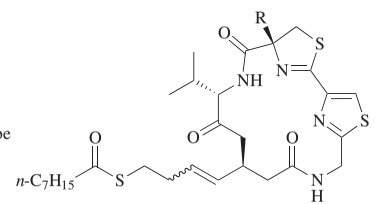
x	R	*y*	Temp	Time (h)		(*E*)/(*Z*)	
2	Me	0.5	reflux	4	(54)	(*E*) only	397
2	$CH_3(CH_2)_6$	0.5	reflux	4	(41)	(*E*) only	397
1	$CH_3(CH_2)_6$	0.2	60°	24	(34)	—	404



4 eq

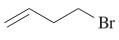


Hov II (*x* eq), DCE, 90°, overnight, sealed tube

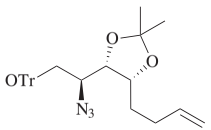


405

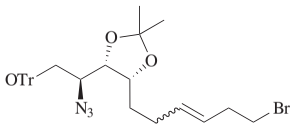
R	*x*	
H	0.14	(35)
H	0.18	(20)
Me	0.14	(27)
Et	0.18	(23)
Bn	0.18	(21)



10 eq



Gr II (0.1 eq),
DCM, rt, 18 h

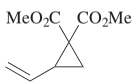


(56)

406

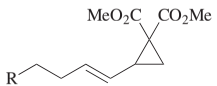
$C_{4–12}$





x eq

Catalyst (*y* eq),
CuI (*z* eq),
solvent

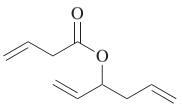
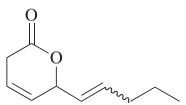
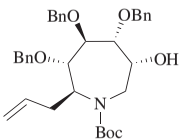
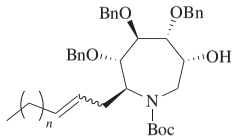
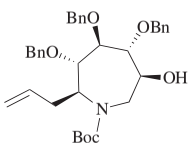
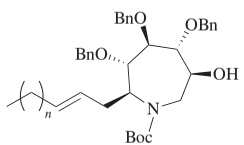


407

R	*x*	Catalyst	*y*	*z*	Solvent	Temp	Time (h)		(*E*)/(*Z*)
Br	1.4	Gr II	0.01	—	DCM	reflux	—	(78)	80:20
Et	1.4	Gr II	0.05	—	DCM	reflux	2	(70)	86:14
Et	1.4	Gr II	0.01	—	DCM	reflux	3	(67)	86:14
Et	1.4	Gr I	0.01	—	DCM	reflux	24	IC	—
Et	1.4	Gr I	0.1	—	DCM	reflux	24	IC	—
Et	1.4	Hov II	0.01	—	DCM	reflux	24	IC	—
Et	1.2	Gr II	0.01	—	DCM	reflux	2	(53)	86:14
Et	2.0	Gr II	0.01	—	DCM	reflux	2	(67)	86:14
Et	1.4	Gr II	0.01	—	DCM	rt	24	(50)	66:34
Et	1.4	Gr II	0.01	—	DCM	0°	72	IC	—
Et	1.4	Gr II	0.01	0.03	Et_2O	reflux	40	IC	—
n-Pr	1.4	Gr II	0.01	—	DCM	reflux	—	(74)	86:14
n-C_8H_{17}	1.4	Gr II	0.01	—	DCM	reflux	—	(69)	75:25
$TBSO(CH_2)_2$	1.4	Gr II	0.01	—	DCM	reflux	—	(73)	75:25

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{5-6}  5 eq		Gr II (0.025 eq), DCM, 40°, 16 h		408
C_{5-12}  *x* eq		Catalyst (*y* eq), DCM, 40°, 24 h		409
x eq		Catalyst (*y* eq), DCM, 40°, 24 h		409

n	2	3
	(60)	(61)

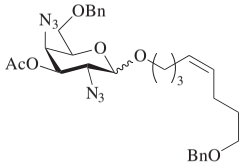
n	*x*	Catalyst	*y*	
2	13	Hov I	0.06	(42)
5	4	Hov II	0.035	(46)
9	4	Hov II	0.03	(67)

n	*x*	Catalyst	*y*	
2	13	Hov I	0.12	(60)
5	4	Hov II	0.4	(69)
9	4	Hov II	0.3	(83)

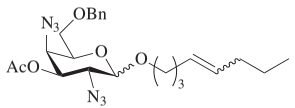
C_5



10 eq

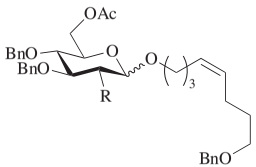


Ru cat **66** (0.1 eq),
DCM, 0°, 10 h

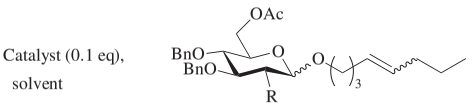


(84)

178



10 eq



Catalyst (0.1 eq),
solvent

178

R	Catalyst	Solvent	Temp (°)	Time (h)	
BnO	Ru cat **66**	DCE	80	12	(73)
N_3	Gr I	DCE	rt	24	(22)
N_3	Gr II	DCE	rt	24	(47)
N_3	Ru cat **66**	DCE	rt	16	(62)
N_3	Ru cat **66**	DCM	0	10	(79)

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

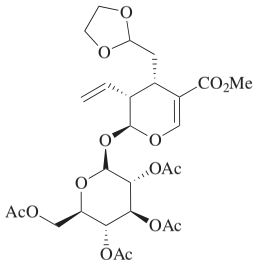
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

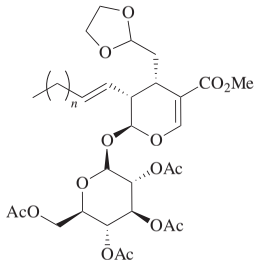
Please refer to the charts preceding the tables for the catalyst structures.

$C_{5–8}$





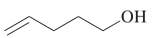
Gr II (0.1 eq), toluene, 100°



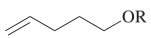
n		(*E*)/(*Z*)
2	(97)	95:5
3	(92)	95:5
5	(90)	95:5

410

C_5



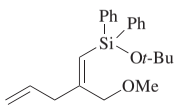
x eq



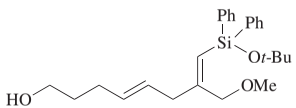
Catalyst (*y* eq), solvent



x	R	Catalyst	*y*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
—	H	Ru cat **217**	0.02	THF	35	1	(72)	28:72	84
2	Ph_3C	Gr II	0.05	DCM	reflux	2	(60)	71:29	182

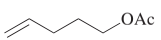


Gr II (0.05 eq), DCM, 40°, 1 h

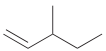


(42) (*E*)/(*Z*) = 75:25

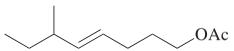
411



3 eq

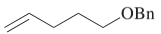


Catalyst (0.05 eq), DCM, reflux, 6 h

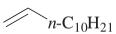


(*E*)/(*Z*) = 95:5

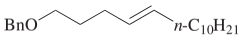
Catalyst		
Hov II	(85)	177
Ru cat **271**	(98)	



10 eq

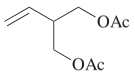


Gr I (0.05 eq), DCM, reflux, 4 h

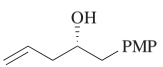


(85) (*E*)/(*Z*) = 75:25

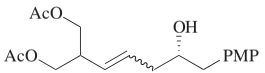
412



2 eq

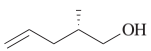


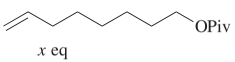
Hov II (0.05 eq), DCM, rt, 24 h



(67)

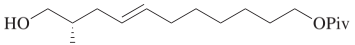
413





x eq

Gr II (*y* eq), DCM

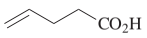
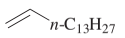
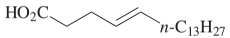
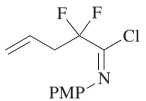
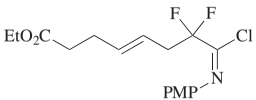
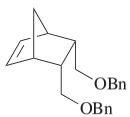
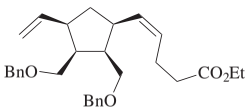
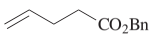
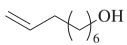
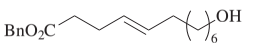


414

x	*y*	Temp (°)	Time (h)		(*E*)/(*Z*)
3	0.05	25	12	(60)	82:18
1	0.05	25	12	(33)	83:17
3	0.05	40	12	(55)	50:50
3	0.01	25	36	(40)	93:7
5	3 × 0.005	25	168	(68)	94:6

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
	 5 eq	Gr II (0.05 eq), DCM, 40°, 12 h		(95) (*E*)/(*Z*) = 95:5	415
2 eq		Gr II (0.1 eq), DCM, reflux, 3 h		(70) (*E*)/(*Z*) = 75:25	392
7 eq		Ru cat **215** (0.01 eq), THF, 23°, 1 h	 (65) er 95.5:4.5, (*Z*)/(*E*) = 95:5		417
 3 eq		1. Ru cat **355** (0.075 eq), (*E*)-butene (75 eq), THF, 22°, 1 h 2. Ru cat **355** (0.05 eq), THF, 100 torr, 22°, 4 h		(66) (*E*)/(*Z*) = 95:5	395

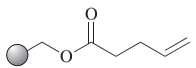
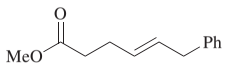
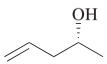
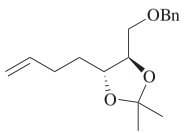
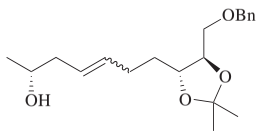
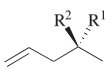
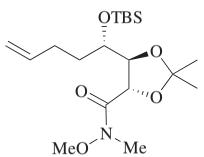
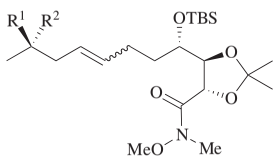
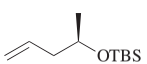
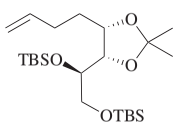
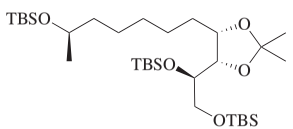
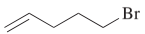
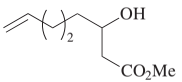
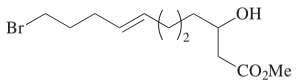
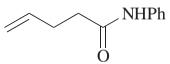
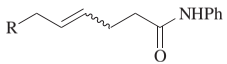
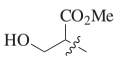
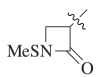
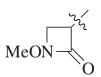
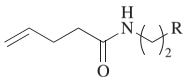
	 5 eq	1. Gr II (0.05 eq), DCM, reflux, 20 h 2. TFA (0.1 eq), DCM, 1 h 3. CH_2N_2, DCM, 0°, 0.5 h		(18) (*E*) only	418
 1.5 eq		Gr II (0.05 eq), DCM, 40°, 22 h		(64)	419
 1.5 eq		Gr II (0.055 eq), DCM, 40°, 7 h		R¹ R² H HO (69) HO H (64)	420
		1. Gr II (0.05 eq), toluene, 110°, 6 h 2. Pd/C (0.05 eq), H_2, EtOH, rt, 2 h		(42)	421

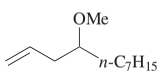
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
 5 eq		Ru cat **35** (0.02 eq), DCM, reflux, 4–12 h	 (83) (*E*)/(*Z*) = 90:10	393
 *x* eq		Gr II (0.05 eq), DCM, reflux		422

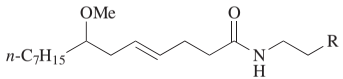
x	R	Time (h)	
2.5		20	(47)
2.15		12	(58)
2.5		4	(37)
2.5		20	(44)





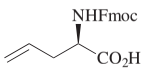
5 eq

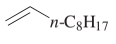
Gr II (0.05 eq),
DCM, reflux



416

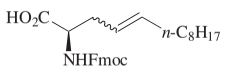
R		(*E*)/(*Z*)
Ph	(54)	95:5
3-indolyl	(44)	95:5





x eq

Catalyst (0.05 eq),
solvent, overnight

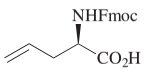
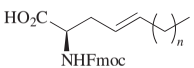
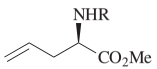
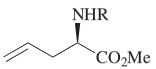
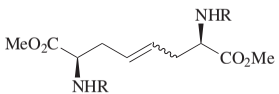
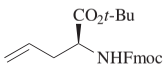
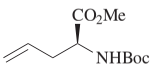
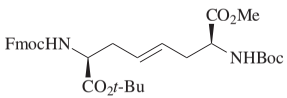


127

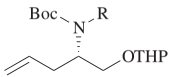
x	Catalyst	Solvent	Temp	Conv. (%)[a]
5	Hov II	DCM	reflux	93
5	Hov II	EtOAc	reflux	90
5	Hov II	DCM	rt	66
5	Gr II	EtOAc	rt	52
5	Hov II	EtOAc	rt	62
5	Hov II	DCM	rt	52
1	Hov II	DCM	rt	32
2	Hov II	DCM	rt	65
10	Hov II	DCM	rt	70
5	Hov II	DCM	rt	87

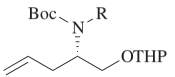
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

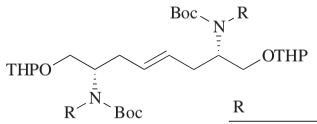
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
	 5 eq	1. Hov II (0.05 eq), DCM, rt 2. H_2 (60 psi), MeOH		127
			n (%): 2 (65); 3 (81); 4 (73); 5 (76); 6 (80); 7 (75)	
		Gr II (0.1 eq), DCM, rt, 2.5 h		423
			R (%): Boc (76); Fmoc (86)	
	 1.1 eq	Gr II (*x* eq), DCM		331

x	Temp	Time (h)	
0.1	reflux	6.5	(57)
0.1	MW	—	(36)
0.05	reflux	6.5	(46)



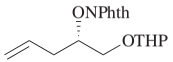


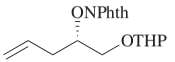
Gr I (0.05 eq)
DCM, 40°, 48 h



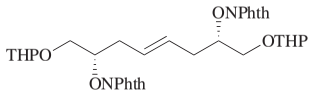
R		(*E*)/(*Z*)
BocHN	(80)	55:45
(*o*-NB)O	(94)	55:45

424



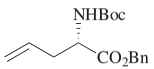


Gr I (0.05 eq)
DCM, 40°, 48 h

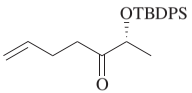


(80) (*E*)/(*Z*) = 60:40

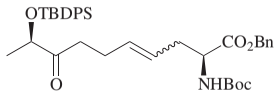
424



3 eq

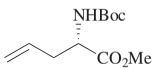


Gr II (0.05 eq),
DCM, rt, 7 d

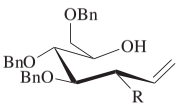


(55)

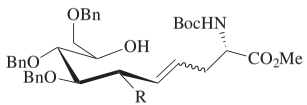
425



x eq



Gr II (*y* eq),
DCM, reflux



426

x	R	*y*	Time (h)	
0.5	HO	0.15	15	(48)
1	HO	0.15	15	(45)
2	HO	0.15	15	(54)
4	HO	0.15	15	(70)
2	AcHN	0.2	16	(16)

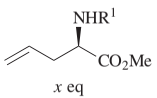
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

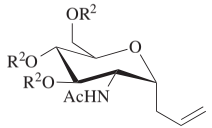
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

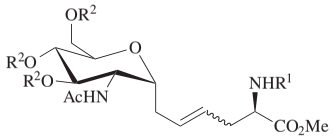
C_5



x eq

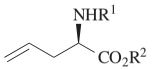


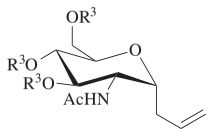
Catalyst (*y* eq),
DCM, reflux



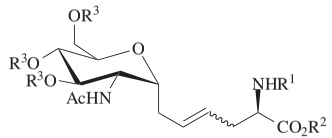
427

R^1	*x*	R^2	Catalyst	*y*	Time (h)	
Fmoc	2	Ac	Gr I	0.2	24	(0)
Fmoc	2	Ac	Gr II	0.2	48	(65)
Fmoc	3	Ac	Gr II	0.2	48	(70)
Boc	2	Ac	Gr II	0.2	48	(60)
Fmoc	2	Bn	Gr I	0.2	22	(41)
Boc	2	Bn	Gr I	0.2	12	(50)
Fmoc	2	Bn	Gr II	0.1	16	(74)
Boc	2	Bn	Gr II	0.1	16	(78)
Fmoc	1	Bn	Gr II	0.1	16	(49)



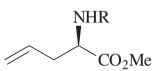


Gr II (*x* eq),
DCM, rt

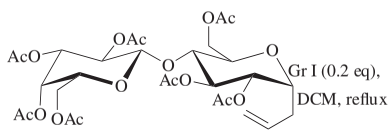


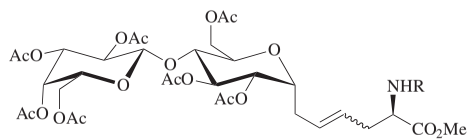
423

R^1	R^2	R^3	*x*	Time (h)	
Fmoc	Me	Bn	0.1	24	(74)
Boc	Me	Bn	0.1	24	(78)
Fmoc	Me	Ac	0.2	48	(70)
Boc	Me	Ac	0.2	48	(60)
Cbz	Bn	Ac	0.2	48	(70)



2 eq



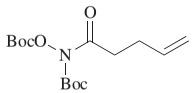
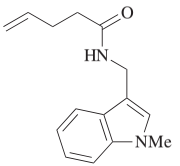
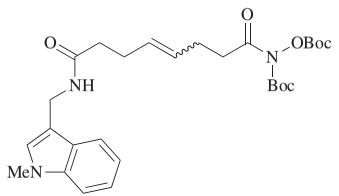
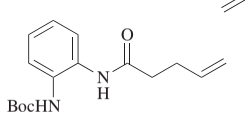
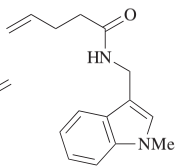
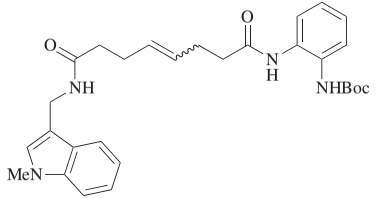
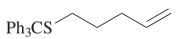
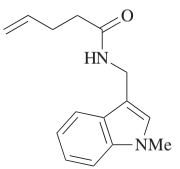
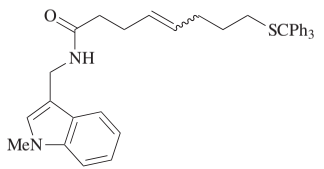
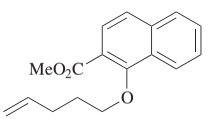
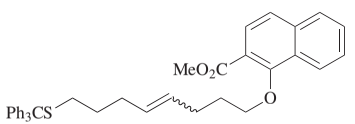


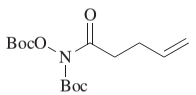
427

R	Time (h)	
Fmoc	48	(57)
Boc	24	(73)

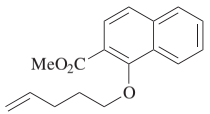
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS
(*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

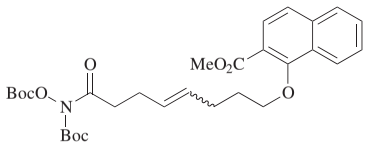
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
 2 eq		Gr I (0.15 eq), DCM, reflux, 7 h	 (43)	428
 1 eq		Gr II (0.15 eq), DCM, reflux, 7 h	 (27)	428
 2 eq		Gr I (0.36 eq), DCM, reflux, 7 h	 (32)	428
2 eq		Gr I (0.36 eq), DCM, reflux, 7 h	 (48)	428



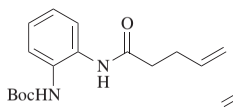
2 eq



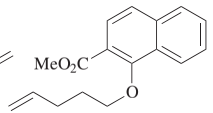
Gr I (0.15 eq),
DCM, reflux, 7 h



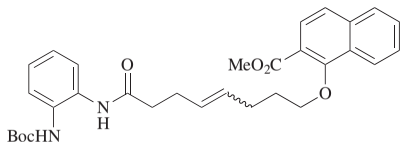
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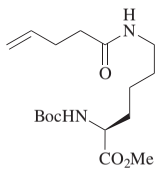
1 eq

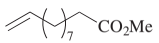


Gr II (0.17 eq),
DCM, reflux, 7 h



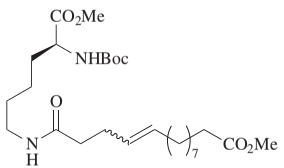
(36) 428





3 eq

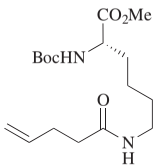
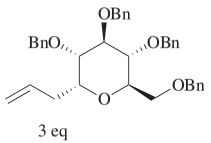
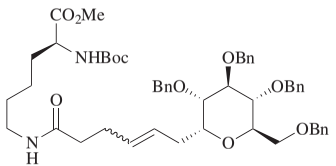
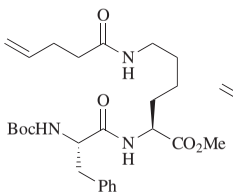
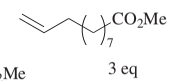
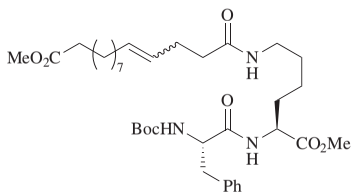
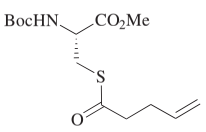
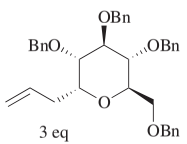
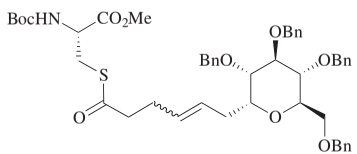
Gr II (0.2 eq),
DCM, 40°, 6 h

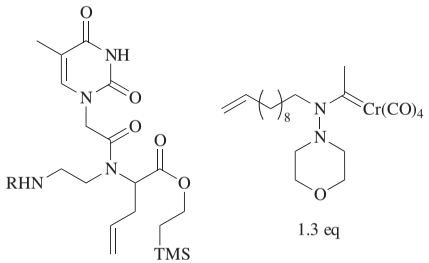


(45) 429

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

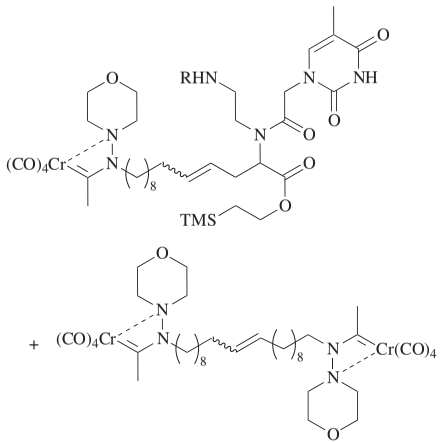
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
	 3 eq	Gr II (0.2 eq), DCM, 40°, 6 h	 (33)	429
	 3 eq	Gr II (0.2 eq), DCM, 40°, 6 h	 (39)	429
	 3 eq	Gr II (0.2 eq), DCM, 40°, 6 h	 (43)	429



1.3 eq

Catalyst (0.1 eq),
DCM, reflux, 23 h



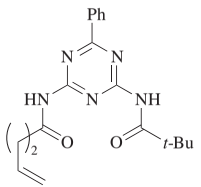
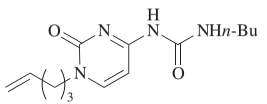
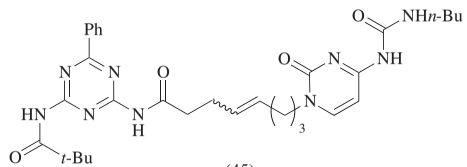
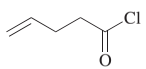
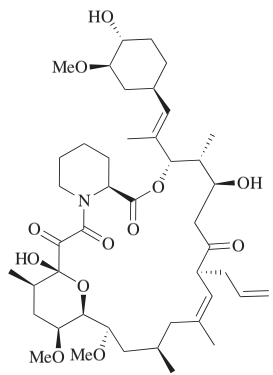
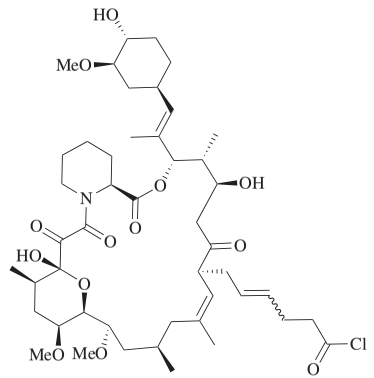
(26–77)

R	Catalyst	
Fmoc	Gr I	(34)
Fmoc	Gr II	(40)
Phth	Gr I	(25)
Phth	Gr II	(35)

430

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
		Gr II, DCM, reflux	 (45)	431
 20 eq		Gr II (0.1 eq), DCB, MW	 (25)	432

C_6





Catalyst (0.02 eq), benzene, 24 h



433

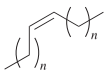
Catalyst	Temp (°)	Conv. (%)[a]
Ru cat **230**	25	<5
Ru cat **230**	40	5
Ru cat **230**	50	11
Ru cat **230**	60	35
Ru cat **230**	85	90
Ru cat **226**	85	41

C_{6-8}





Ru cat **217** (0.02 eq), THF, 35°, sealed tube



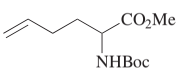
n	Time (h)		(*Z*)/(*E*)
3	3	(21)	69:31
5	4	(79)	83:17

84

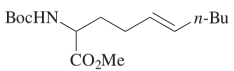
C_6



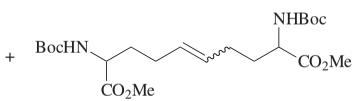
2 eq



Gr I (0.05 eq), DCE, rt, 30 h



(55) (*E*)/(*Z*) = 80:20

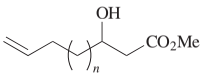
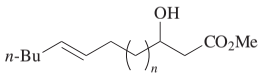
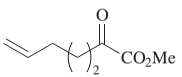
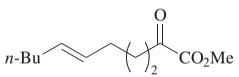
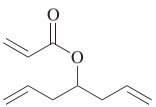
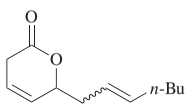
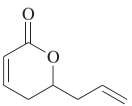
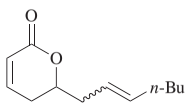


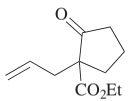
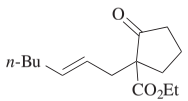
(43)

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TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6				
 5 eq		Ru cat **35** (0.02 eq), DCM, reflux, 4–12 h		*n* (1) 70 (2) 82 (*E*)/(*Z*) 90:10 90:10	393
5 eq		Ru cat **35** (0.02 eq), DCM, reflux, 4–12 h		(78) (*E*)/(*Z*) = 95:5	393
5 eq		Gr II (0.025 eq), DCM, 40°, 16 h	 (21)		394
5 eq		Gr II (0.025 eq), DCM, 40°, 16 h	 (61)		408

2 eq		Gr II (0.02 eq), neat		435

Temp (°)	Time (min)		(*E*)/(*Z*)
90	960	(50)	80:20
60 (MW)	1.25	(68)	80:20

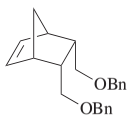
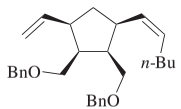
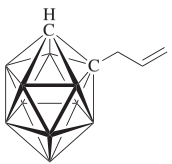
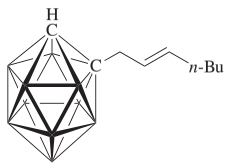
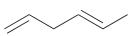
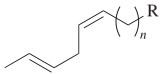
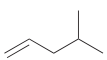
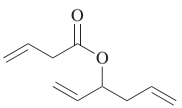
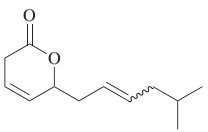
7 eq		Ru cat **215** (0.01 eq), THF, 23°, 1 h	 (62) er 94.5:5.5, (*Z*)/(*E*) = 95:5	417
13 eq		Hov II (0.005 eq), DCM, reflux, 14 h	 (88) (*E*)/(*Z*) = 88:12	436

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6				
 9 eq		Catalyst (*x* eq), THF, rt, 5 h		437

R	*n*	Catalyst	*x*		(*Z*)/(*E*)
Ph	1	Ru cat **216**	0.01	(63)	>95:5
Ac	2	Ru cat **216**	0.01	(49)	>95:5
HO	7	Ru cat **215**	0.01	(87)	89:11
HO	7	Ru cat **216**	0.01	(80)	>95:5
HO	7	Ru cat **216**	0.005	(77)	>95:5
HO	7	Ru cat **216**	0.001	(50)	>95:5
HO	7	Hov II	0.01	(<5)	—
HO	7	Hov I	0.01	(28)	29:71
MeO_2C	7	Ru cat **216**	0.01	(82)	>95:5
OHC	8	Ru cat **216**	0.01	(70)	>95:5

		Gr II (0.025 eq), DCM, 40°, 16 h	 (61)	394

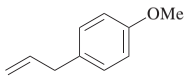
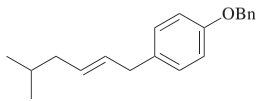
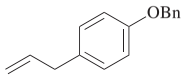
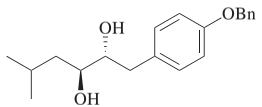
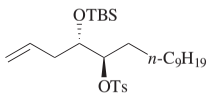
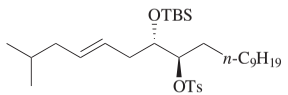
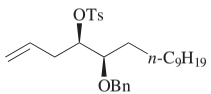
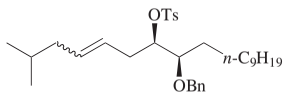
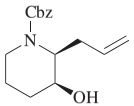
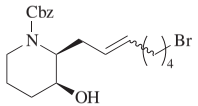
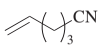
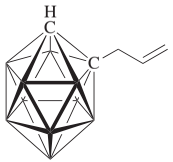
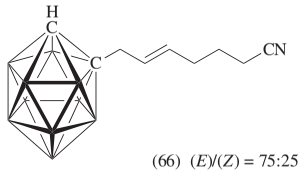
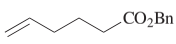
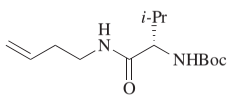
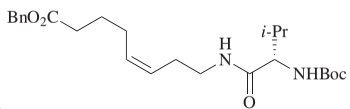
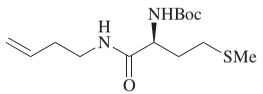
5 eq		1. Gr II (0.025 eq), 2,6-Cl_2BQ (0.1 eq), DCM, 40°, 3 h 2. BBr_3, DCM, 0°, 0.5 h 3. BnBr (1.1 eq), K_2CO_3 (4 eq), acetone, reflux, 6 h		(64) (*E*)/(Z) = 88:12	438
3 eq		1. Ru cat **215** (0.025 eq), THF, reflux, 6 h 2. OsO_4, NMO (2 eq), THF/H_2O (99:1), 5 h		(6) dr > 98:2	438
5 eq		Gr II (0.05 eq), DCM, reflux, 5 h		(84) (*E*)/(*Z*) = 83:17	439
5 eq		Gr II (0.05 eq), DCM, reflux, 8 h		(92)	440

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

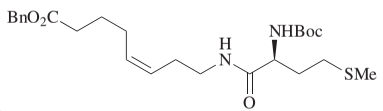
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6				
 2 eq		Gr II (0.1 eq) DCM, reflux, overnight	 (53)	441
 17.5 eq		Hov II (0.025 eq), DCM, reflux, 14 h	 (66) (*E*)/(*Z*) = 75:25	436
 3 eq		1. Ru cat **152** (0.01 eq), (*Z*)-butene (20 eq), THF, 22°, 16 h 2. Ru cat **152** (0.04 eq), THF, 100 torr, 22°, 8 h	 (47) (*Z*)/(*E*) = 91:9	395

3 eq

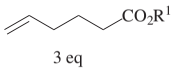


1. Ru cat **152** (0.01 eq), (*Z*)-butene (20 eq), THF, 22°, 16 h
2. Ru cat **152** (0.04 eq), THF, 100 torr, 22°, 8 h

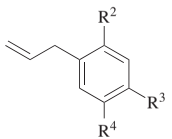


(51) (*Z*)/(*E*) > 98:2

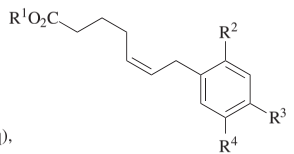
395



3 eq

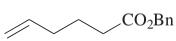


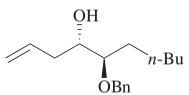
1. Ru cat **152** (0.01 eq), (*Z*)-butene (20 eq), THF, 22°, 1 h
2. Ru cat **152** (0.04 eq), THF, 100 torr, 22°, 8 h



R^1	R^2	R^3	R^4		(*Z*)/(*E*)
H	H	MeO	MeO	(64)	98:2
Bn	HO	H	Ac	(63)	97:3

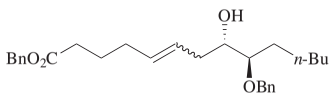
395





5 eq

Gr II (0.15 eq), DCM, rt, 16 h

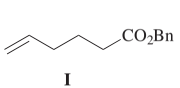
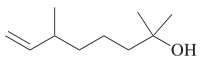
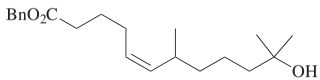
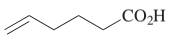
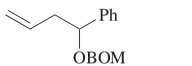
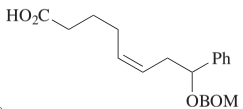
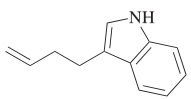
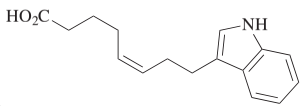


(70)

442

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6				
 **I**		1. Ru cat **152** (0.01 eq), (*Z*)-butene (20 eq), THF, 22°, 1 h 2. Ru cat **152** (0.04 eq), **I** (3 eq), THF, 100 torr, 22°, 8 h	 (58) (*Z*)/(*E*) = 98:2	395
 3 eq		1. Ru cat **152** (0.01 eq), (*Z*)-butene (20 eq), THF, 22°, 1 h 2. Ru cat **152** (0.04 eq), THF, 100 torr, 22°, 8 h	 (64) (*Z*)/(*E*) > 98:2	395
3 eq		1. Ru cat **152** (0.01 eq), (*Z*)-butene (20 eq), THF, 22°, 1 h 2. Ru cat **152** (0.04 eq), THF, 100 torr, 22°, 8 h	 (58) (*Z*)/(*E*) > 98:2	395

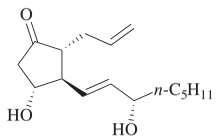
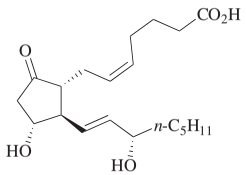
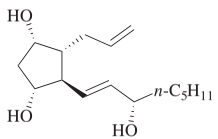
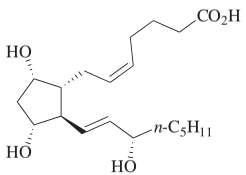
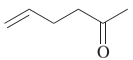
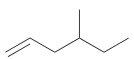
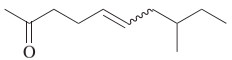
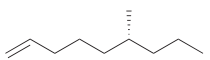
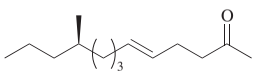
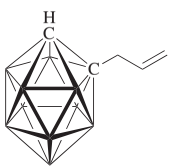
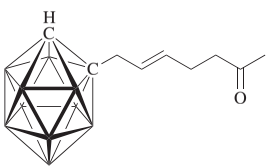
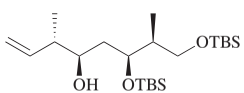
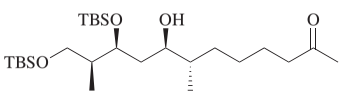
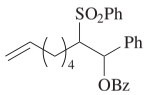
I		1'. Ru cat **152** (0.02 eq), (*Z*)-butene (20 eq), THF, 22°, 16 h 1". Ru cat **152** (0.01 eq), **I** (3 eq), (*Z*)-butene (20 eq), THF, 22°, 1 h 2. Ru cat **152** (0.15 eq), THF, 100 torr, 22°, 1 h 3. 400 torr, 7 h		(51) (*Z*)/(*E*) > 98:2	395
I		1'. Ru cat **152** (0.02 eq), (*Z*)-butene (20 eq), THF, 22°, 16 h 1". Ru cat **152** (0.01 eq), **I** (3 eq), (*Z*)-butene (20 eq), THF, 22°, 1 h 2. Ru cat **152** (0.15 eq), THF, 100 torr, 22°,1 h 3. 400 torr, 7 h		(59) (*Z*)/(*E*) > 98:2	395

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

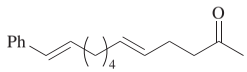
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6				
 3 eq		Gr I (0.01 eq), DCM, reflux, 5 h	 (24)	443
6 eq		Gr I (0.1 eq), DCM, reflux, 9.5 h	 (73) (*E*)/(*Z*) = 66:34	444
8.3 eq		Hov II (0.025 eq), DCM, reflux, 18 h	 (69) (*E*)/(*Z*) = 95:5	436
2 eq		1. Hov II (0.2 eq), DCM, reflux, 20 h 2. H_2, Pd/C, AcOEt, rt	 (64)	162

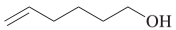
10 eq

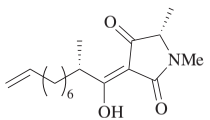


1. Gr II (0.1 eq), toluene, 60°, 12 h
2. SmI_2 (3 eq), THF/DMPU (4:1), –78°, 1 h

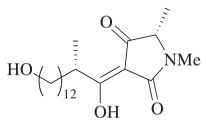


(70) (*E,E*)/(*Z,E*) = 88:12 445



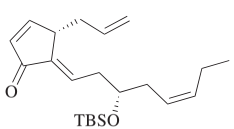


1. Gr II (0.015 eq), DCM, reflux, 6 h
2. H_2, Pd/C, MeOH

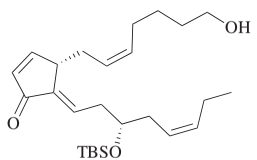


(28) 248

8 eq

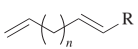


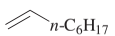
Ru cat **216** (0.2 eq), THF, 40°, 4 h



(52) (*Z*)/(*E*) > 99:1 446

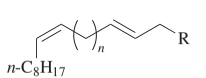
$C_{6–13}$





9 eq

Ru cat **216** (0.01 eq), THF, rt, 5 h

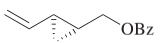
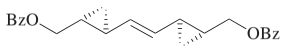
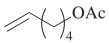
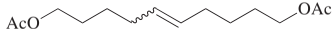


437

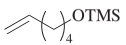
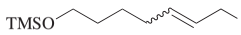
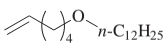
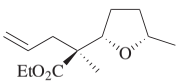
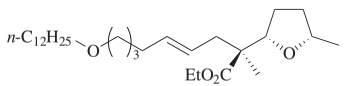
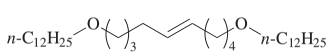
R	*n*		(*Z*)/(*E*)
$HOCH_2$	1	(<5)	—
$BzOCH_2$	1	(<5)	—
$HOCH_2$	2	(51)	>95:5
MeO_2C	8	(80)	>95:5
$HOCH_2$	8	(60)	>95:5

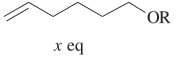
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

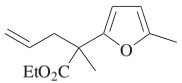
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6				
		Gr I (0.2 eq), DCM, reflux, 12 h	 (64) (*E*)/(*Z*) = 92:8	447
		Catalyst (*x* eq), solvent		

Catalyst	*x*	Solvent	Temp (°)	Time (h)	Conv. (%)[a]	
Ru cat **230**	0.02	benzene	85	22	62	433
Ru cat **150**	0.0007	toluene	30	0.5	28	448
Ru cat **150**	0.0007	toluene	30	1	57	448
Ru cat **150**	0.0007	toluene	30	5	69	448

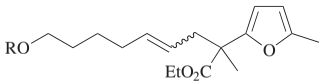
		Ru cat **162** (0.02 eq), toluene, 80°, 1 h	 (79)	449
 1.21 eq		Gr I (0.24 eq), DCE, reflux, 62 h	 (46) (*E*)/(*Z*) = 75:25 +  (42) (*E*)/(*Z*) = 75:25	450



x eq

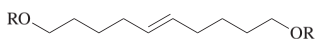


Gr I (0.1 eq),
DCM, reflux, 20 h



I

\+

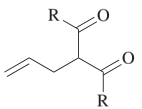


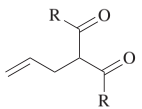
II

450

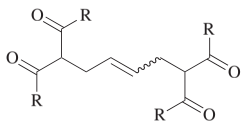
R	*x*	**I**	**II**	(*E*)/(*Z*) **I**
H	1.6	(81)	(—)	65:35
n-$C_{12}H_{25}$	1.2	(54)	(21)	65:35
n-$C_{12}H_{25}$	1	(30)	(3)	65:35

C_{6-18}





Catalyst (0.1 eq),
solvent, 24 h

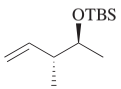
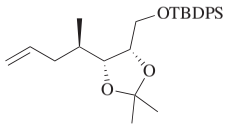
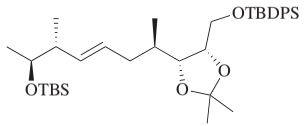


492

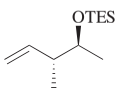
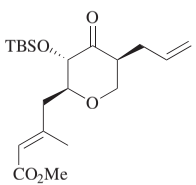
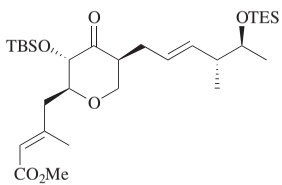
R	Catalyst	Solvent	Temp (°)	Conv. (%)	
EtO	Gr I	DCM	40	69	(—)
EtO	Gr II	DCM	40	95	(—)
EtO	Ru cat **67**	DCM	40	99	(—)
EtO	Hov II	toluene	110	99	(—)
Me	Gr I	DCM	40	37	(—)
Me	Gr II	DCM	40	99	(83)
Me	Gr III	DCM	40	99	(—)
Me	Hov II	benzene	80	85	(—)
Et	Gr II	DCM	40	99	(71)
Ph	Gr II	DCM	40	74	(61)

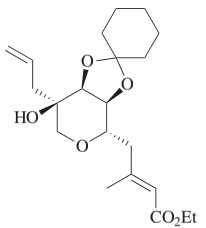
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

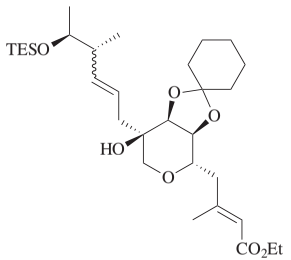
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6				
 6.7 eq		Gr II (*x* eq), solvent, reflux, 24 h		452

x	Solvent		(*E*)/(*Z*)
0.05	DCM	(—)	—
0.15	DCM	(—)	—
0.05	benzene	(71)	—
0.15	benzene	(74)	—
0.05	toluene	(82)	—
0.1	toluene	(90	95:5
0.15	toluene	(90)	95:5

 2 eq		Gr II (0.05 eq), toluene, 50°, 5 h		(56)	(*E*) only	453

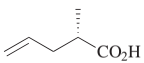


Gr II, toluene, 55°

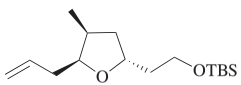


(66)

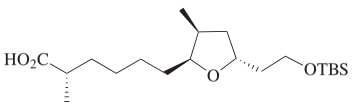
454



4 eq



1. Gr II, DCM, 40°, 5 h
2. Pd/C (0.1 eq), H_2, EtOAc, rt, 1 h

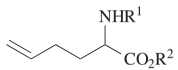
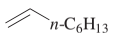
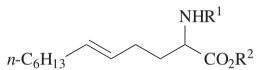
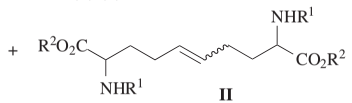
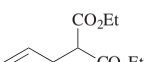
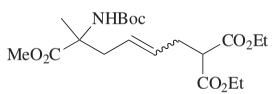
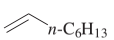


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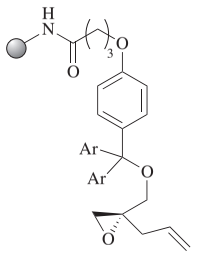
456

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

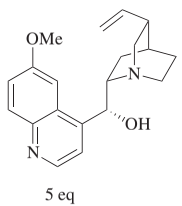
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6				
	 2 eq	Gr I (0.05 eq), DCE, rt, 30 h	 **I** (*E*)/(*Z*) = 80:20 +  **II**	434
	 4 eq	Gr II (0.05 eq), toluene, rt, 17 h	 (55)	457
	 4 eq	Gr II (0.05 eq), toluene, rt, 17 h	 (55)	457

R^1	R^2	**I**	**II**
Fmoc	H	(58)	(18)
Fmoc	Me	(58)	(25)
Boc	*t*-Bu	(66)	(28)

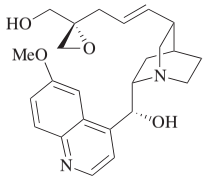


Ar = 4-ClC_6H_4



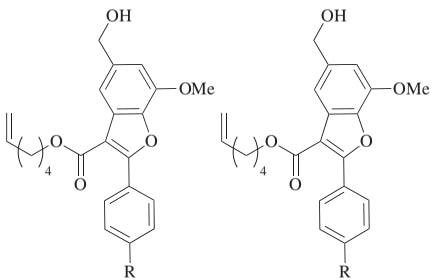
5 eq

1. Hov II (0.05 eq), $Ti(Oi\text{-}Pr)_4$, DCE, rt, 24 h
2. TFA

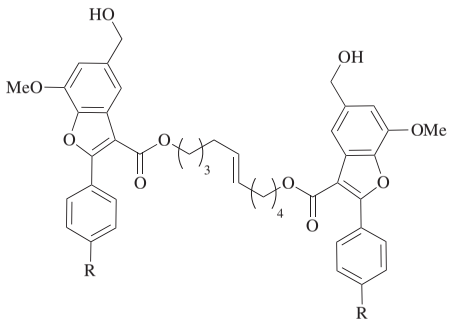


(60)

458



Gr I (0.1 eq), DCM, 40°, 24 h

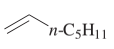
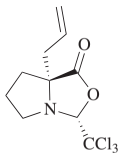
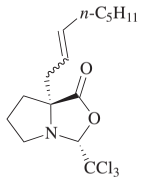
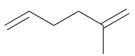
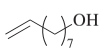
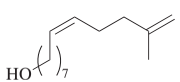
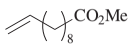
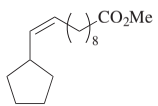


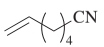
R		(*E*)/(*Z*)
H	(75)	66:34
MeO	(80)	91:9
Me	(80)	91:9
n-Bu	(80)	91:9
t-Bu	(80)	60:40

459

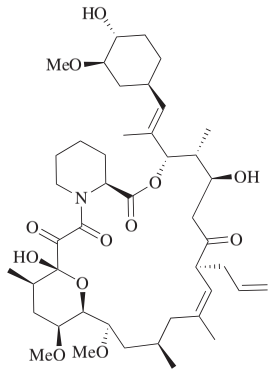
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

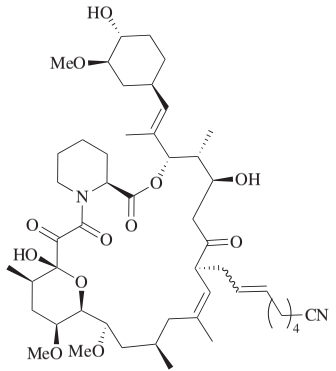
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_7				
 2 eq		Gr II (0.05 eq), DCM, 80° (MW), 20 min	 (74) (*E*)/(*Z*) = 74:26	460
 *x* eq	 *y* eq	Ru cat **216** (0.01 eq), THF, rt, 5 h		437
			x *y* (*Z*)/(*E*) 1 5 (45) >95:5 7 1 (66) >95:5	
	 4 eq	Ru cat **216** (0.02 eq), THF, 20°, 5 h	 (44) (*Z*)/(*E*) = 94:6	461



20 eq

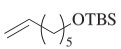


Gr II (0.1 eq),
DCB, MW

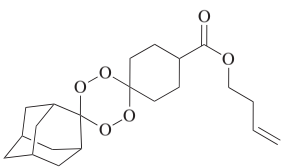


(36)

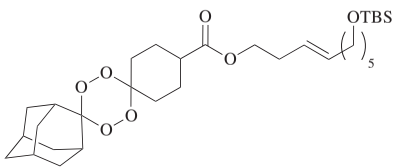
432



3 eq



Ru cat **88** (0.1 eq),
DCM, 45°, 2 h

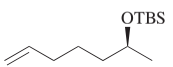
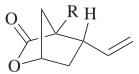
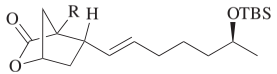
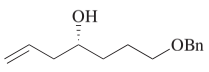
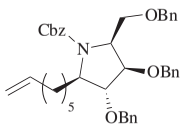
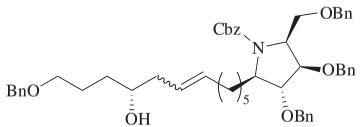
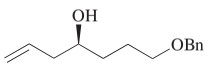
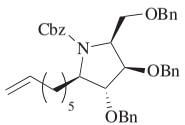
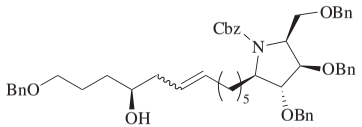


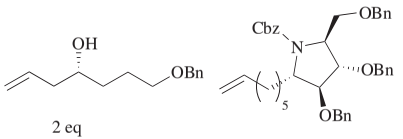
(68) (*E*)/(*Z*) = 89:11

193

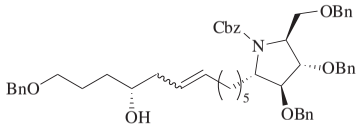
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

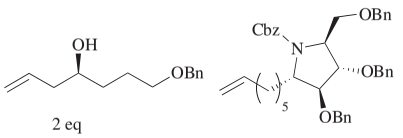
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)		Refs.
Please refer to the charts preceding the tables for the catalyst structures.					
C_7					
		Gr I, DCM, reflux			462
			R / Time (h) / (79) / (*E*)/(*Z*) H / 24 / (79) / 88:12 PhO_2S / 48 / (15) / 83:17		
 2 eq		Gr II (0.01 eq), DCM, reflux, 4 h		(43)	463
 2 eq		Gr II (0.01 eq), DCM, reflux, 4 h		(43)	463



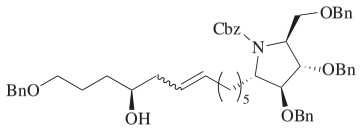
Gr II (0.01 eq),
DCM, reflux, 4 h



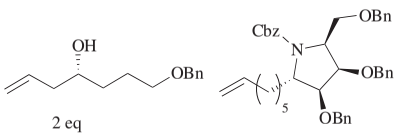
(41) 463



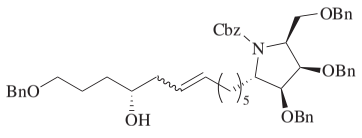
Gr II (0.01 eq),
DCM, reflux, 4 h



(45) 463



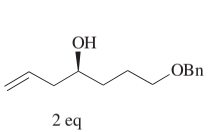
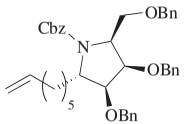
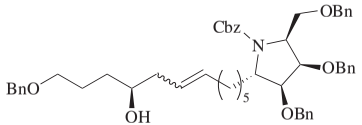
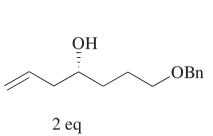
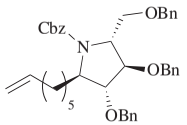
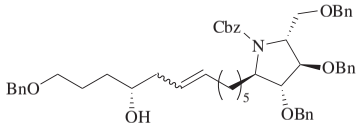
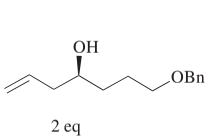
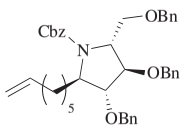
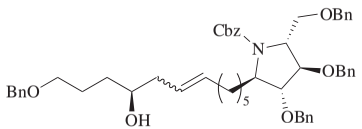
Gr II (0.01 eq),
DCM, reflux, 4 h

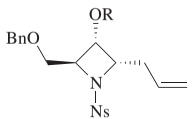


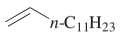
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TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

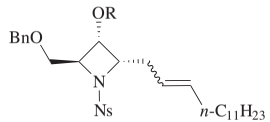
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)		Refs.
Please refer to the charts preceding the tables for the catalyst structures.					
C_7					
 2 eq		Gr II (0.01 eq), DCM, reflux, 4 h		(41)	463
 2 eq		Gr II (0.01 eq), DCM, reflux, 4 h		(43)	463
 2 eq		Gr II (0.01 eq), DCM, reflux, 4 h		(43)	463





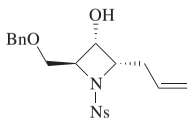
x eq

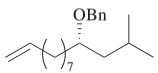
Gr II (*y* eq),
DCM, reflux



464

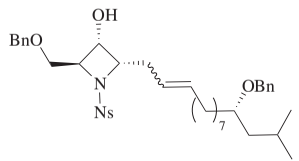
R	*x*	*y*	Time (h)	
H	4	0.05	2	(63)
PMB	12	0.2	48	(<30)





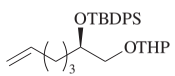
6.15 eq

Gr II (0.05 eq),
DCM, reflux, 3.5 h



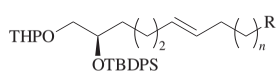
(74)

464





Gr I (0.05 eq),
BQ (0.2 eq),
DCM, 40°

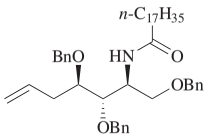
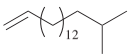
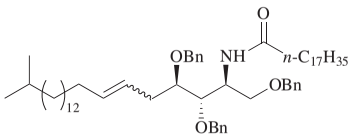
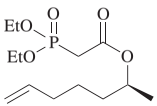
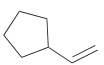
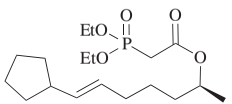
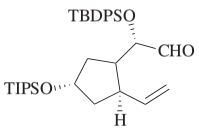
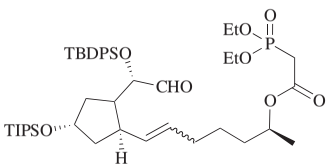


465

n	R	Time (h)		(*E*)/(*Z*)
7	Bn-Gly-C(O)	12	(80)	80:20
8	TBSO	20	(65)	64:36

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

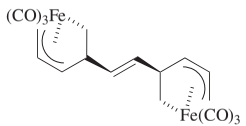
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_7				
	 *x* eq	Gr I (0.05 eq), DCM, reflux, 6 h		466
			x (%): 1 (62); 2 (70); 3 (79); 4 (81)	
 3 eq		Catalyst (0.025 eq), DCM, reflux, 22 h	 (*E*)/(*Z*) = 80:20	467
			Catalyst: Gr I (74); Gr II (44)	
x eq		Catalyst (0.025 eq), DCM, reflux, 22 h		467
			x / Catalyst: 1 / Gr I (17); 0.25 / Gr I (30); 3 / Gr I (20); 4 / Gr I (50); 2 / Gr II (84); 2 / Gr II (100)	



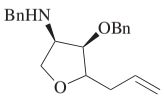


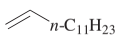
Gr I
(0.05 + 0.05 eq),
DCM, 40°, 20 h



(88)

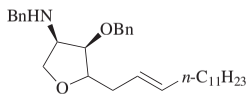
468





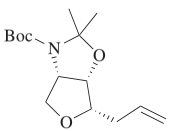
5 eq

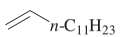
Gr I (0.3 eq),
DCM,
reflux, 12 h



(78)

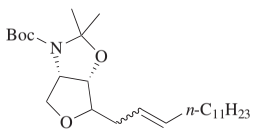
469





2.5 eq

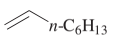
Gr II
(0.05 + 0.03 eq),
DCM, 45°, 8 h

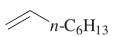


(82)

470

C_8





Ru cat **185** (*x* eq),
BMIM•NTf_2, 50°

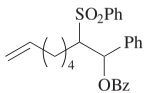
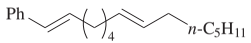
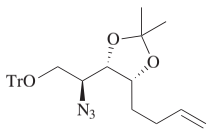
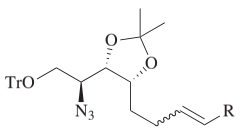
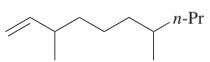
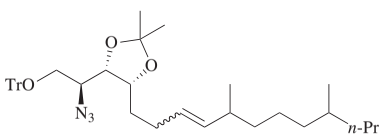


471

x	Flow rate/cm^{-1}	Time (h)	Conv. (%)[c]
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0.024	0.1	5	40

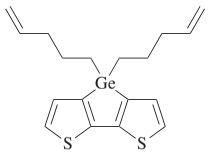
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
10 eq		1. Gr II (0.1 eq), toluene, 60°, 12 h 2. SmI_2 (3 eq), THF/DMPU (4:1), –78°, 1 h	 (80) (*E*,*E*)/(*Z*,*E*) = 91:9	445
	 10 eq	Gr II (0.1 eq), DCM, rt, 18 h	 R: n-C_7H_{15} (57); $Ph(CH_2)_2$ (57); n-$C_{10}H_{21}$ (60); n-$C_{15}H_{31}$ (59)	406
	 10 eq	Gr II (0.1 eq), DCM, rt, 18 h	 (25)	406

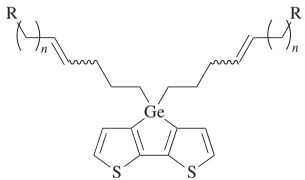
C_{8-15}





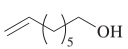
16 eq

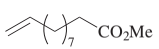
Gr II (0.06 eq),
DCM,
reflux, 24 h



R	*n*		
Br	6	(90)	472
H	9	(90)	
H	13	(92)	

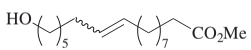
C_8



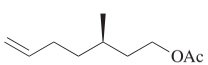


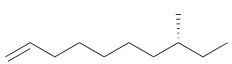
3 eq

Gr II (0.07 eq),
DCM, rt, 24 h



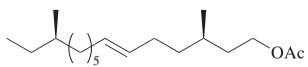
(51) 473





10 eq

Gr I (0.05 eq),
DCM, reflux, 6 h

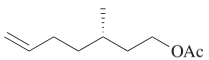
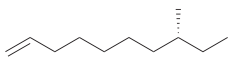
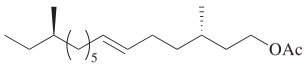
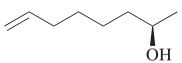
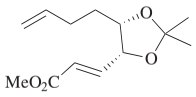
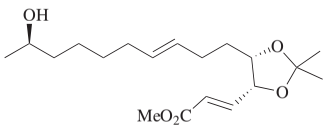
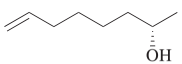
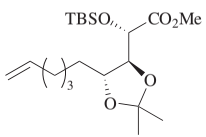
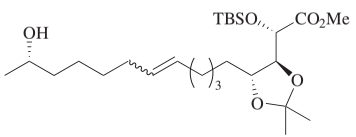


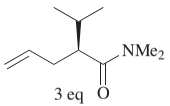
(88) (*E*)/(*Z*) = 83:17

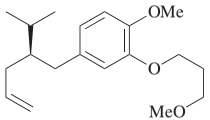
474

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

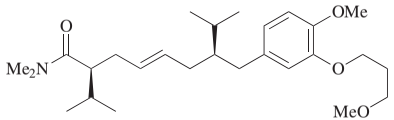
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
	 10 eq	Gr I (0.05 eq), DCM, reflux, 6 h	 (86) (*E*)/(*Z*) = 83:11	474
		Gr I (0.1 eq), DCM, reflux, 16 h	 (75) (*E*)/(*Z*) = 75:25	475
 2 eq		Gr II (0.1 eq), DCM, reflux, 15 h	 (71)	476





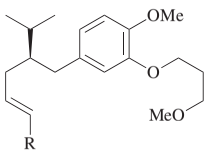
Catalyst (0.05 eq),
solvent,
reflux, 24 h



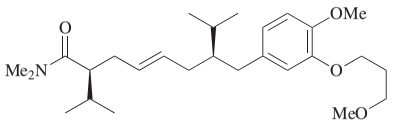
477

Catalyst	Solvent		(*E*)/(*Z*)
Gr I	DCM	(18)	—
Gr II	DCM	(76)	76:24
Gr II	*n*-hexane	(66)	84:16
Hov II	DCM	(65)	77:23
Hov II	*n*-hexane	(56)	77:23
Gr II	PE	(66)	85:15
Gr II	toluene	(53)	81:19
Gr II	DCE	(30)	—
Gr II	cyclohexane	(28)	—

4 eq



Catalyst (0.05 eq),
BQ (0.5 eq)
PE, reflux, 24 h

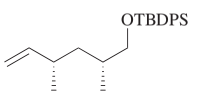
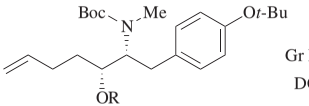
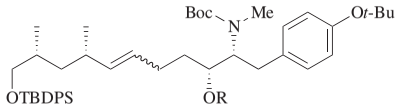
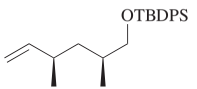
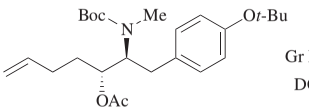
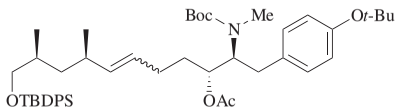
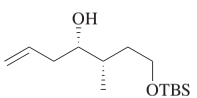
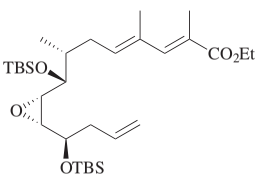
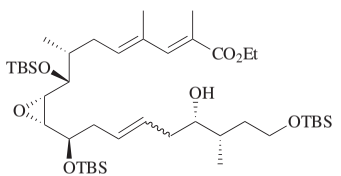
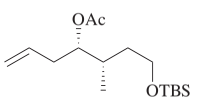
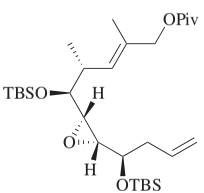
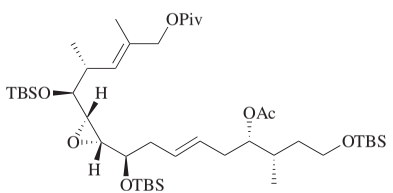


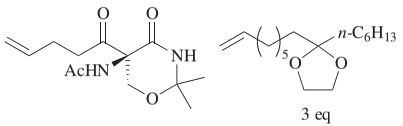
477

R	Catalyst		(*E*)/(*Z*)
H	Hov II	(88)	79:21
H	Gr II	(72)	81:19
Me	Hov II	(72)	82:18
Me	Gr II	(78)	81:19

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

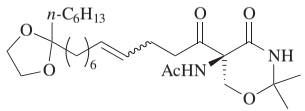
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
 2 eq		Gr II (0.05 eq), DCM, 40°, 19 h	 R: H (<25); Ac (89)	478
 2 eq		Gr II (0.05 eq), DCM, 40°, 19 h	 (88)	478
 1.3 eq		Gr II (0.019 eq), DCM, 40°, 8 h	 (65)	479
 3 eq		Ru cat **35** (0.05 eq), DCM, 40°	 (78) (*E*)/(*Z*) = 87:13	480



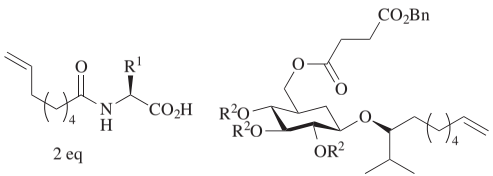
3 eq

Catalyst (0.2 eq),
DCM, reflux



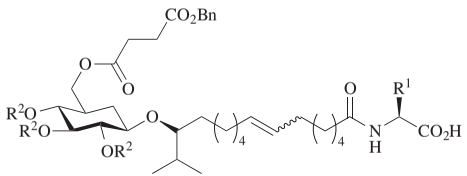
Catalyst	Time (h)	
Gr I	24	(62)
Gr II	18	(46)
Hov I	24	(54)
Hov II	18	(46)

508



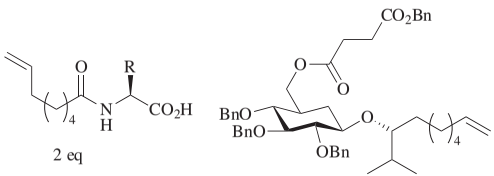
2 eq

Gr II (0.05 eq),
BQ (0.2 eq),
DCM, reflux, 5 h



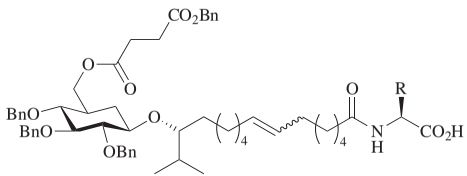
R^1	R^2	
H	Bn	(85)
H	Bz	(85)
Me	Bn	(86)
Me	Bz	(84)

481



2 eq

Gr II (0.05 eq),
BQ (0.2 eq),
DCM, reflux, 5 h

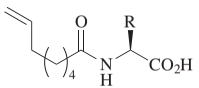
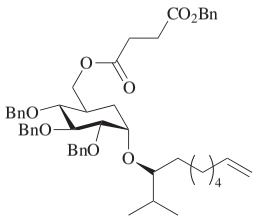
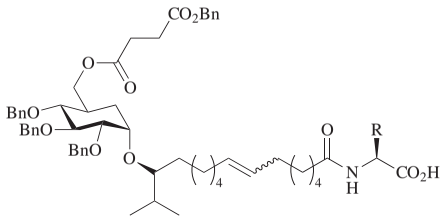
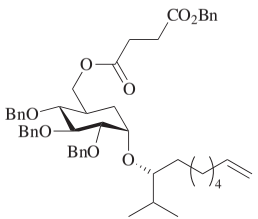
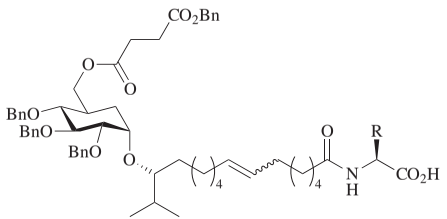


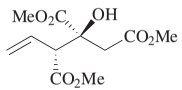
R	
H	(87)
Me	(85)

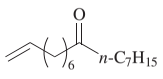
481

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

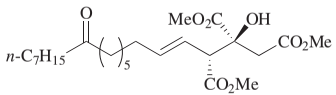
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
 2.08 eq		Gr II (0.05 eq), BQ (0.02 eq) DCM, reflux, 5 h	 R: H (84); Me (82)	482
2.08 eq		Gr II (0.05 eq), BQ (0.02 eq) DCM, reflux, 5 h	 R: H (85); Me (84)	482



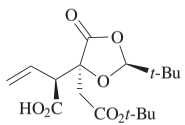


Gr II (0.2 eq), toluene, 80°

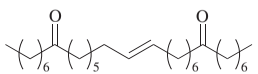


(62) (*E*) only, *syn*/*anti* = 7:1

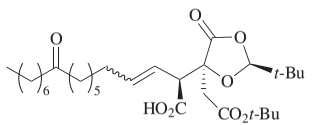
483



2 eq

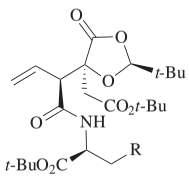


Ru cat **88** (0.2 eq), DCM, 55° (MW), 1 h

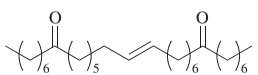


(57)

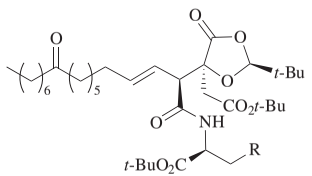
483



2 eq



Ru cat **88** (0.2 eq), DCM, 65° (MW), 4 h



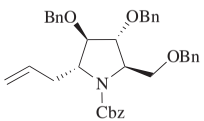
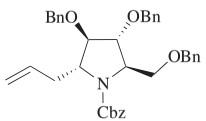
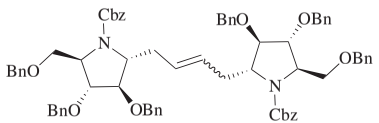
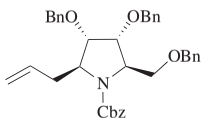
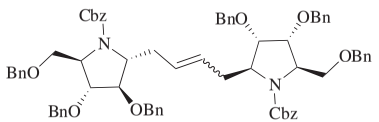
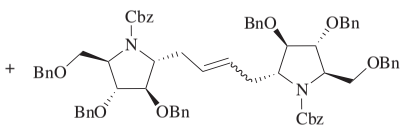
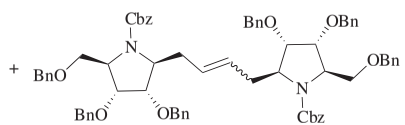
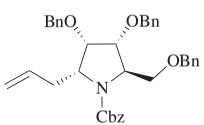
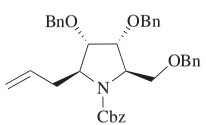
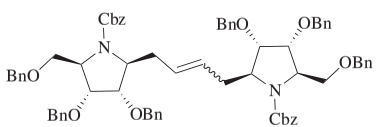
R	
4-*t*-BuC_6H_4	(87)
Ph	(96)
3-indolyl	(92)

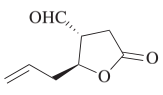
(*E*) only

483

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

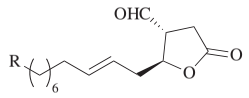
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
		Hov II (0.05 eq), DCM, rt, overnight	 (54)	484
		Hov II (0.05 eq), DCM, rt, overnight	 (12) +  (20) +  (20)	484
		Hov II (0.05 eq), DCM, rt, overnight	 (42)	484





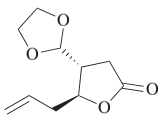
x eq

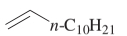
Gr II (*y* eq),
DCM, reflux



(*E*)/(*Z*) = 88:12, dr 95:5 249

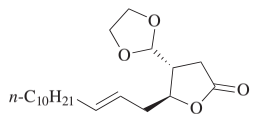
R	*x*	*y*	Time (h)	
Me	4	0.05	30	(53)
$MeO_2C(CH_2)_4$	1.3	0.027	24	(38)





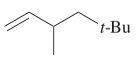
1.5 eq

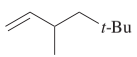
Gr I (0.05 eq),
DCM, reflux, 18 h



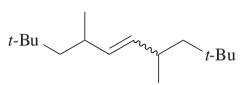
(57) (*E*)/(*Z*) = 78:22, dr 95:5 249

C_9



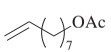


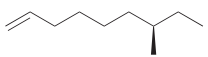
Ru cat **230**
(0.02 eq),
benzene, 22 h



Temp (°)	Conv. (%)[a]
25	0
85	3

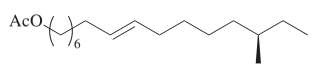
433





1.4 eq

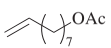
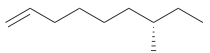
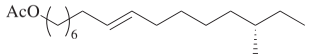
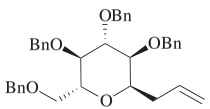
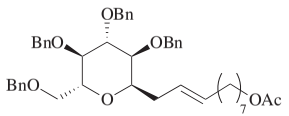
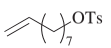
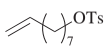
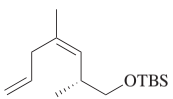
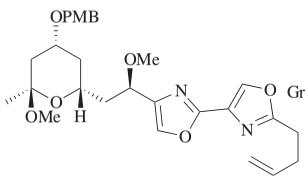
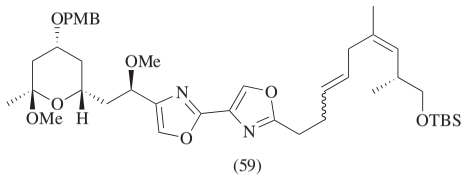
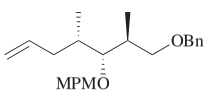
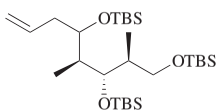
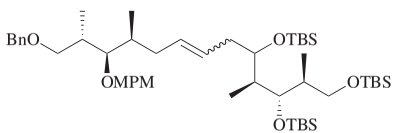
Gr I (0.0.12 eq),
DCM, reflux, 6 h

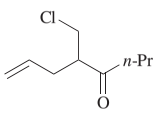


(56) (*E*)/(*Z*) = 80:20 485

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS
(*Continued*)

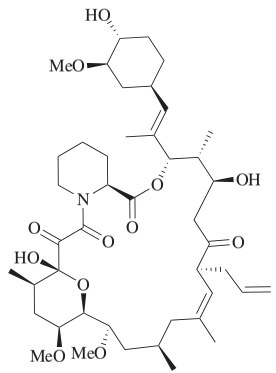
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
	 1.4 eq	Gr II (0.012 eq), DCM, reflux, 7 h	 (47) (*E*)/(*Z*) = 80:20	485
	 2 eq	Gr I (0.05 eq), DCM, 45°, 4 h	 (73) (*E*)/(*Z*) = 74:26	124
		Gr II (0.075 eq), DCM, 20°, 16 h	 (79)	403
 3.2 eq		Gr II, DCM, 60°	 (59)	486
 2 eq		Gr II (0.1 eq), DCM, rt, 36 h	 (50)	487



20 eq

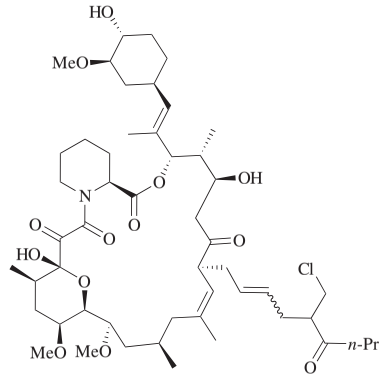


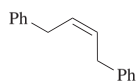




Gr II (0.1 eq), DCB, MW

Catalyst (x eq), solvent





(44) 432

Catalyst	x	Solvent	Temp (°)	Time (h)	Conv. (%)[a]		(Z)/(E)	
Ru cat **217**	0.02	THF	70	6	>95	(—)	83:17	84
Ru cat **217**	0.02	MeCN	70	2.5	12	(—)	95:5	84
Ru cat **217**	0.02	THF	35	1	>95	(81)	92:8	84
Ru cat **217**	0.001	THF	35	3	—	(73)	86:14	488
Ru cat **215**	0.001	THF	35	3	—	(89)	92:8	488
Gr I	0.05	DCM	40	12	—	(82)	20:80	156

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

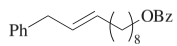
C_9



2 eq



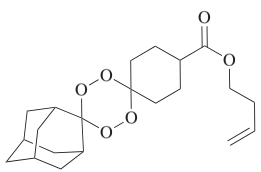
Catalyst (*x* eq), DCM



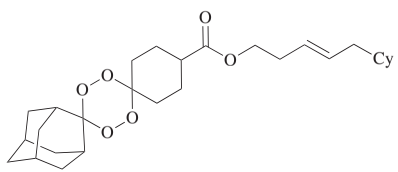
Catalyst	*x*	Temp	Time (h)	Conv (%)[a]		(*E*)/(*Z*)	
Ind II	0.01	rt	2.5	14	(—)	60:40	489
Ru cat **282**	0.01	rt	2.5	8	(—)	57:43	489
Ru cat **284**	0.01	rt	20	0	(—)	—	489
Ru cat **283**	0.01	rt	20	0	(—)	—	489
Ru cat **285**	0.01	rt	2.5	30	(—)	73:27	489
Ru cat **286**	0.01	rt	2.5	12	(—)	78:22	489
Gr I	0.05	45°	4	69	(68)	79:21	124



3 eq



Ru cat **88** (0.05 eq)
DCM, 45°, 2 h

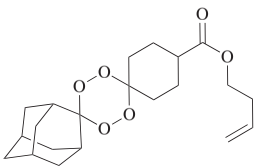


(87) (*E*)/(*Z*) = 80:20

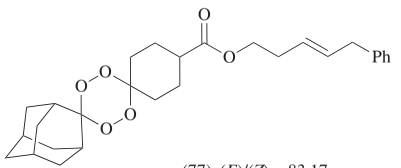
193



3 eq

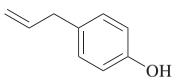


Ru cat **88** (0.05 eq)
DCM, 45°, 2 h

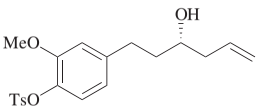


(77) (*E*)/(*Z*) = 83:17

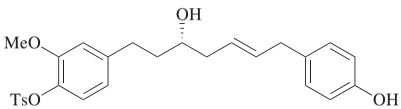
193



5 eq

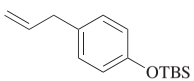


Gr II (0.05 eq),
DCM, 40°, 2 h

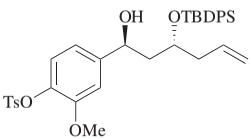


(81) (*E*)/(*Z*) = 90:10

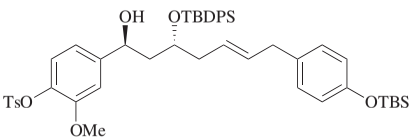
490



2 eq

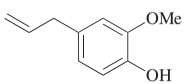


Gr II (0.05 eq),
DCM, rt, 6 h

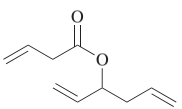


(65) (*E*)/(*Z*) = 86:14

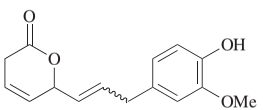
451



3 eq



Gr II (0.025 eq),
DCM, 40°, 12 h



(70)

394

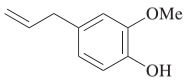
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

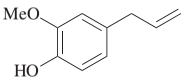
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

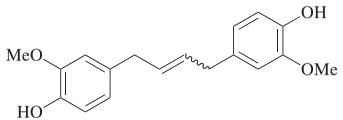
Please refer to the charts preceding the tables for the catalyst structures.

C_9



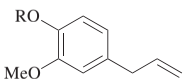


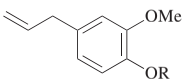
Ru cat **40** (*x* eq), solvent



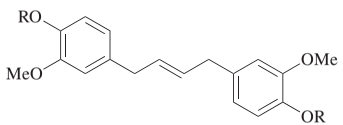
382

x	Solvent	Temp (°)	Time (h)	Conv. (%)[a]
0.05	toluene	rt	1	48
0.005	toluene	80	1	60
2 x 0.005	toluene	80	1 + 1	93
0.005	DCM	80	1	0



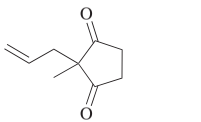


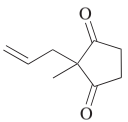
Ru cat **360** (0.005 eq), toluene, 40°, 15 h



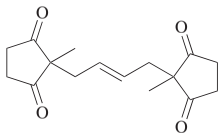
491

R		(*E*)/(*Z*)
Ac	(85)	83:17
Me	(96)	84:16



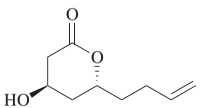


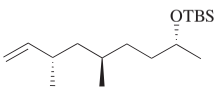
Gr II (0.05 eq), toluene, 110°, 24 h



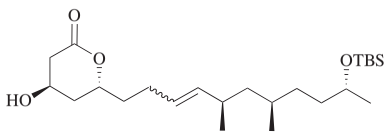
(79) (*E*)/(*Z*) = 95:5

492



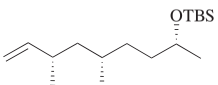


Gr II (0.5 eq), DCM, reflux, 12 h

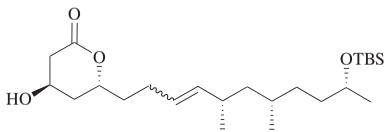


(55)

493

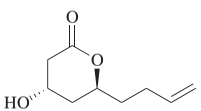


Gr II (0.5 eq), DCM, reflux, 12 h

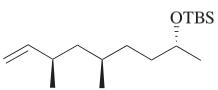


(60)

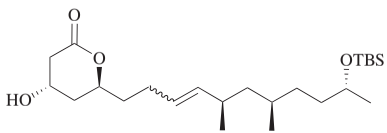
493



1.03 eq



Gr II (0.5 eq), DCM, reflux, 12 h

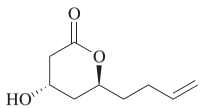
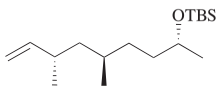
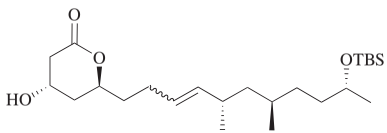
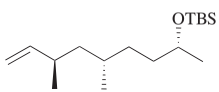
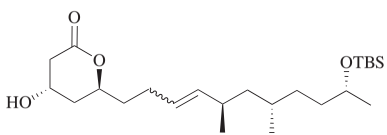
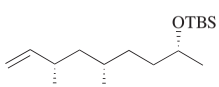
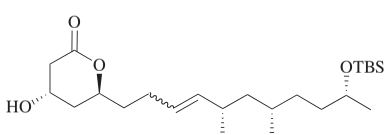
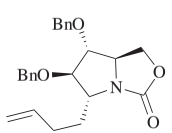
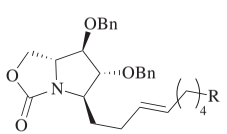
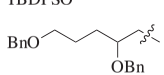


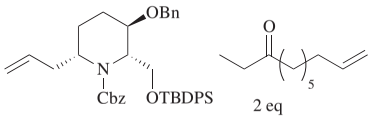
(60)

493

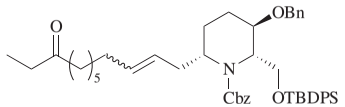
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
 1 eq		Gr II (0.5 eq), DCM, reflux, 12 h	 (55)	493
1 eq		Gr II (0.5 eq), DCM, reflux, 12 h	 (54)	493
1 eq		Gr II (0.5 eq), DCM, reflux, 12 h	 (58)	493
	 2 eq	Gr II (0.1 eq), DCM, 110° (MW), 12 h	 (*E*)/(*Z*) = 80:20	494
			R  (62)  (60)	

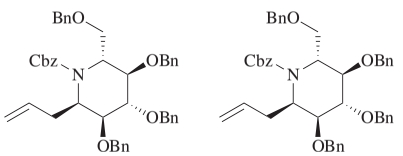


Gr II (0.05 eq),
DCM, reflux, 4 h

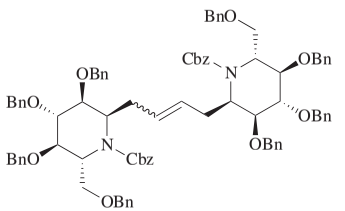


(58)

495, 496

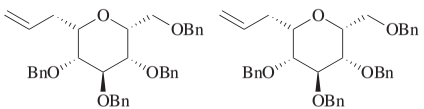


Hov II (0.05 eq),
DCM,
rt, overnight

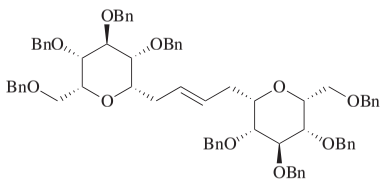


(51)

484



Gr I (0.05 eq),
DCM, 45°, 4 h

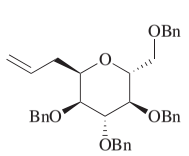
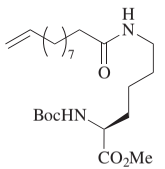
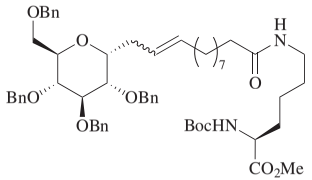
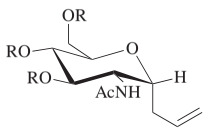
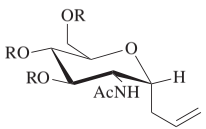
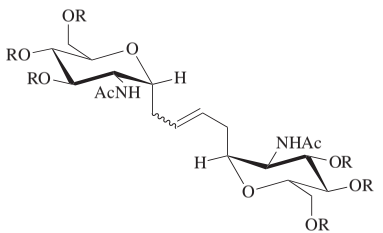
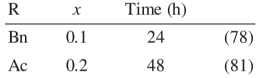
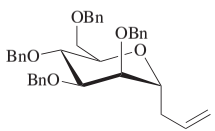
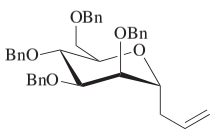
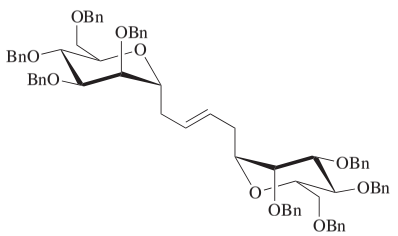


124

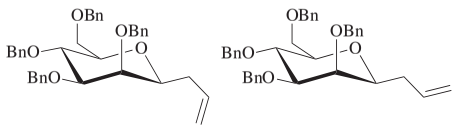
(93) (*E*)/(*Z*) = 80:20

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
 3 eq		Gr II (0.2 eq), DCM, reflux, 6 h	 (64)	429
		Gr II (x eq), DCM, rt	 	423
		Gr I (0.1 eq), DCM, reflux, 8 h	 (83) (*E*)/(*Z*) = 50:50	497

R	x	Time (h)	
Bn	0.1	24	(78)
Ac	0.2	48	(81)

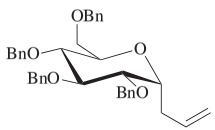


Gr I (0.1 eq),
DCM, reflux, 8 h

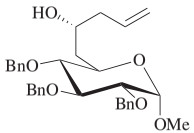


(70) (*E*)/(*Z*) = 58:42

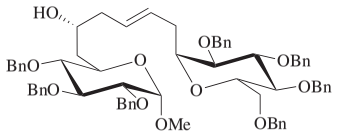
497



1.18 eq

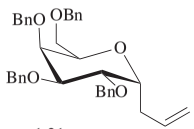


Hov II (0.1 eq),
DCM, rt,
overnight

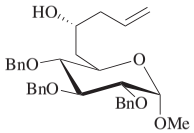


(25) (*E*)/(*Z*) > 95:5

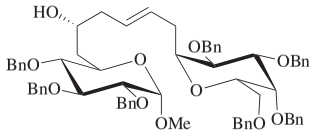
498



1.21 eq



Hov II (0.1 eq),
DCM, rt,
overnight

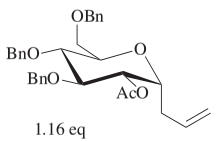
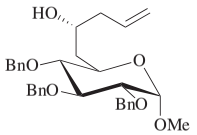
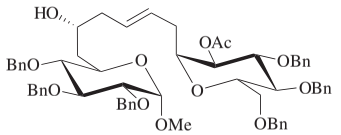
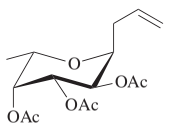
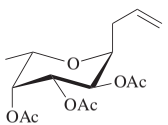
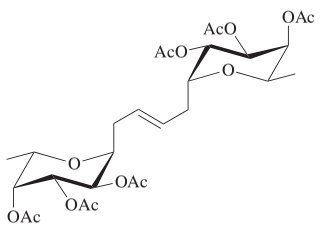
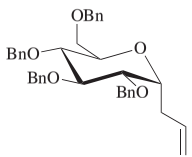
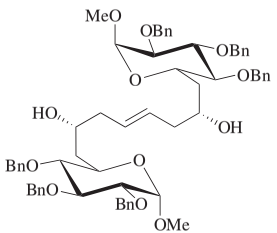
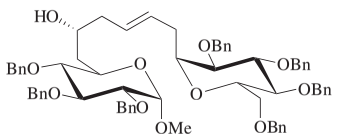


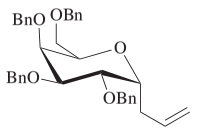
(34) (*E*)/(*Z*) > 95:5

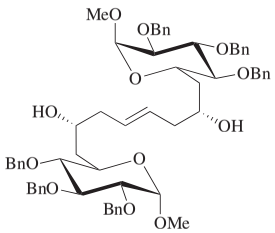
498

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

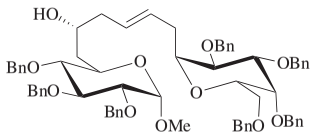
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
 1.16 eq		Hov II (0.1 eq), DCM, rt, overnight	 (40) (*E*)/(*Z*) > 95:5	498
		Gr I (0.1 eq), DCM, reflux, 8 h	 (95) (*E*)/(*Z*) = 75:25	497
	 2 eq	Hov II (0.1 eq), DCM, rt	 (55) (*E*)/(*Z*) = >95:5	498





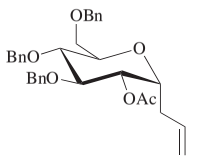
2 eq

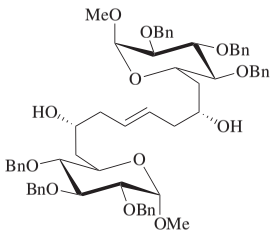
Hov II (0.1 eq),
DCM, rt



(64) (*E*)/(*Z*) > 95:5

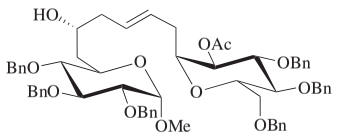
498





2 eq

Hov II (0.1 eq),
DCM, rt



(68) (*E*)/(*Z*) > 95:5

498

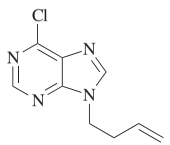
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

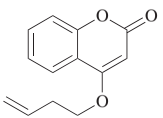
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

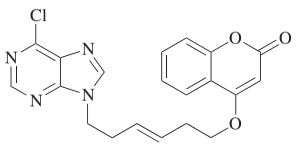
C_9



3 eq

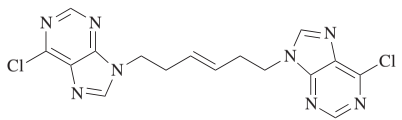


Gr II (0.1 + 0.04 eq),
DCM,
100° (MW), 2 + 1 h

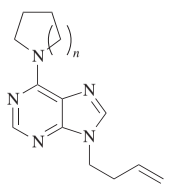


(76) (*E*)/(*Z*) = 76:24 499

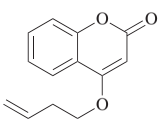
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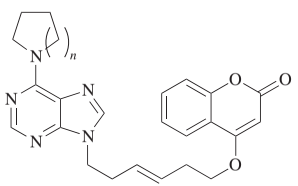
(51) (*E*)/(*Z*) = 75:25



3 eq

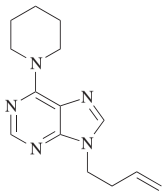


Gr II (0.1 + 0.04 eq),
DCM,
100° (MW), 2 + 1 h

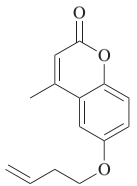


n		(*E*)/(*Z*)
1	(89)	75:25
2	(86)	76:24

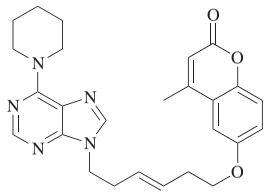
499



3 eq

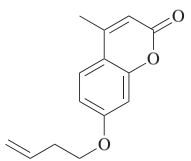


Gr II (0.1 + 0.04 eq),
DCM,
100° (MW), 2 + 1 h

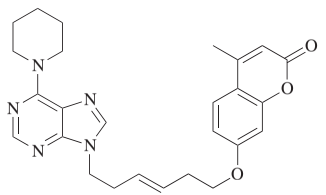


(76) (*E*)/(*Z*) = 76:24 499

3 eq



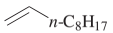
Gr II (0.1 + 0.04 eq),
DCM,
100° (MW), 2 + 1 h

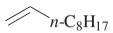


499

(74) (*E*)/(*Z*) = 75:25

C_{10}





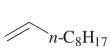
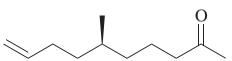
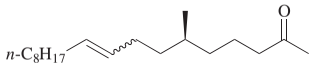
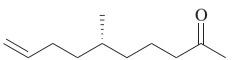
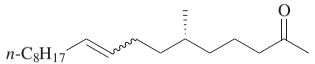
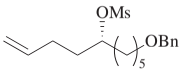
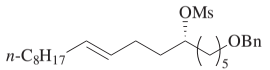
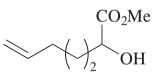
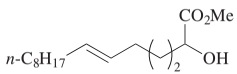
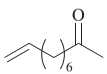
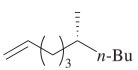
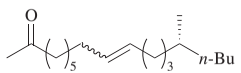
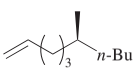
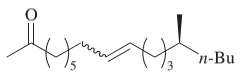
Catalyst
(0.0001 eq),
60°, 4 h



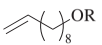
Catalyst	Conv. (%)[c]	
Gr I	8	377
Gr II	52	
Ru cat **5**	77	

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

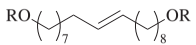
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{10}				
 6.25 eq		Gr I (0.03 eq), DCM, reflux, 4 h		(83) 500
6.25 eq		Gr I (0.03 eq), DCM, reflux, 4 h		(80) 500
4 eq		Gr II (0.03 eq), DCM, reflux, 10 h		(75) (*E*)/(*Z*) = 94:6 501
5 eq		Ru cat **35** (0.02 eq), DCM, reflux, 4–12 h		(76) (*E*)/(*Z*) = 52:48 393
	 6.2 eq	Gr I (0.067 eq), DCM, reflux, 5 h		(78) 500
	 4.4 eq	Gr I (0.063 eq), DCM, reflux, 5 h		(81) 500





Gr I (0.05 eq),
DCM, 45°, 12 h

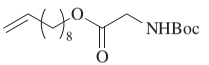


R		(*E*)/(*Z*)
Ac	(95)	82:18
Bz	(94)	79:21

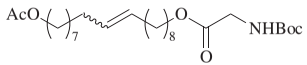
124



x eq



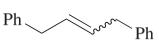
Gr I (0.05 eq),
DCM, 45°, 12 h



x	
1	(45)
2	(69)
4	(80)

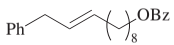
124





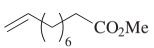
2 eq

Catalyst (0.01 eq),
DCM, rt

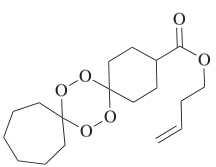


489

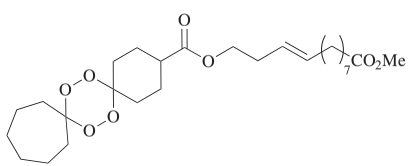
Catalyst	Time (h)	Conv (%)[a]	(*E*)/(*Z*)
Ind II	2.5	92	52:48
Ru cat **282**	2.5	59	38:63
Ru cat **284**	20	88	44:56
Ru cat **283**	20	63	52:48
Ru cat **285**	2.5	97	71:29
Ru cat **286**	2.5	92	58:42



3 eq



Ru cat **88** (0.03 eq),
DCM, 45°, 2 h

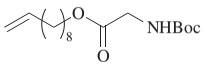
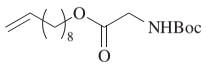
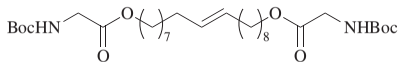
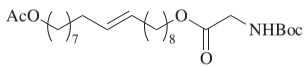
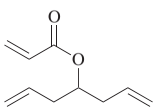
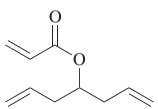
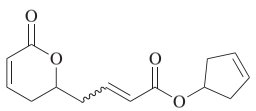


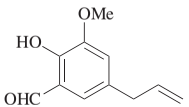
193

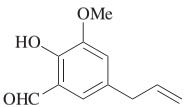
(55) (E)/(Z) = 93:7

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

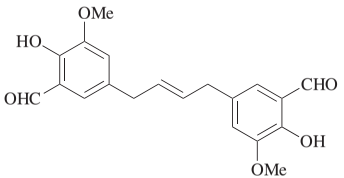
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{10}				
		Gr I (0.003 eq), DCM, rt, 12 h	 (93) (E)/(Z) = 79:21	124
	 *x* eq	Gr I (0.05 eq), DCM, 45°, 12 h		124
			x (28) (*E*)/(*Z*) 0.5 (28) — 1 (47) — 2 (72) 77:23	
		Gr II (0.025 eq), DCM, reflux, 16 h	 (53)	394



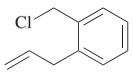


Catalyst (0.01 eq), toluene, 80°, 20 h

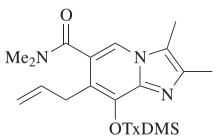


491

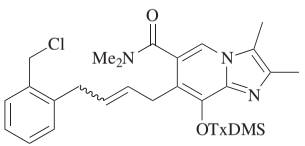
Catalyst		(*E*)/(*Z*)
Ru cat **359**	(55)	87:13
Ru cat **360**	(66)	88:12
Ru cat **361**	(58)	90:10
Ru cat **362**	(64)	84:16



2 eq



Hov II (0.08 eq), DCM, 45°, 20 h



(72)

502

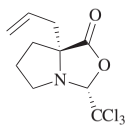
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

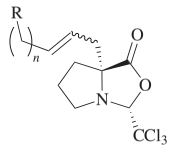
C_{10}





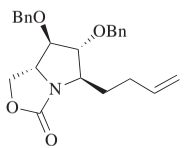
x eq

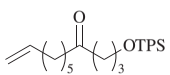
Gr II (*y* eq), solvent



460

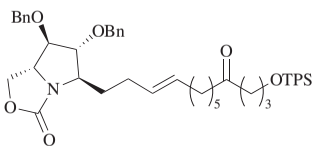
R	*n*	*x*	*y*	Solvent	Conc (M)	Temp (°)	Time (min)	
Me	9	7	0.05	DCM	0.1	80 (MW)	40	(86)
MeO_2C	8	2	0.05	DCM	0.1	80 (MW)	40	(63)
MeO_2C	8	1	0.05	DCM	0.1	80 (MW)	20	(57)
Et	8	1	0.05	DCM	0.1	40	150	(58)
HO	9	2	0.05	DCM	0.1	80 (MW)	40	(40)
HO	9	5	0.1	THF	0.5	40 (MW)	40	(56)
TBDPSO	9	2	0.1	DCM	0.5	80 (MW)	40	(40)
GlcNHC(O)	8	2	0.1	THF	0.3	80 (MW)	40	(48)





2 eq

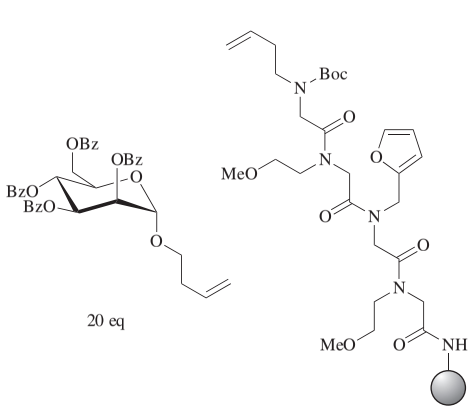
Gr II (0.1 eq), DCM



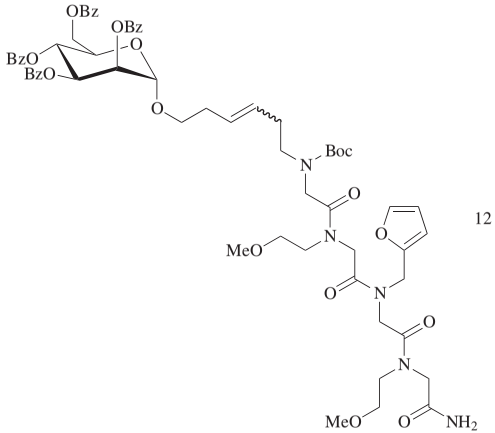
(*E*)/(*Z*) = 80:20

503

Temp (°)	Time (h)	
reflux	24	(61)
100 (MW)	1	(60)



1. Catalyst (0.05 eq), solvent, temp, time
2. TFA (92%), H_2O (5%), TIS (3%), 12 h



12

Catalyst	Solvent	Temp (°)	Time	Conv (%)[e]
Gr I	DCM	40	8 h	18
Gr II	DCM	40	8 h	22
Hov II	DCM	40	8 h	47
Gr I	DCB	40 (MW)	3 min	<5
Gr II	DCB	40 (MW)	3 min	<5
Hov II	DCB	40 (MW)	3 min	25

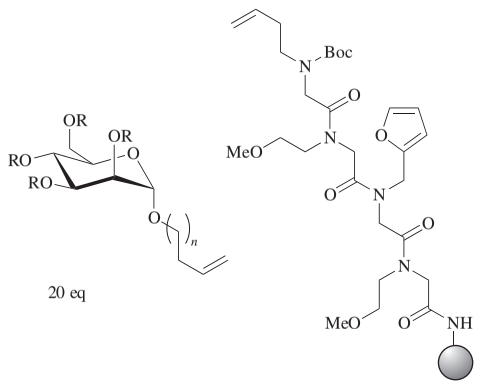
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

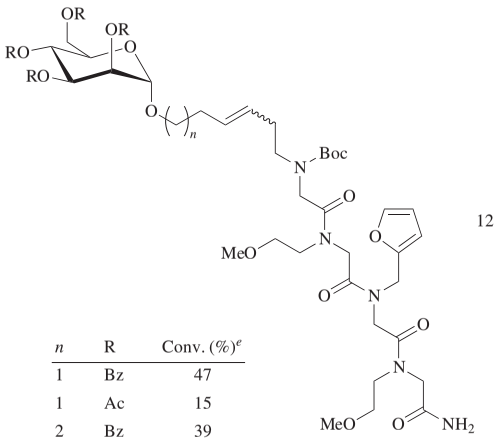
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

C_{10-11}

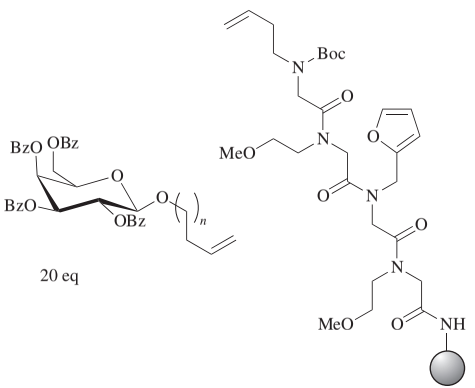


1. Hov II (0.05 eq), DCM, 40°, 8 h
2. TFA (92%), H_2O (5%), TIS (3%), 1–2 h

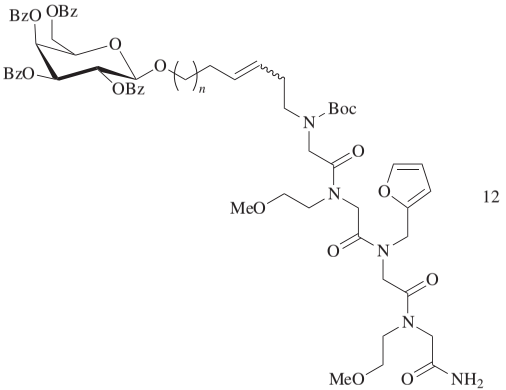


12

n	R	Conv. (%)[e]
1	Bz	47
1	Ac	15
2	Bz	39
2	Ac	30



1. Hov II (0.05 eq), DCM, 40°, 8 h
2. TFA (92%), H_2O (5%), TIS (3%), 1–2 h



12

n	Conv. (%)[e]
1	40
2	46

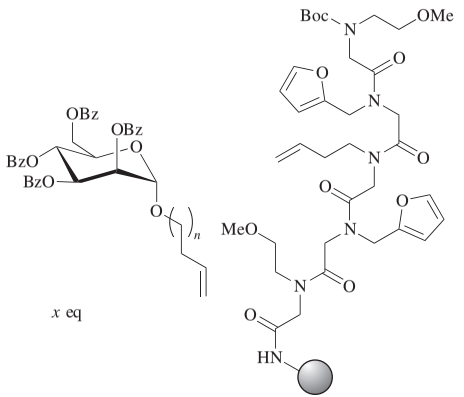
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

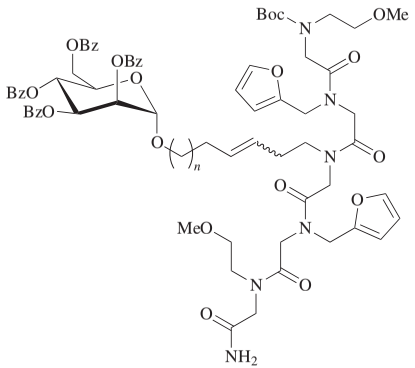
Please refer to the charts preceding the tables for the catalyst structures.

C_{10-11}



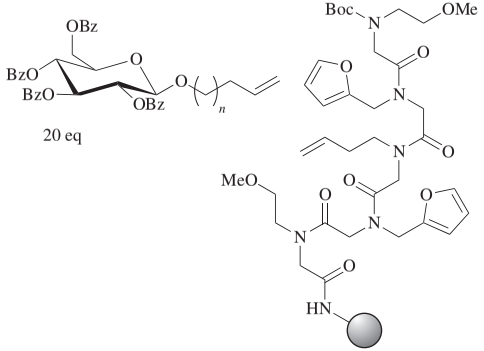
x eq

1. Hov II (0.05 eq), DCM, 40°, 8 h
2. TFA (92%), H_2O (5%), TIS (3%), 1–2 h

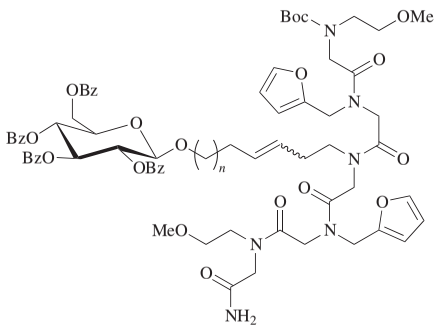


12

n	*x*	Resin	Conv. (%)[c]
1	20	Rink Amide (0.4 mmol/g)	46
1	20	Rink Amide (0.2 mmol/g)	37
1	40	Rink Amide (0.2 mmol/g)	50
1	56	Rink Amide (0.2 mmol/g)	49
1	80	Rink Amide (0.2 mmol/g)	51
2	20	Rink Amide (0.4 mmol/g)	44
2	20	Rink Amide (0.2 mmol/g)	40



1. Hov II (0.05 eq), DCM, 40°, 8 h
2. TFA (92%), H_2O (5%), TIS (3%), 1–2 h



12

n	Conv. (%)[e]
1	49
2	32

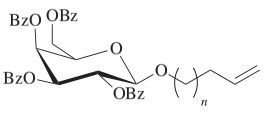
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

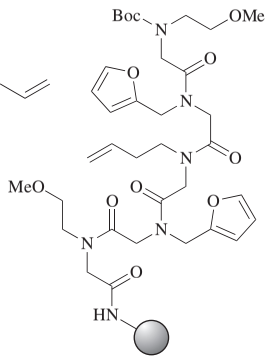
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

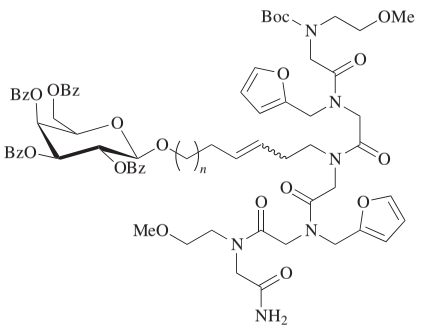
C_{10-11}



20 eq

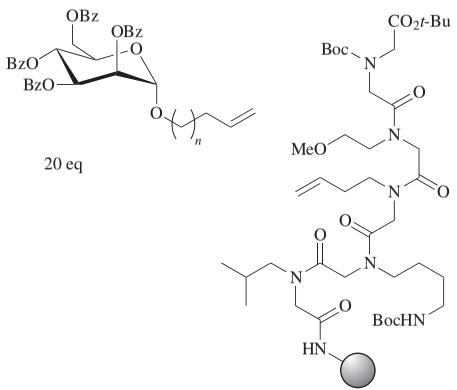


1. Hov II (0.05 eq), DCM, 40°, 8 h
2. TFA (92%), H_2O (5%), TIS (3%), 1–2 h

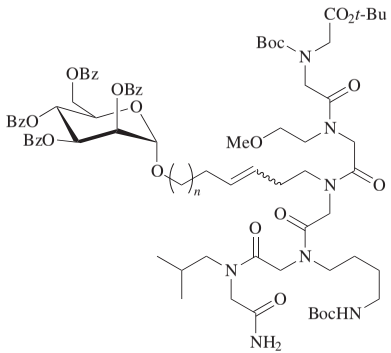


n	Conv (%)[e]
1	47
2	49

12



1. Hov II (0.05 eq), DCM, 40°, 8 h
2. TFA (92%), H_2O (5%), TIS (3%), 1–2 h

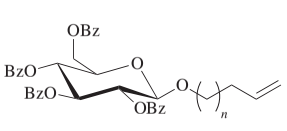
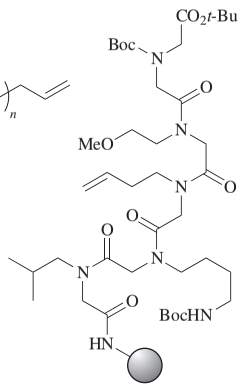
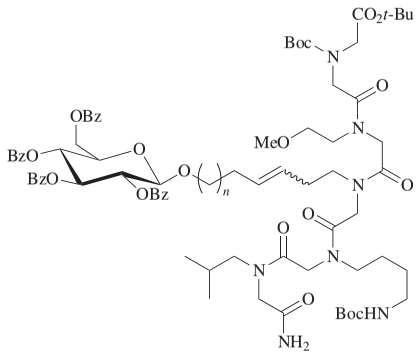
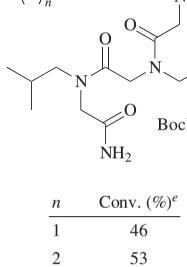


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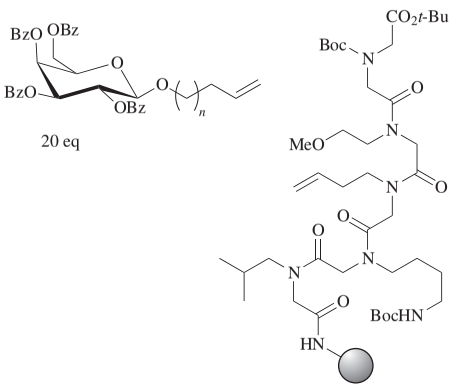
n	Conv. (%)[e]
1	52
2	63

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

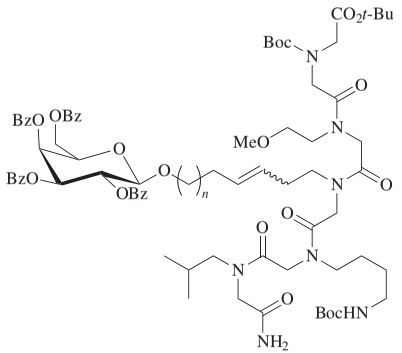
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{10-11}	 20 eq 	1. Hov II (0.05 eq), DCM, 40°, 8 h 2. TFA (92%), H_2O (5%), TIS (3%), 1–2 h	 	12

n	Conv. (%)[e]
1	46
2	53



1. Hov II (0.05 eq), DCM, 40°, 8 h
2. TFA (92%), H_2O (5%), TIS (3%), 1–2 h

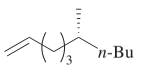
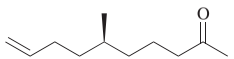
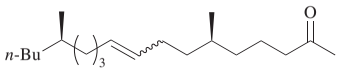
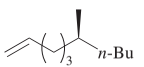
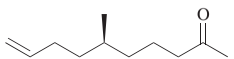
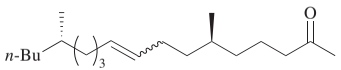
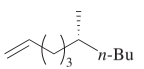
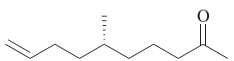
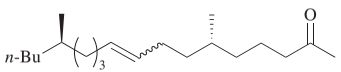
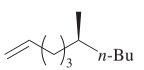
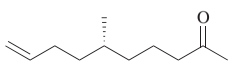
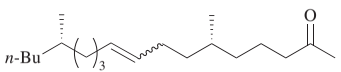
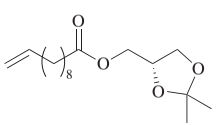
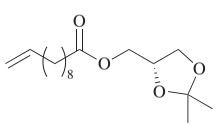
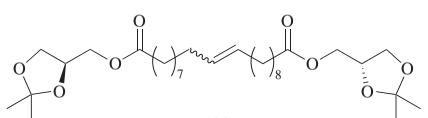


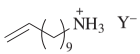
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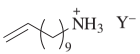
n	Conv. (%)[e]
1	35
2	51

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

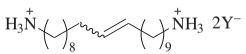
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{11}				
 6.25 eq		Gr I (0.03 eq), DCM, reflux, 4 h	 (86)	500
 6.25 eq		Gr I (0.03 eq), DCM, reflux, 4 h	 (92)	500
 6.25 eq		Gr I (0.03 eq), DCM, reflux, 4 h	 (76)	500
 6.25 eq		Gr I (0.03 eq), DCM, reflux, 4 h	 (73)	500
		Hov II (0.05 eq), DCM, rt, 24 h	 (55)	473





Hov II (0.05 eq), DCM



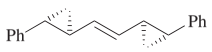
402

Y	Temp (°)	Time (h)	Conv. (%)[a]
TsO	40	24	92
Cl	40	24	81
TsO	100 (MW)	2	88
Cl	100 (MW)	2	82



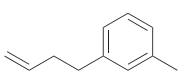


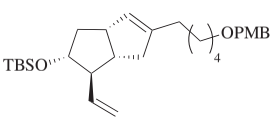
Gr I (0.05 eq), DCM, reflux



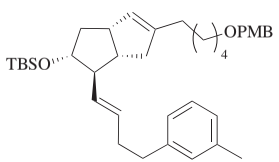
(62) (*E*)/(*Z*) = 86:14

447



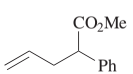


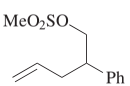
Gr II (0.06 eq), toluene, 80°, 8 h



(54) (*E*)/(*Z*) = 88:12

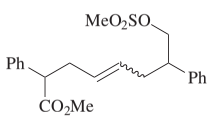
128





2 eq

Catalyst (0.025 eq), DCM, 45°, 2 h



Catalyst	Conv. (%)[a]
Gr I	9
Gr II	44
Hov II	72
Ind II	28

504

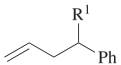
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS
(*Continued*)

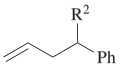
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

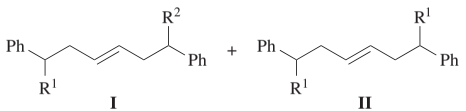
C_{11}



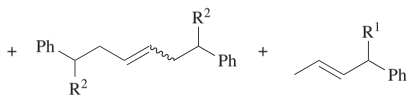


x eq

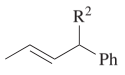
Hov II (0.025 eq), DCM, 45°, 2 h



I + **II**



III + **IV**



V

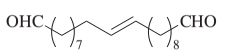
504

R^1	R^2	*x*	**I**	(*E*)/(*Z*) **I**	**II**	(*E*)/(*Z*) **II**	**III**	**IV**	(*E*)/(*Z*) **IV**	**V**	(*E*)/(*Z*) **V**
MeO_2C	$MsOCH_2$	0.5	(28)	80:20	(35)	82:18	(—)	(—)	—	(—)	—
BzO	$HOCH_2$	1.2	(36)	80:20	(—)	—	(—)	(12)	68:32	(20)	71:29
MeO_2C	$BrCH_2$	2	(40)	—	(—)	—	(25)	(—)	—	(—)	—
$MsOCH_2$	$HOCH_2$	2	(—)	—	(—)	—	(—)	(30)	67:33	(21)	89:11
$HOCH_2$	Bn_2NOC	0.5	(16)	—	(3)	—	(—)	(24)	86:14	(41)	76:24
MeO_2C	Bn_2NOC	0.5	(17)	60:40	(10)	68:32	(—)	(—)	—	(10)	67:33
$MsOCH_2$	Bn_2NOC	0.5	(3)	—	(—)	—	(—)	(—)	—	(—)	—
$MsOCH_2$	Me(MeO)NOC	2	(—)	—	(—)	—	(—)	(—)	—	(—)	—





Catalyst (*x* eq), toluene, 40°

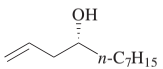


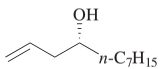
(*E*) only

1088

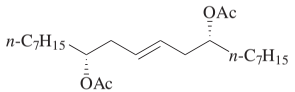
Catalyst	*x*	Time (h)	Conv. (%)[c]
Gr I	0.01	48	81
Gr I	0.005	48	74
Ru cat **79**	0.0165	16	72
Ru cat **79**	0.0066	4	61

Ru cat **79**	0.0033	48	70
Hov II	0.025	23	84
Ru cat **144**	0.0125	13	72
Ru cat **144**	0.025	22	85

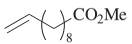


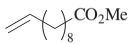


1. Ac_2O, pyridine
2. Ru cat **35** (0.007 eq), DCM, 50° (MW), 1 h

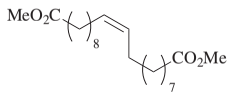


(98) (*E*)/(*Z*) = 77:23 505





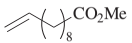
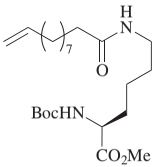
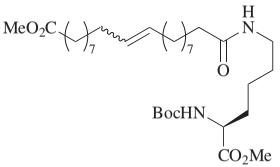
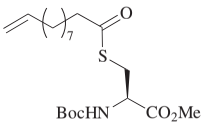
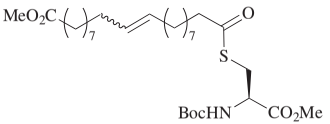
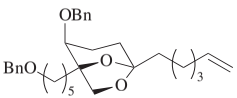
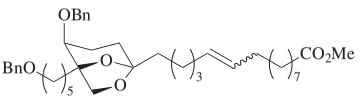
Catalyst (*x* eq), solvent

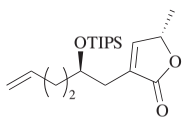


Catalyst	*x*	Solvent	Temp (°)	Time (h)	Conv. (%)[a]		(*Z*)/(*E*)	
Ru cat **217**	0.001	THF	35	12	16	(—)	90:10	488
Ru cat **218**	0.02	THF	35	6	67	(—)	81:19	488
Ru cat **219**	0.001	THF	35	12	3	(—)	>95:5	488
Ru cat **220**	0.001	THF	35	12	8.4	(—)	>95:5	488
Ru cat **217**	0.001	THF	35	12	—	(13)	90:10	488
Ru cat **215**	0.001	THF	35	12	—	(85)	91:9	488
Ru cat **216**	0.001	THF	35	12	—	(94)	92:8	488
Ru cat **217**	0.02	THF	35	5.5	95	(>95)	73:27	84
Ru cat **217**	0.04	THF	70	4	78	(—)	87:13	84
Ru cat **217**	0.02	MeCN	70	2.5	7	(—)	95:5	84
Ru cat **217**	0.02	MeCN	25	3	19	(—)	94:6	84
Ru cat **217**	0.02	MeOH	25	3	49	(—)	88:12	84
Ru cat **217**	0.02	EtOH	25	3	50	(—)	89:11	84
Ru cat **217**	0.02	benzene	25	3	13	(—)	>95:5	84
Ru cat **217**	0.02	Et_2O	25	3	50	(—)	93:7	84
Ru cat **217**	0.02	DMF	25	3	44	(—)	92:8	84
Ru cat **217**	0.02	DCM	25	3	35	(—)	93:7	84
Ru cat **217**	0.02	diglyme	25	3	31	(—)	95:5	84
Gr I	0.003	DCM	25	12	90	(—)	83:17	124

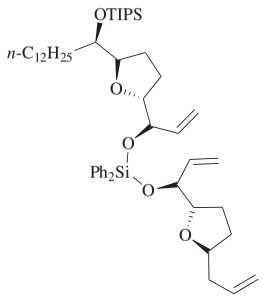
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

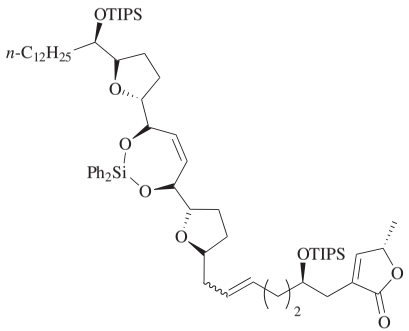
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{11}				
 3 eq		Gr II (0.2 eq), DCM, 40°, 6 h	 (64)	429
3 eq		Gr II (0.2 eq), DCM, 40°, 6 h	 (61)	429
3 eq		Gr II (0.15 eq), DCM, reflux, 24 h	 (80)	506



3 eq



Gr II (0.2 eq),
DCM, 45°, 9 h



(63) 507

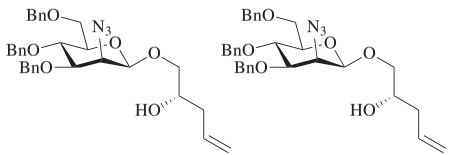
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

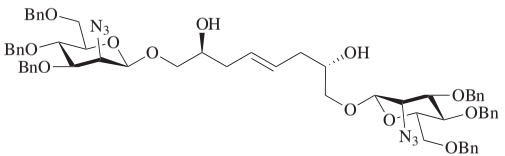
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

C_{11}

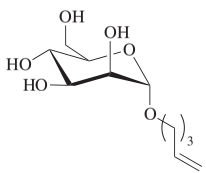


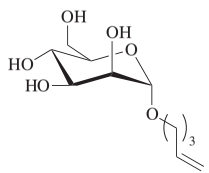
Hov II (0.05 eq), DCM, 40°, 24 h



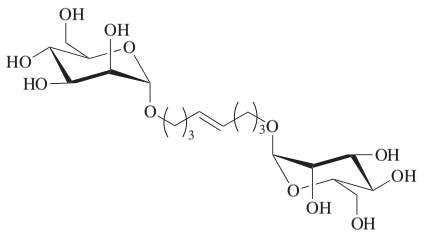
509

(77) (*E*)/(*Z*) = 75:25





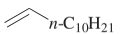
Gr I (0.1 eq), DCM/MeOH

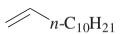


497

Temp (°)	Time (h)		(*E*)/(*Z*)
rt	8	(67)	57:43
40	16	(42)	52:48

C_{12}

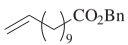




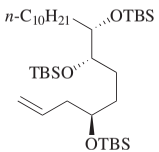
Ru cat **156** (0.00002 eq), 2-Cl-BQ (0.00004 eq), 60°, 6 h



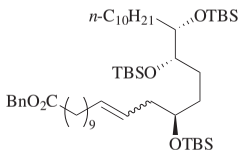
(91) 510



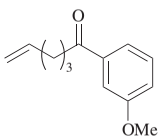
10 eq

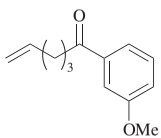


Gr I (0.1 eq), DCM, 40°, 4 h

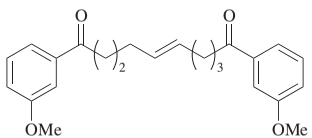


(73) 412





Gr II (0.1 eq), paraffin, DCM, 40°, 12 h

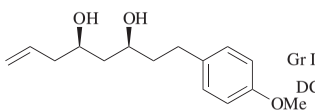


(46) $(E)/(Z) = 95:5$ 511

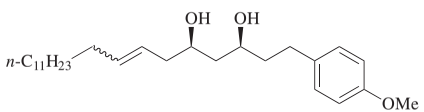
C_{13}



10 eq



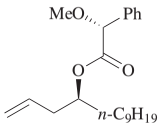
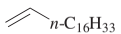
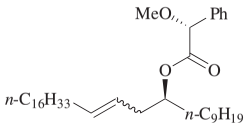
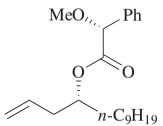
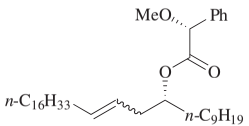
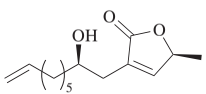
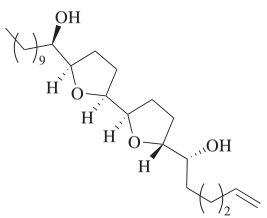
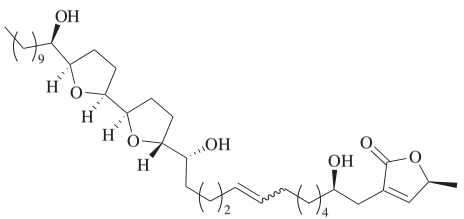
Gr II (0.05 eq), DCM, reflux, 12 h

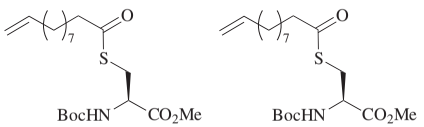


(85) 512

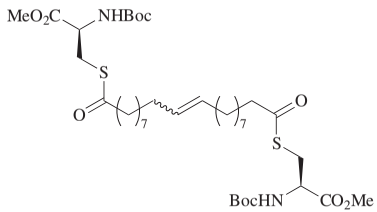
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

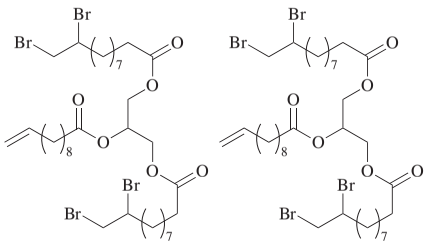
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{13}				
	 2 eq	Gr II (0.17 eq), DCM, reflux, 4 h	 (58)	513
	 2 eq	Gr II (0.17 eq), DCM, reflux, 4 h	 (87)	513
C_{14}				
 4 eq		1. Gr I (0.1 eq), DCM, reflux, 6 h 2. DMSO, rt, 15 h	 (73)	514



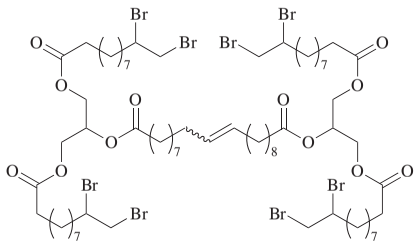
Gr II (0.2 eq),
DCM, reflux



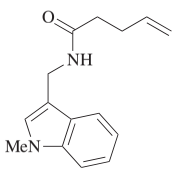
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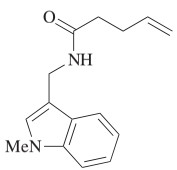


Gr II (0.05 eq),
DCM, 40°, 8 h

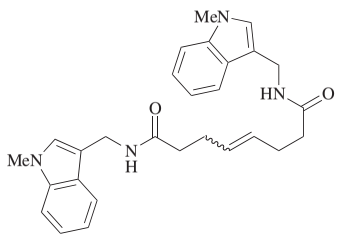


(67) 515





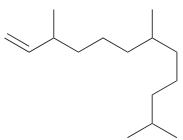
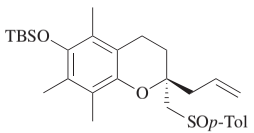
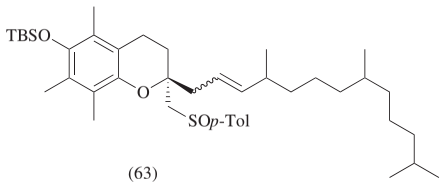
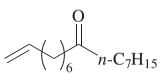
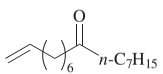
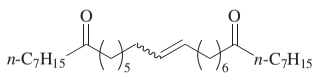
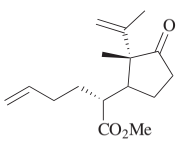
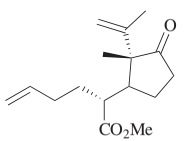
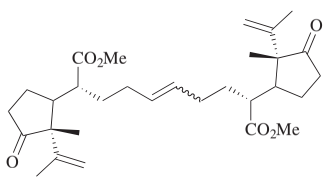
Gr II (0.08 eq),
DCM, reflux, 7 h

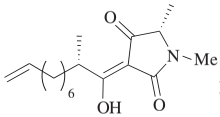


(20) 428

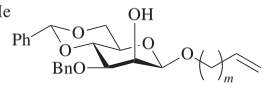
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

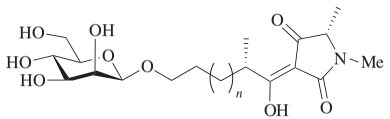
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{15}				
 2.9 eq		Ru cat **271** (0.2 eq), DCM, 65° (MW), 1 h	 (63)	516
C_{16}				
		Gr II (0.1 eq), DCM, 25°, 4 h	 (92)	483
		Ru cat **126** (0.5 eq), DCM, rt, 12 h	 (55)	517



1.3 eq

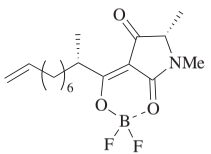


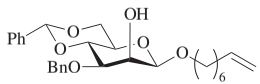
1. Gr II (0.01 eq), toluene, 80°, 1.5 h
2. TFA, DCM, H_2O, rt, 1.5 h
3. H_2, $Pd(OH)_2/C$, EtOAc, rt, 20 min



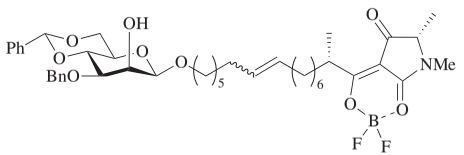
m	*n*	
6	12	(20)
8	14	(16)

248



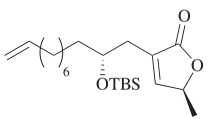


Gr II (0.015 eq), toluene, reflux

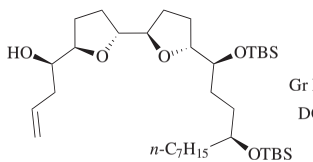


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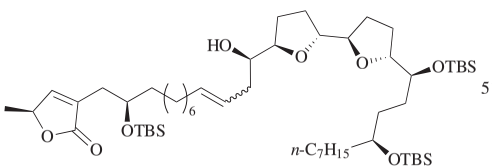
(47)



4 eq



Gr II (0.2 eq), DCM, reflux, 12 h

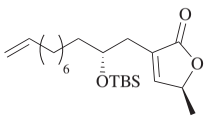
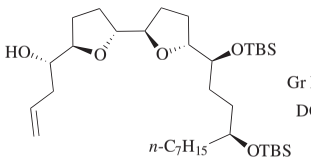
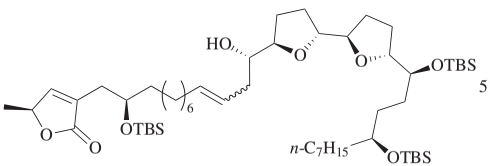
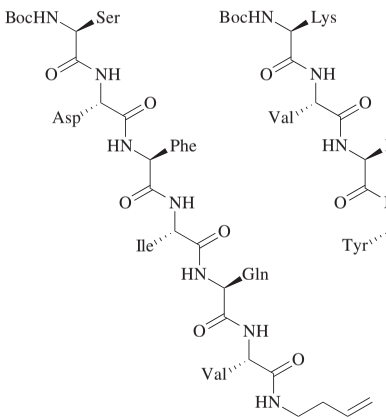
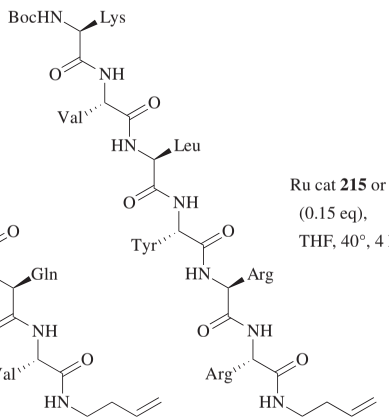
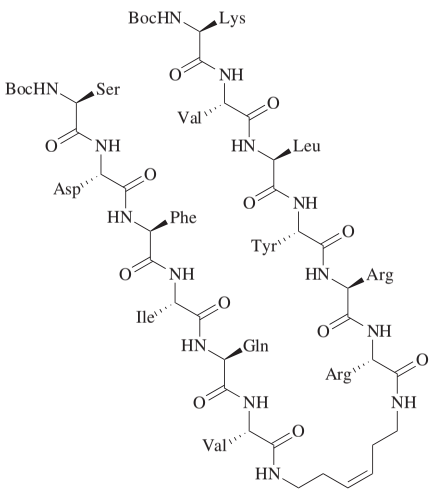


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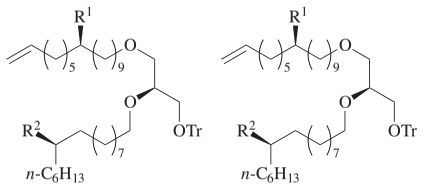
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TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

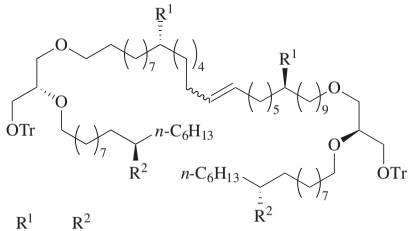
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{16}				
 4 eq		Gr II (0.2 eq), DCM, reflux, 12 h	 (58)	518
		Ru cat **215** or **216** (0.15 eq), THF, 40°, 4 h	 60% conv.[a], (*Z*)/(*E*) = 60:40	401

C_{17}

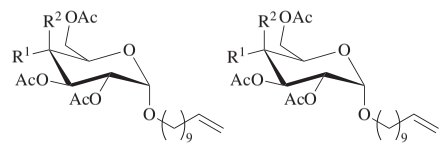


Gr I (0.29 eq),
DCM, reflux, 24 h

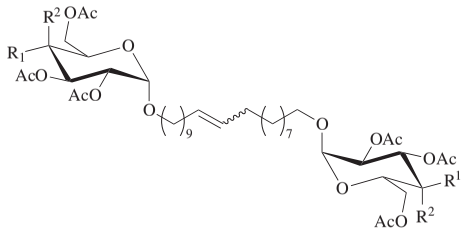


519

R^1	R^2	
H	Me	(31)
Me	H	(27)
Me	Me	(35)



Gr I (x eq),
DCM, rt



520

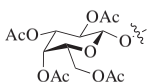
R^1	R^2	x	Time (h)	
H	AcO	0.115	20.5	(83)
AcO	H	0.078	15	(85)
	H	0.176	27	(61)

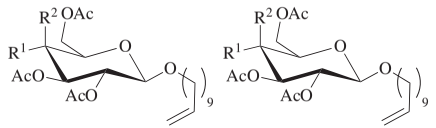
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

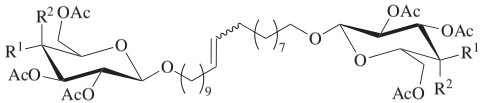
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

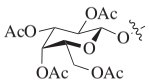
C_{17}



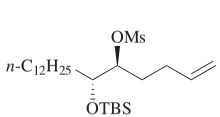
Gr I (*x* eq), DCM, rt

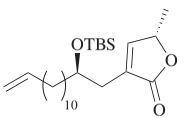


520

R^1	R^2	*x*	Time (h)	
H	AcO	0.126	18	(62)
AcO	H	0.086	15	(95)
	H	0.152	21	(50)

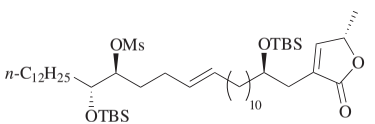
C_{18}





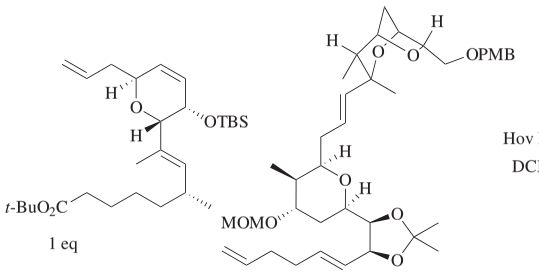
4 eq

Gr I (0.4 eq), benzene, 50°, 13 h

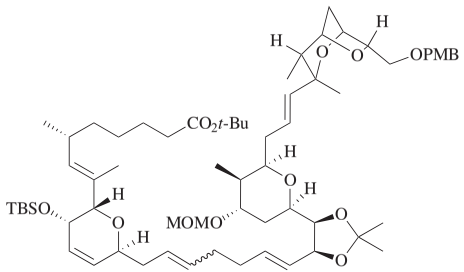


521

(62) (*E*) only

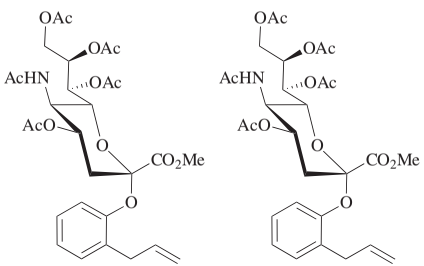


Hov II (0.1 eq),
DCM, rt, 14 h

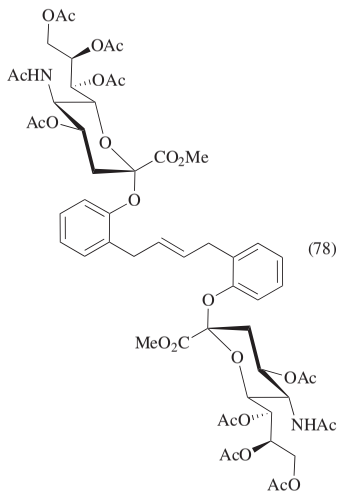


(16)

522



Gr I (0.1 eq),
DCM, reflux, 2 h

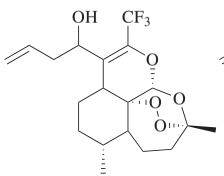
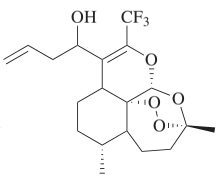
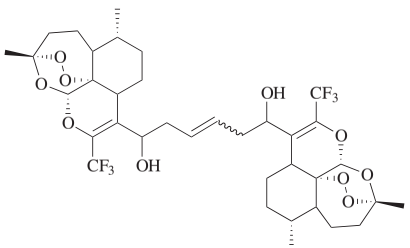
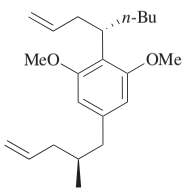
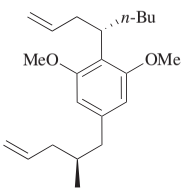
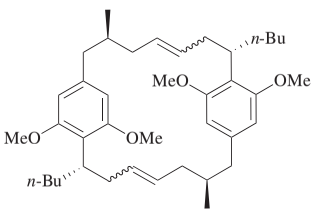


(78) (*E*)/(*Z*) = 63:37

497

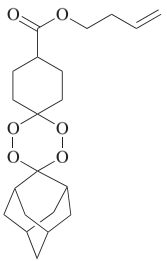
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

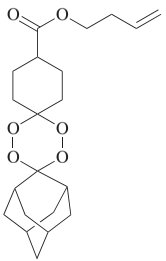
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{18}				
		Ru cat **35** (0.1 eq), DCM	 (50)	195
C_{20}				
		Catalyst (*x* eq), solvent		263

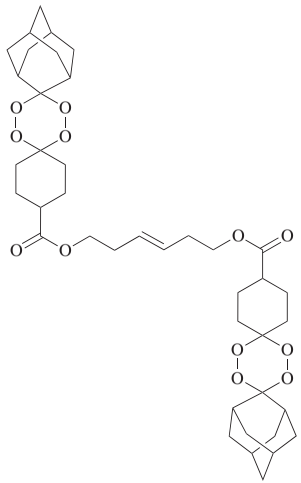
Catalyst	*x*	Solvent	Temp (°)	Time (h)	
Gr I	0.15	DCM	20	25	(55)
Gr I	0.2	DCM	20	75	(61)
Gr II	0.15	DCM	40	4	(48)
Gr II	0.15	benzene	40	27	(58)
Mo cat **1**	0.3	benzene	20	2	(72)

C_{21}





Ru cat **88** (0.025 eq)
DCM, 45°, 2 h



(87) (*E*)/(*Z*) = 67:33 193

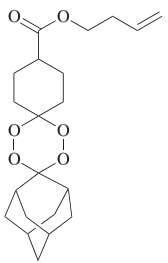
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

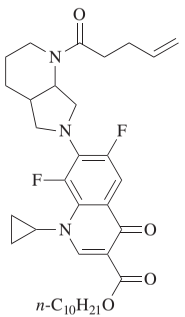
Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

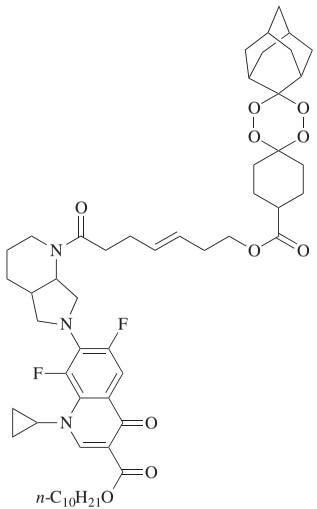
C_{21}



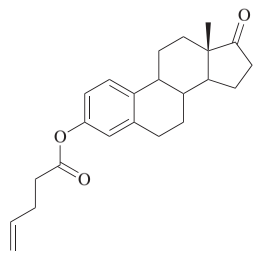
3 eq



Ru cat **88** (0.1 eq)
DCM, 45°, 2 h

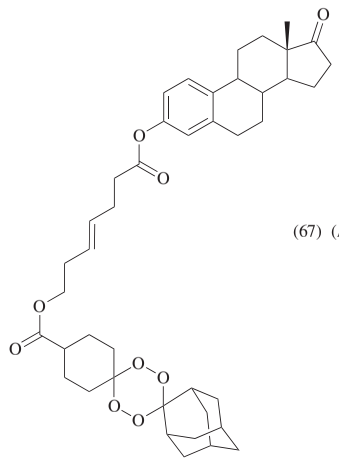


(40) (*E*)/(*Z*) = 80:20 193



3 eq

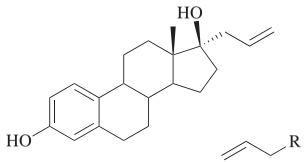
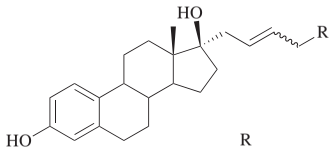
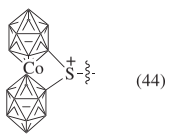
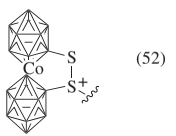
Ru cat **88** (0.03 eq)
DCM, 45°, 2 h



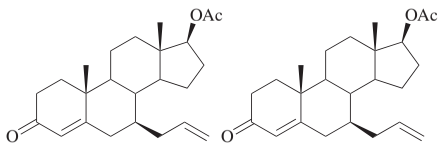
(67) (*E*)/(*Z*) = 67:33 193

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

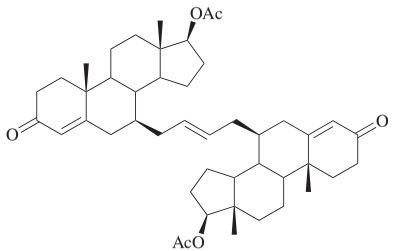
A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{21}				
 1 eq		Hov II (0.1 eq), DCM, reflux, 12 h	 R =  (57);  (55);  (44);  (52)	523

C_{22}



Hov II (0.18 eq),
DCM, reflux,
overnight

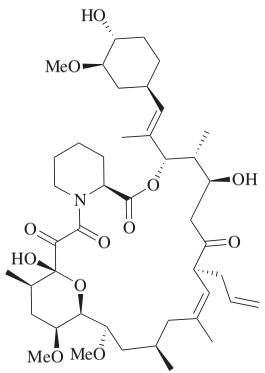
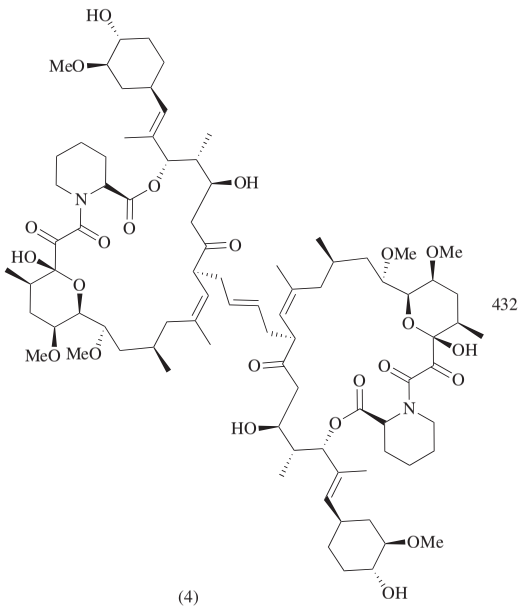


524

(75) (*E*)/(*Z*) = 67:33

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

A. ETHYLENE AND COMPOUNDS WITH A TERMINAL DOUBLE BOND (*Continued*)

Terminal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{41}		Gr II (0.1 eq), DCB, MW	 (4)	432

[a] The conversion was determined by ^{1}H NMR analysis.

[b] The conversion was based on recovered starting material.

[c] The conversion was determined by GC analysis.

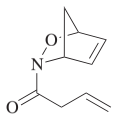
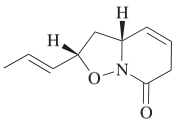
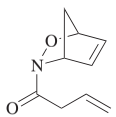
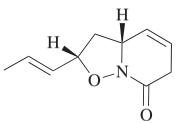
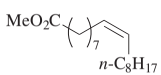
[d] The conversion was determined by GC-MS analysis.

[e] The conversion was determined by HPLC analysis.

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS

(*Continued*)

B. COMPOUNDS WITH AN INTERNAL DOUBLE BOND

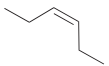
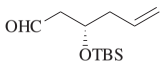
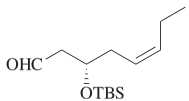
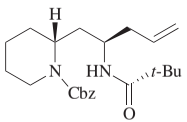
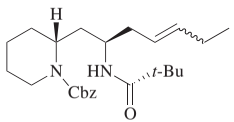
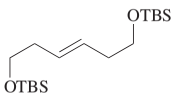
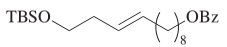
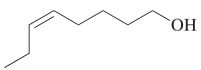
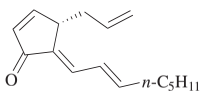
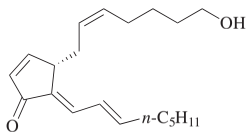
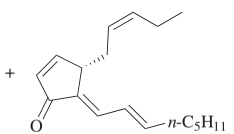
Internal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 excess	 *rac*	Gr II (2 × 0.03 eq), toluene, 50–60°, 1 + 2 + 2 h	 *rac*	(75) (*E*)/(*Z*) = 90:10	525
excess	 er 96.0:4.0	Gr II (2 x 0.03 eq), toluene, 50–60°, 1 + 2 + 2 h		(55) (*E*)/(*Z*) = 90:10, er 96.0:4.0	525
		Catalyst (0.02 eq), TMSCl (*x* eq) toluene, 80°, 18 h			526

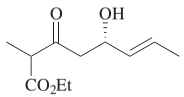
Catalyst	*x*	Conv. (%)[a]
Hov II	—	95
Ru cat **194**	0.2	31
Ru cat **195**	0.2	91
Ru cat **196**	0.2	13

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS

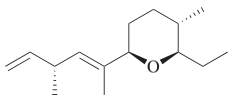
(*Continued*)

B. COMPOUNDS WITH AN INTERNAL DOUBLE BOND (*Continued*)

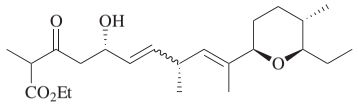
Internal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6				
 4 eq		Ru cat **358** (0.04 eq), THF, 23°, 1 h	 (88) (*Z*)/(*E*) > 99:1	446
4 eq		Gr II (0.031 eq), Ti(*i*-PrO)$_4$ (0.31 eq), DCM, 40°, 6 h	 (79)	527
 2 eq		Gr I (0.05 eq), DCM, 45°, 12 h	 (49) (*E*)/(*Z*) = 74:26	124
C_8				
 8 eq		Ru cat **358** (0.05 eq), THF, 40°, 16 h, static vacuum	 (47) (*Z*)/(*E*) > 99:1	528
			+  (53) (*Z*)/(*E*) > 99:1	



4.67 eq

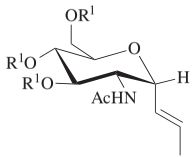


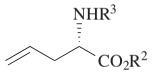
Ru cat **88**
(0.06 + 0.09 eq),
$C_6F_5CF_3$, 70°, 4 h



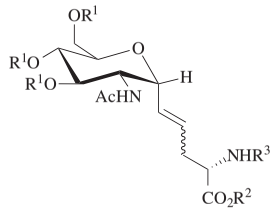
(75) 529

C_9





Gr II (*x* eq),
DCM, rt

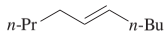
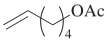
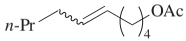
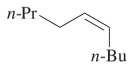
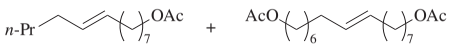


423

R^1	R^2	R^3	*x*	Time (h)	
Bn	Me	Fmoc	0.1	24	(82)
Bn	Me	Boc	0.1	24	(77)
Ac	Me	Fmoc	0.2	48	(69)
Ac	Me	Boc	0.2	48	(77)
Ac	Bn	Cbz	0.2	48	(62)

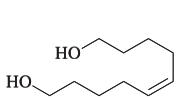
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

B. COMPOUNDS WITH AN INTERNAL DOUBLE BOND (*Continued*)

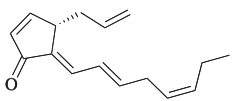
Internal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{10}				
 5 eq		Catalyst (0.01 eq), DCM, 25°, 8 h, 50 mbar		Catalyst / Conv. (%)[a]: Gr I 10; Gr II 85; Ind II 78; Ru cat **282** 35	530
2 eq		Catalyst (*x* eq), THF, 35°	 **I** + **II**	See table below	352
 2 eq		Catalyst (*x* eq), THF, 35°	 **I** + **II**	See table below	352

Catalyst	*x*	Time (h)	**I**	(*E*)/(*Z*) **I**	**II**	(*E*)/(*Z*) **II**
Ru cat **215**	0.002	24	(<1)	—	(19)	13:87
Ru cat **214**	0.025	2	(53)	75:25	(17)	77:23

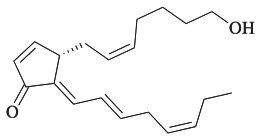
Catalyst	*x*	Time (h)	**I**	(*E*)/(*Z*) **I**	**II**	(*E*)/(*Z*) **II**
Ru cat **215**	0.002	6	(57)	9:91	(21)	17:83
Ru cat **214**	0.025	2	(69)	77:23	(14)	78:22



4 eq

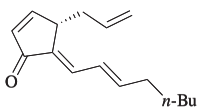


Ru cat **358** (0.05 eq),
THF, 23°, 12 h

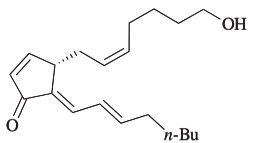


(36) (*Z*)/(*E*) > 99:1 446

4 eq

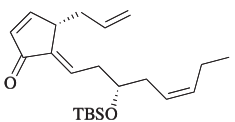


Ru cat **358** (0.05 eq),
THF, 40°, 24 h

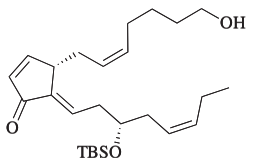


(93) (*Z*)/(*E*) > 99:1 446

4 eq

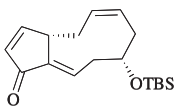


Ru cat **358** (0.05 eq),
THF, 23°, 12 h



(44) (*Z*)/(*E*) > 99:1 446

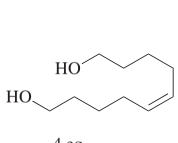
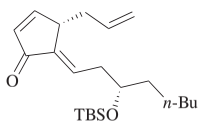
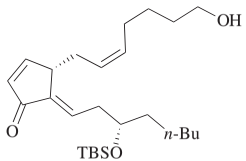
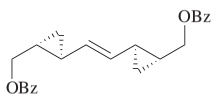
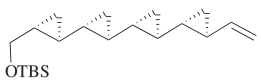
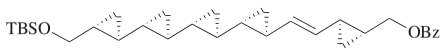
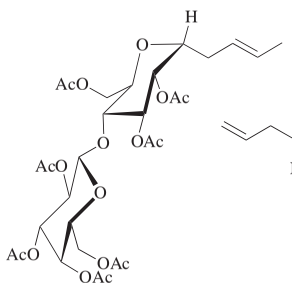
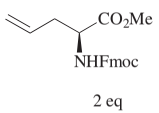
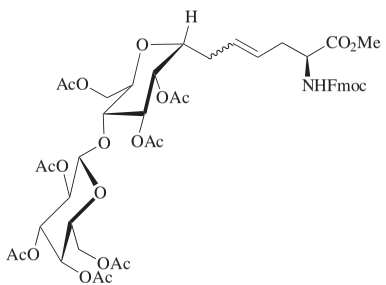
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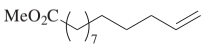
(31)

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

B. COMPOUNDS WITH AN INTERNAL DOUBLE BOND (*Continued*)

Internal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{10}				
 4 eq		Ru cat **358** (0.05 eq), THF, 40°, 24 h	 (95) (*Z*)/(*E*) > 99:1	446
 2 eq		Gr I (0.05 eq), DCM, reflux, 12 h	 (82) (*E*)/(*Z*) = 83:17	447
	 2 eq	Gr I (0.2 eq), DCM, reflux, 48 h	 (60)	427

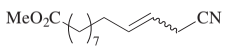
C_{11}





x eq

Catalyst (*y* eq), additive (*z* eq), solvent



536

x	Catalyst	*y*	Additive	*z*	Solvent	Temp (°)	Time (h)	Conv. (%)[a]
5	Hov II	0.01	—	—	toluene	80	17	7
2	Hov II	0.01	—	—	toluene	95	21	95
5	Hov II	0.01	—	—	toluene	95	8	92
5	Hov II	0.01	BQ	0.1	toluene	95	5	79
5	Hov II	0.02	BQ	0.1	toluene	95	4	92
5	Hov II	0.02	acetic acid	0.1	toluene	95	6	48
5	Hov II	0.02	BQ	0.1	toluene	110	6	84
5	Hov II	0.02	BQ	0.1	toluene	95	6	43
5	Hov II	0.02	BQ	0.1	toluene	95	6	49
5	Gr II	0.02	BQ	0.1	toluene	110	4	94
5	Hov II	0.02	BQ	0.1	toluene	95	6	65
10	Hov II	0.02	BQ	0.1	toluene	110	6	38
5	Hov II	0.02	BQ	0.5	toluene	110	4	85
5	Hov II	0.02	BQ	0.5	toluene	110	4	70
5	Hov II	0.02	BQ	0.1	toluene	110	4	79
5	Hov II	0.02	BQ	0.1	DCE	80	8	41
5	Hov II	0.02	BQ	0.1	C_6F_5Cl	110	2	95
5	Hov II	0.02	BQ	0.1	C_6H_5Cl	110	2	90
5	Hov II	0.02	BQ	0.1	$C_6F_5CF_3$	110	5	77
5	Hov II	0.045	BQ	0.1	C_6H_5Cl	110	3	94

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS

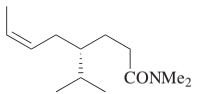
(*Continued*)

B. COMPOUNDS WITH AN INTERNAL DOUBLE BOND (*Continued*)

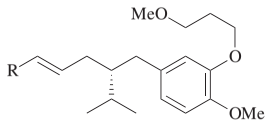
Internal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

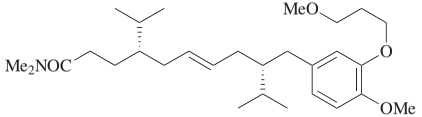
C_{11}



4 eq



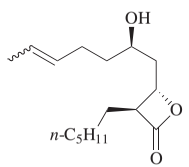
Catalyst (0.05 eq),
BQ (*x* eq),
solvent, reflux, 24 h

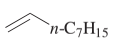


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R	Catalyst	Solvent	*x*		(*E*)/(*Z*)
H	Hov II	PE	0.5	(82)	75:25
H	Gr II	PE	0.5	(80)	81:19
Me	Hov II	PE	0.5	(72)	80:20
Me	Gr II	PE	0.5	(80)	81:19
Me	Hov II	DCM	0.5	(68)	85:15
Me	Gr II	DCM	0.5	(62)	87:13
Me	Gr II	DCM	0.6	(62)	88:12
Me	Gr II	DCM	0.7	(67)	88:12
Me	Gr II	DCM	0.8	(66)	87:13

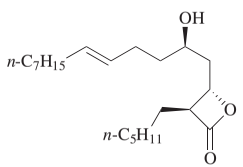
C_{16}





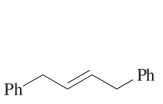
5 eq

Gr I (0.15 eq),
DCM, 40°

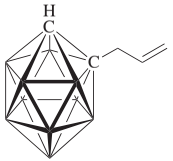


(20) (*E*)/(*Z*) = 80:20

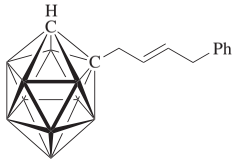
531



4 eq

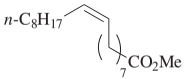


Gr II (0.0056 eq), DCM, reflux, 24 h



(62) $(E)/(Z) = 94:6$ 436

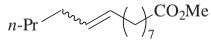
C_{18}

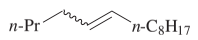




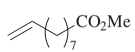
x eq

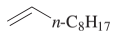
Ru cat **8** (0.003 eq), cyclohexane, 30°



I + 

II 532

+ 

III + 

IV

+ 

V

+ 

VI

+ 

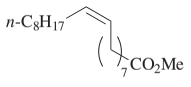
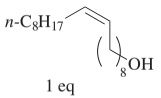
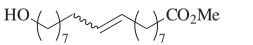
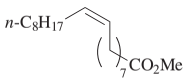
VII

x	**I** + **II** + **III** + **IV**[b]	**V**[b]	**VI** + **VII**[b]
1	(46)	(23)	(21)
2	(55)	(22)	(20)
3	(69)	(20)	(15)
4	(78)	(22)	(10)
5	(83)	(19)	(8)
6	(86)	(17)	(6)
7	(87)	(15)	(6)

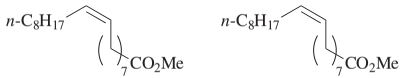
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS

(*Continued*)

B. COMPOUNDS WITH AN INTERNAL DOUBLE BOND (*Continued*)

Internal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{18}				
	 1 eq	Gr II (0.01 eq), 45°, 24.5 h	 (40)	533
		Catalyst (0.01 eq), dodecane (0.6 eq), toluene, 50°	 **I** +  **II** (40)	534

Catalyst	Conv. (%)[c] (1 h)	Selectivity **I/II**[c] (1 h)	**I**[c] (1 h)	**II**[c] (1 h)	Conv. (%)[c] (5 h)	Selectivity **I/II**[c] (5 h)	**I**[c] (5 h)	**II**[c] (5 h)
Ind II	52	87:66	(45)	(34)	53	88:67	(47)	(36)
Ru cat **283**	54	88:73	(47)	(39)	55	89:75	(49)	(41)
Ru cat **332**	53	89:69	(47)	(36)	54	89:75	(49)	(38)
Ru cat **297**	50	89:58	(44)	(29)	53	89:58	(48)	(32)
Ru cat **331**	53	88:69	(47)	(37)	53	88:69	(47)	(32)
Ru cat **320**	51	84:56	(43)	(29)	53	87:60	(46)	(32)
Ru cat **282**	5	100:100	(5)	(5)	52	91:57	(47)	(30)
Ru cat **327**	50	88:60	(44)	(30)	52	88:60	(47)	(31)
Ru cat **326**	48	68:90	(33)	(43)	50	67:92	(34)	(46)
Ru cat **328**	51	81:47	(38)	(22)	55	88:53	(42)	(26)
Ru cat **330**	43	88:63	(37)	(27)	43	89:72	(38)	(31)
Ru cat **294**	0	—	(0)	(0)	30	100:95	(30)	(29)
Ru cat **329**	26	89:69	(23)	(18)	28	93:72	(26)	(20)
Ru cat **316**	5	100:100	(5)	(5)	5	91:71	(5)	(4)
Gr II	49	65:69	(32)	(33)	50	58:68	(29)	(34)
Hov II	52	87:65	(34)	(45)	54	88:66	(48)	(36)



Catalyst (x eq), solvent



I + 

II

Catalyst	x	Solvent	Temp (°)	Time (h)	Conv. (%)[a]	**I**	**II**	
Gr I	0.000025	—	60	4	7	(—)	(—)	377
Gr II	0.000025	—	60	4	51	(—)	(—)	377
Ru cat **5**	0.000025	—	60	4	47	(—)	(—)	376
Ru cat **287**	0.000025	—	50	3	49	(—)	(—)	376
Ru cat **287**	0.000006	—	50	3	37	(—)	(—)	376
Ru cat **75**	0.01	—	80	12	99	(96)	(96)	379
Ru cat **76**	0.01	—	80	12	99	(85)	(80)	379
Hov II	0.01	[bmim][PF_6]	40	4	78	(—)	(—)	535
Gr II	0.01	[bmim][PF_6]	60	4	75	(—)	(—)	535
Hov II	0.01	[bmim][PF_6]	60	4	87	(—)	(—)	535
Hov II	0.01	[bmim][BF_4]	40	4	79	(—)	(—)	535
Gr II	0.01	[bmim][BF_4]	60	4	78	(—)	(—)	535
Hov II	0.01	[bmim][BF_4]	60	4	87	(—)	(—)	535
Hov II	0.01	[bmim][NTf_2]	40	4	74	(—)	(—)	535
Gr II	0.01	[bmim][NTf_2]	60	4	73	(—)	(—)	535
Hov II	0.01	[bmim][NTf_2]	60	4	85	(—)	(—)	535
Hov II	0.01	[bdmim][PF_6]	40	4	81	(—)	(—)	535
Hov II	0.01	[bdmim][PF_6]	60	4	90	(—)	(—)	535
Hov II	0.01	[bdmim][BF_4]	40	4	85	(—)	(—)	535
Hov II	0.01	[bdmim][BF_4]	40	4	92	(—)	(—)	535

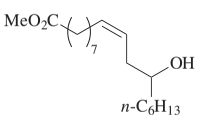
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

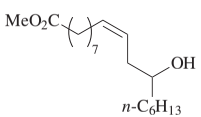
B. COMPOUNDS WITH AN INTERNAL DOUBLE BOND (*Continued*)

Internal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

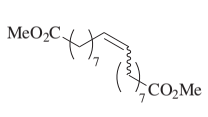
Please refer to the charts preceding the tables for the catalyst structures.

C_{18}

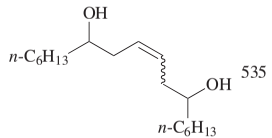




Catalyst (0.01eq), solvent, 60°, 4 h

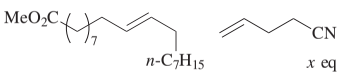


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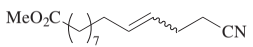


535

Catalyst	Solvent	Conv. (%)[a]
Gr I	[bmim][PF_6]	45
Gr I	[bmim][BF_4]	41
Gr I	[bmim][NTf_2]	38
Gr II	[bmim][PF_6]	58
Gr II	[bmim][BF_4]	56
Gr II	[bmim][NTf_2]	55



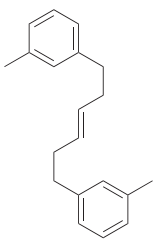
Hov II (0.02 eq),
BQ (0.5 eq),
PhCl, 110°

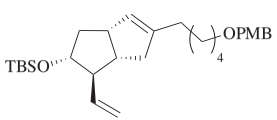


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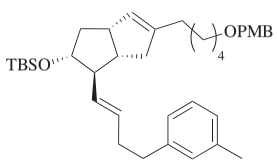
x	Time (h)	Conv. (%)[a]
0.15	6	69
0.25	6	79
0.25	8	74
0.25	4	89
0.3	6	78
0.5	6	23

C_{20}





Gr II (0.06 eq),
toluene, 80°, 8 h

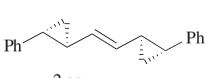
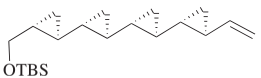
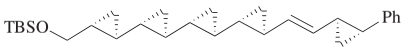
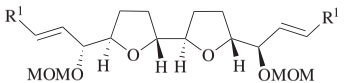
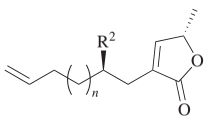
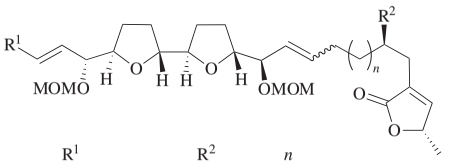


(69) (*E*)/(*Z*) = 90:10

128

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

B. COMPOUNDS WITH AN INTERNAL DOUBLE BOND (*Continued*)

Internal Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{20}  2 eq		Gr I (0.05 eq), DCM, reflux, 12 h	 (94) (*E*)/(*Z*) = 78:22	447
C_{22-32}  1 eq 		Gr II (0.1 eq), BQ (0.2 eq), DCM		537

R^1	R^2	*n*	
$TBSO(CH_2)_4$	TBSO	7	(41)
$TBSO(CH_2)_9$	TBSO	7	(40)
$TBSO(CH_2)_9$	H	6	(41)

[a] The conversion was determined by GC analysis.

[b] The yield was determined by HPLC analysis.

[c] The conversion, selectivity, and yield were determined by GC analysis.

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS
(*Continued*)

C. COMPOUNDS WITH CONJUGATED DOUBLE BONDS

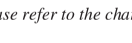
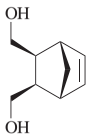
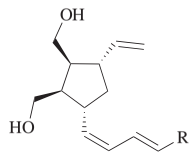
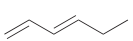
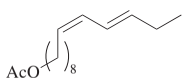
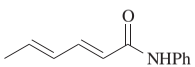
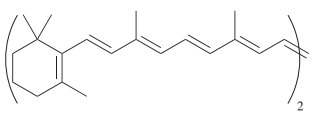
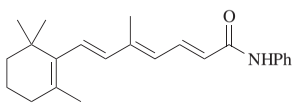
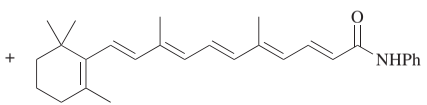
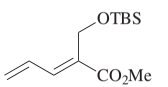
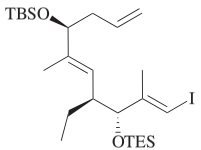
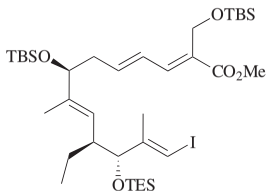
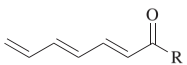
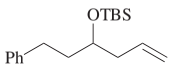
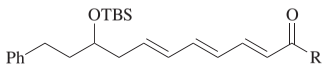
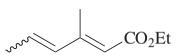
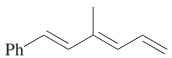
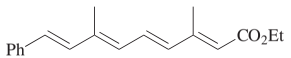
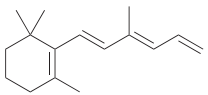
Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{4-10}  10 eq		Ru cat **151** (*x* eq), DCM, 22°, 2 h	 R = MeO: *x* = 0.02 (84) (*Z*)/(*E*) = 91:9; R = *n*-C_6H_{13}: *x* = 0.05 (80) (*Z*)/(*E*) = 98:2	83
C_6  1.5 eq		Ru cat **216** (0.04 eq) DCE, 50°, 24 h	 (56) (*Z*)/(*E*) > 95:5	538
 4 eq		Hov II (0.15 eq), toluene/DCM, rt, 72 h	 (13) (*E*)/(*Z*) = 98:2; +  (22) (*E*)/(*Z*) =91:9	539

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

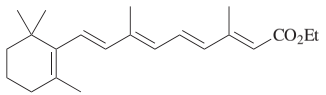
C. COMPOUNDS WITH CONJUGATED DOUBLE BONDS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6				
 2 eq		Hov II (0.15 eq), EtOAc, rt, 3.5 h	 (56) (*E*)/(*Z*) = 87:13	540
C_7				
 *x* eq		Gr I (0.01 eq), DCM, reflux, 5 h		541
			x R (72) (*E*)/(*Z*) = 80:20; 1.5 EtO (84) 83:17	
 3 eq		Hov II (0.1 eq), toluene, rt	 (90) (*E*)/(*Z*) = 99:1	542

3 eq



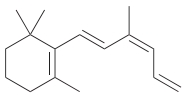
Hov II (0.1 eq),
toluene, rt



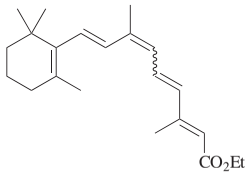
(88) (*E*)/(*Z*) = 97:3

542

3 eq

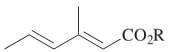


Hov II (0.1 eq),
toluene, rt



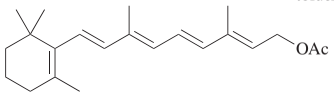
(37)

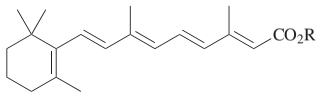
542



4 eq

Catalyst (0.15 eq),
toluene, rt, 96 h





R	Catalyst		(*E*)/(*Z*)
Et	Hov II	(55)	97:3
Et	Gr II	(35)	99:1
Ph	Hov II	(40)	98:2

539

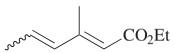
TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

C. COMPOUNDS WITH CONJUGATED DOUBLE BONDS (*Continued*)

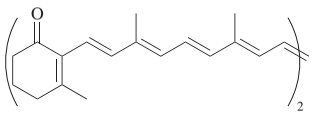
Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

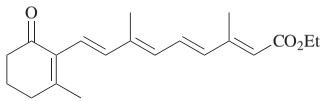
C_7



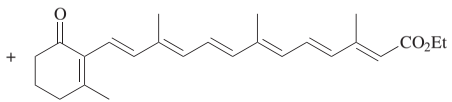
4 eq



Hov II (0.15 eq), toluene, rt

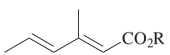


(13) (*E*)/(*Z*) = 94:6

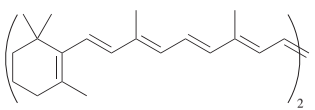


(21) (*E*)/(*Z*) =88:17

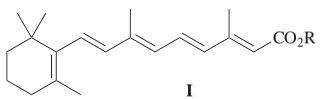
539



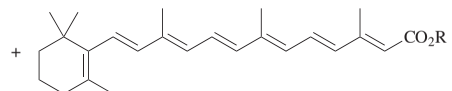
4 eq



Catalyst (0.15 eq), toluene, rt



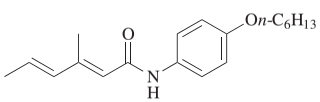
I



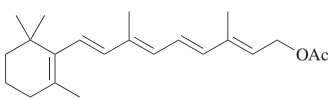
II

539

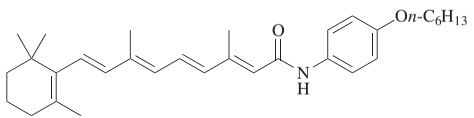
R	Catalyst	Time (h)	**I**	(*E*)/(*Z*) **I**	**II**	(*E*)/(*Z*) **II**
Et	Hov II	24	(9)	97:3	(38)	96:4
Et	Hov II	96	(31)	90:10	(15)	94:6
Ph	Hov II	24	(6)	95:5	(50)	99:1
Ph	Hov II	96	(33)	97:3	(57)	98:2
Ph	Gr II	96	(4)	97:3	(23)	99:1



1.2 eq



Hov II (0.15 eq),
toluene/DCM,
rt, 96 h

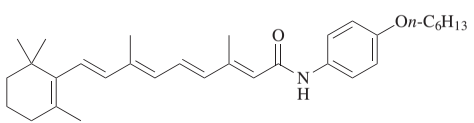


(26) (*E*)/(*Z*) = 99:1

539

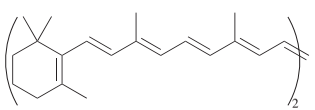
2 eq

Hov II (0.15 eq),
DCM, rt, 96 h

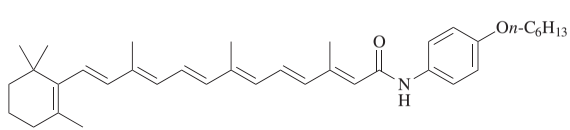


(22) (*E*)/(*Z*) = 99:1

539

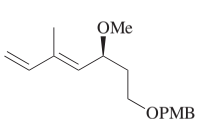


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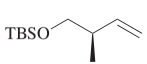


(32) (*E*)/(*Z*) = 95:5

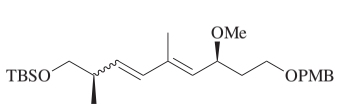
C_8



1.2 eq



Gr II (0.01 eq),
toluene,
reflux, 3 h

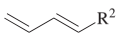
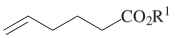
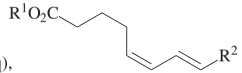
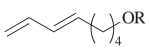
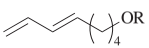
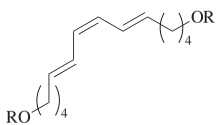
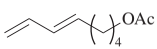
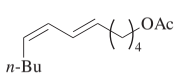
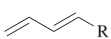
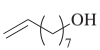
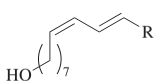


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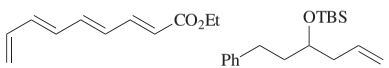
543

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

C. COMPOUNDS WITH CONJUGATED DOUBLE BONDS (*Continued*)

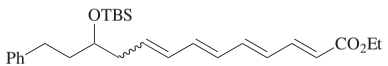
Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{8-10}  3 eq		1. Ru cat **152** (0.01 eq), (*Z*)-butene (20 eq), THF, 22°, 1 h 2. Ru cat **152** (0.04 eq), THF, 100 torr, 22°, 8 h	 R^1 = H, R^2 = $HO(CH_2)_4$ (59) 95:5; R^1 = Bn, R^2 = Ph (80) 97:3; R^1 = Bn, R^2 = 4-$MeOC_6H_4$ (56) 97:3	395
C_8 		Ru cat **216** (0.027 eq), 50°, 24 h	 R = H (57) >95:5; R = Ac (74) >95:5	538
 1.5 eq		Ru cat **216** (0.04 eq), DCE, 50°, 24 h	 (30) (*Z*)/(*E*) > 95:5	538
C_{8-10}  1.5 eq		Ru cat **216** (0.04 eq), 50°, 24 h	 R = $AcO(CH_2)_4$ (75) >95:5; R = Ph (15) >95:5; R = 4-$MeOC_6H_4$ (25) >95:5	538

C_9



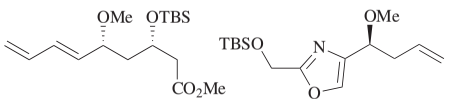
2 eq

Gr I (0.01 eq),
DCM, reflux, 5 h



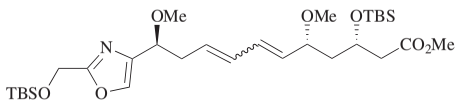
62% conv.[a]

541



3 eq

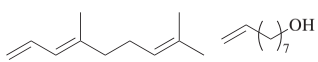
Catalyst (0.1 eq),
solvent



544

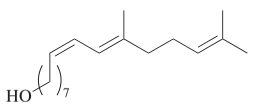
Catalyst	Solvent	Temp (°)	
Gr I	toluene	80	(—)
Gr II	DCM	40	(—)
Hov II	DCM	40	(—)
Gr II	toluene	60	(24)
Hov II	toluene	60	(40)
Hov II	toluene	80	(51)

C_{11}



1.5 eq

Ru cat **216** (0.02 eq)
50°, 24 h

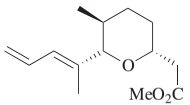
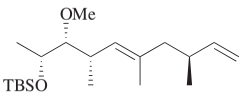
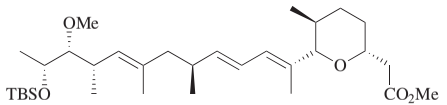
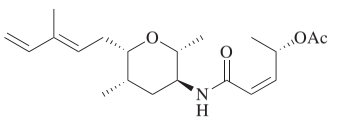
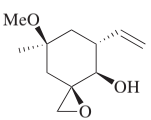
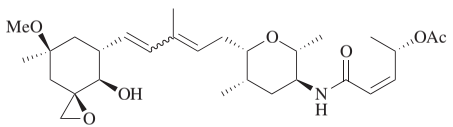
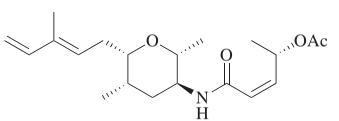
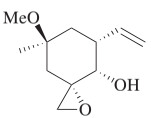
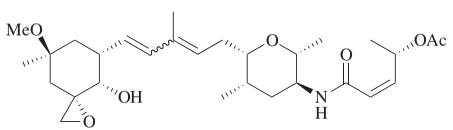


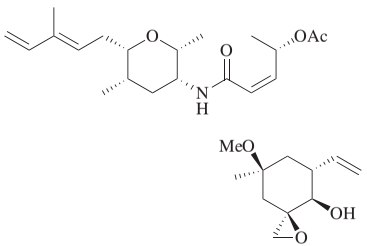
(>95) (*Z*)/(*E*) > 95:5

538

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

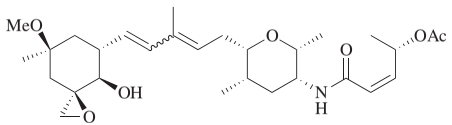
C. COMPOUNDS WITH CONJUGATED DOUBLE BONDS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{13}				
 3 eq		Hov II (0.05 eq), DCM, rt, 48 h	 (76) (*E*)/(*Z*) = 93:7	545
	 1.2 eq	Gr II (0.08 eq), DCM, reflux, 5 h	 (52)	546
	 1.2 eq	Gr II (0.08 eq), DCM, reflux, 5 h	 (55)	546



1.2 eq

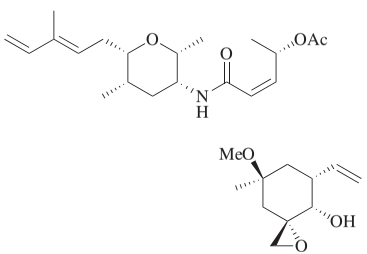
Gr II (0.08 eq),
DCM, reflux, 5 h



(57)

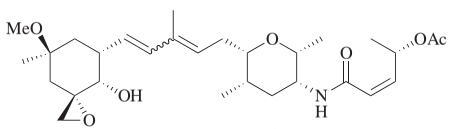
546

C_{13}



1.2 eq

Gr II (0.08 eq),
DCM, reflux, 5 h

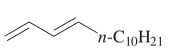
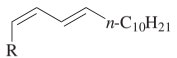
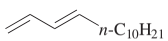
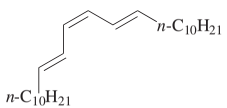
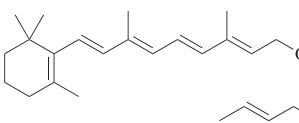
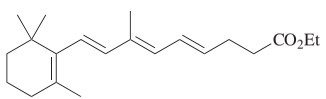


(53)

546

TABLE 1. CROSS-METATHESIS OF UNSATURATED COMPOUNDS WITH FUNCTIONAL GROUPS IN HOMOALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

C. COMPOUNDS WITH CONJUGATED DOUBLE BONDS (*Continued*)

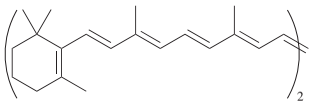
Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{14}				
 1.5 eq		Ru cat **216** (*x* eq) 50°, 24 h		538
				
				
C_{20}				
 2 eq		Hov II (0.15 eq), toluene, rt, 96 h		539

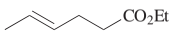
R	*x*		(*Z*)/(*E*)
$HO(CH_2)_7$	0.02	(84)	>95:5
$OHC(CH_2)_8$	0.04	(59)	>95:5
$AcO(CH_2)_4$	0.04	(69)	>95:5
$Ac(CH_2)_2$	0.04	(41)	>95:5
$Br(CH_2)_6$	0.04	(34)	>95:5
$NC(CH_2)_2$	0.04	(12)	>95:5

Ru cat **216** (0.027 eq) DCE, 50°, 24 h — (62) (*Z*)/(*E*) > 95:5 — 538

(10) (*E*)/(*Z*) = 83:17

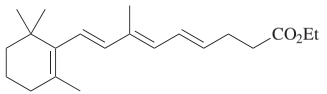
C_{40}





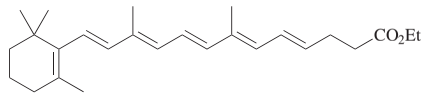
3 eq

Hov II (0.15 eq),
toluene, rt, 96 h



(20) (*E*)/(*Z*) = 60:40

\+



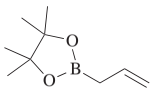
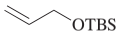
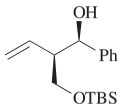
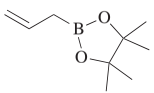
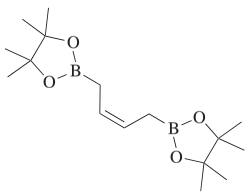
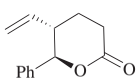
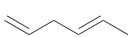
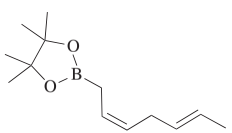
(6) (*E*)/(*Z*) = 83:17

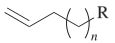
539

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[a] The conversion was determined by ^{1}H NMR analysis.

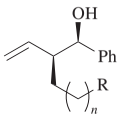
TABLE 2. CROSS-METATHESIS OF ALLYLIC BORONATES

Allylic Boronate	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
	 5 eq	1. W cat **3** (0.05 eq), benzene, 100 torr, 22°, 2 h 2. PhCHO (2 eq), THF, rt, 2 h	 (79) dr 91:9	547
		Catalyst (0.02 eq), THF, 35°		
			Catalyst / Time (h) / (Z)/(E): Ru cat **217**: 4 (74) 95:5 — 84 Ru cat **215**: 3 (36) 95:5 — 488	
	 5 eq	1. W cat **3** (0.05 eq), benzene, 100 torr, 22°, 2 h 2. NaOH, H_2O	 (68) dr > 98:2	547
	 9 eq	Ru cat **216** (0.01 eq), THF, rt, 5 h	 (65) (Z)/(E) > 95:5	437

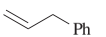


5 eq

1. W cat **3** (0.05 eq), benzene, 100 torr, 22°, 2 h
2. PhCHO (2 eq), THF, rt, 2 h

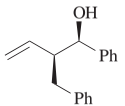


R	*n*		dr	
Br	5	(82)	95:5	547
PMBO	5	(84)	96:4	
Me	6	(72)	92:8	

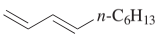


5 eq

1. W cat **3** (0.05 eq), benzene, 100 torr, 22°, 2 h
2. PhCHO (2 eq), THF, rt, 2 h

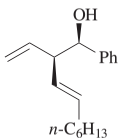


(91) dr 95:5 547

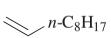


5 eq

1. W cat **3** (0.05 eq), benzene, 100 torr, 22°, 2 h
2. PhCHO (2 eq), THF, rt, 2 h

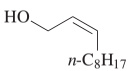


(72) dr 95:5 547



5 eq

1. Catalyst (0.05 eq), benzene, 100 torr, 22°, 2 h
2. H_2O_2, NaOH, 22°, 2 h



Catalyst		(*E*)/(*Z*)	
Mo cat **1**	(54)	74:26	547
Hov II	(31)	85:15	
Gr II	(16)	80:20	
W cat **3**	(65)	5:95	

TABLE 2. CROSS-METATHESIS OF ALLYLIC BORONATES (*Continued*)

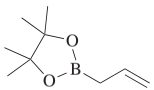
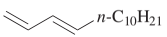
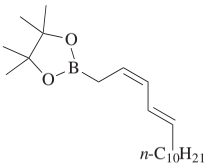
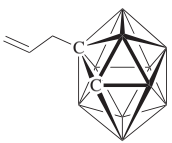
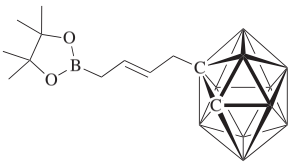
Allylic Boronate	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
	 1.5 eq	Ru cat **216** (0.04 eq) 50°, 24 h	 (60) (*Z*)/(*E*) > 95:5	538
3.5 eq		Gr II (0.013 eq), DCM, reflux, 14 h	 (55) (*E*)/(*Z*) = 89:11	436

TABLE 3. CROSS-METATHESIS OF ALLYLIC AMINES (NOT INCLUDING AMINES WITH A SUBSTITUTED CARBON IN THE α-POSITION)

A. PRIMARY AMINES

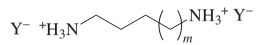
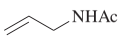
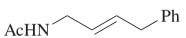
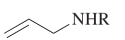
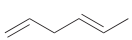
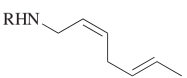
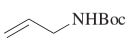
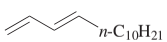
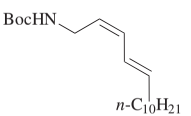
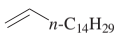
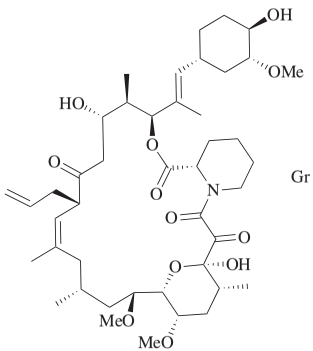
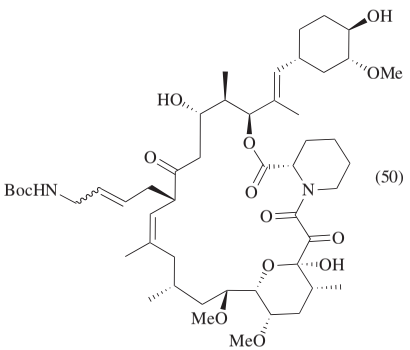
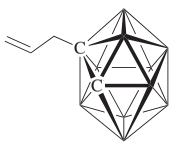
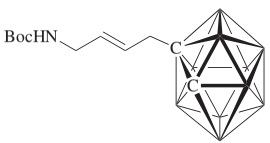
Primary Amine	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{3-11}				
		1. Hov II (0.05 eq) EtOAc, reflux, 16 h 2. H_2 (60 psi), MeOH rt, 16 h		548
			R Y n m H TfO 1 1 (91) H BF_4 1 1 (>99) H TsO 2 3 (90) Me TsO 8 15 (>99)	
C_3				
 2 eq		Gr I (0.05 eq), DCM, reflux, 16 h		(49) (*E*)/(*Z*) = 90:10 156
	 9 eq	Ru cat **216** (0.01 eq), THF, rt, 5 h		R (*Z*)/(*E*) Ph (68) >95:5 437 Boc (54) >95:5
	 1.5 eq	Ru cat **216** (0.04 eq), 50°, 24 h		(60) (*Z*)/(*E*) > 95:5 538

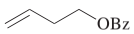
TABLE 3. CROSS-METATHESIS OF ALLYLIC AMINES (NOT INCLUDING AMINES WITH A SUBSTITUTED CARBON IN THE α-POSITION) (*Continued*)

A. PRIMARY AMINES (*Continued*)

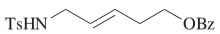
Primary Amine	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 3 eq		Mo cat **18** (0.03 eq), benzene, 7.0 torr, 5 h, 22°	 (75) (*Z*)/(*E*) = 81:19	5
20 eq		Gr II (0.1 eq), DCB	 (50)	432
5.5 eq		Gr II (0.036 eq), DCM, reflux, 48 h	 (70) (*E*)/(*Z*) > 95:5	436



2 eq

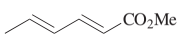


Catalyst (*x* eq),
DCM, 40°

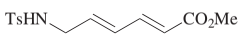


Catalyst	*x*	Time (h)		(*E*)/(*Z*)	
Ru cat **286**	0.05	8	(39)	>95:5	161
Ru cat **93**	0.02	24	(60)	>95:5	550

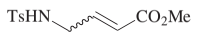
5 eq



Hov II (0.05 eq),
DCM, rt, 48 h

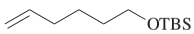


(36) (*E*)/(*Z*) = 95:5 549

+ 

(9)

2 eq

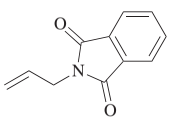


Ru cat **286** (*x* eq),
DCM, 40°, 8 h



161

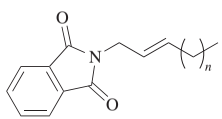
x		(*E*)/(*Z*)
0.02	(18)	>95:5
0.05	(45)	>95:5





5 eq

Catalyst (*x* eq),
solvent



551

n	Catalyst	*x*	Solvent	Temp (°)		(*E*)/(*Z*)
3	Hov II	0.05	DCM	40	(70)	88:12
7	Ru cat **216**	0.02	THF	rt	(62)	>5:95

TABLE 3. CROSS-METATHESIS OF ALLYLIC AMINES (NOT INCLUDING AMINES WITH A SUBSTITUTED CARBON IN THE α-POSITION) (*Continued*)

A. PRIMARY AMINES (*Continued*)

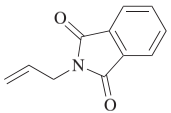
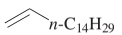
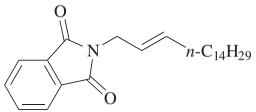
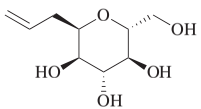
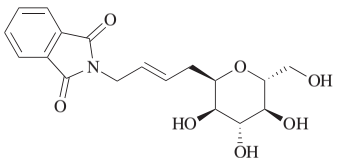
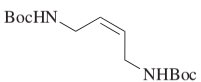
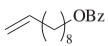
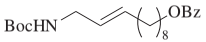
Primary Amine	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
	 3 eq	Mo cat **18** (0.03 eq), benzene, 7.0 torr, 5 h, 22°	 (87) (*Z*)/(*E*) = 85:15	5
4.4 eq		Hov II (0.1 eq), MeOH, $CHCl_3$, 40°, 36 h	 (57) (*E*)/(*Z*) = 80:20	552
C_4				
 4 eq		Gr II (0.05 eq), DCM, 45°	 (71) (*E*)/(*Z*) = 75:25	176

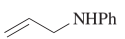
TABLE 3. CROSS-METATHESIS OF ALLYLIC AMINES (NOT INCLUDING AMINES WITH A SUBSTITUTED CARBON IN THE α-POSITION) (*Continued*)

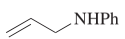
B. SECONDARY AMINES

Secondary Amine	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

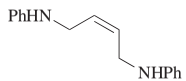
Please refer to the charts preceding the tables for the catalyst structures.

C_3

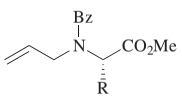


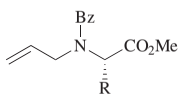


Catalyst (0.02 eq), THF, 35°

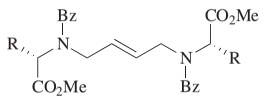


Catalyst	Time (h)		(*Z*)/(*E*)	
Ru cat **217**	2	(67)	71:29	84
Ru cat **215**	12	(12)	90:10	488





Gr II (*x* eq), DCE



553

R	*x*	Temp (°)	Time		(*E*)/(*Z*)
i-Pr	0.15	24	18 h	(0)	—
i-Pr	0.15	80	72 h	(27)	81:19
i-Pr	0.20	100 (MW)	10 min	(40)	83:17
i-Bu	0.15	24	18 h	(0)	—
i-Bu	0.15	80	72 h	(32)	75:25
i-Bu	0.20	100 (MW)	10 min	(54)	68:32
Bn	0.075	24	18 h	(0)	—
Bn	0.075	24	72 h	(0)	—
Bn	0.075	80	18 h	(29)	70:30
Bn	0.075	80	72 h	(34)	70:30
Bn	0.05	100 (MW)	10 min	(48)	73:27

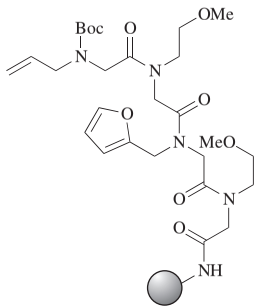
TABLE 3. CROSS-METATHESIS OF ALLYLIC AMINES (NOT INCLUDING AMINES WITH A SUBSTITUTED CARBON IN THE α-POSITION) (*Continued*)

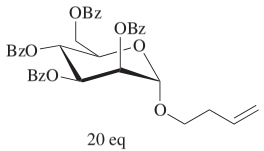
B. SECONDARY AMINES (*Continued*)

Secondary Amine	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

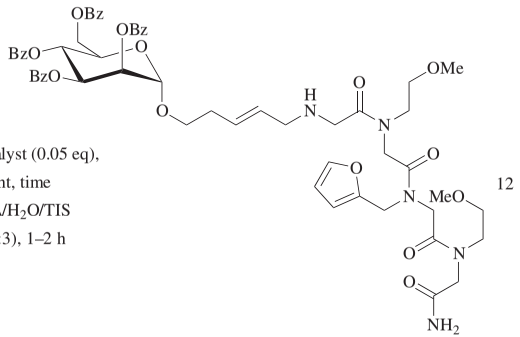
C_{11}





20 eq

1. Catalyst (0.05 eq), solvent, time
2. TFA/H_2O/TIS (92:5:3), 1–2 h



12

Catalyst	Solvent	Temp (°)	Time	Conv. (%)[a]
Gr I	DCM	40	8 h	<5
Gr II	DCM	40	8 h	10
Hov II	DCM	40	8 h	29
Gr I	DCB	MW	3 min	<5
Gr II	DCB	MW	3 min	<5
Hov II	DCB	MW	3 min	20

[a] The conversion was determined by HPLC analysis.

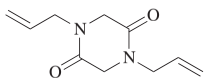
TABLE 3. CROSS-METATHESIS OF ALLYLIC AMINES (NOT INCLUDING AMINES WITH A SUBSTITUTED CARBON IN THE α-POSITION) (*Continued*)

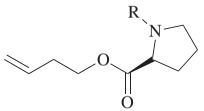
C. TERTIARY AMINES

Tertiary Amine	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

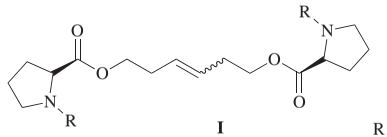
C_{10}





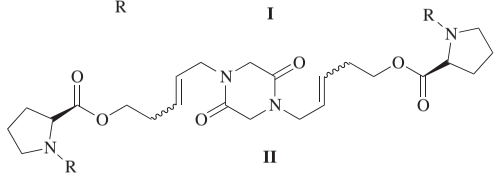
3 eq

Gr II (0.10 eq), $CHCl_3$, reflux, 10 h



I

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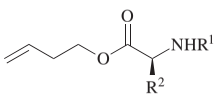


II

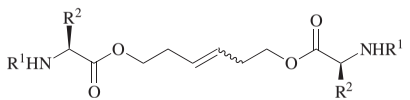
R	I	II
Boc	(55)	(35)
Fmoc	(52)	(46)

554

3 eq

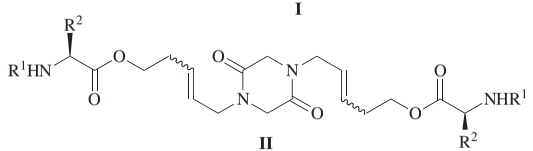


Gr II (0.10 eq), $CHCl_3$, reflux, 10 h



I

\+



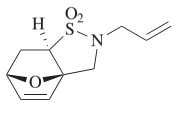
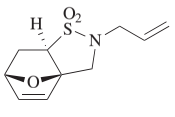
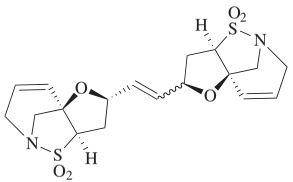
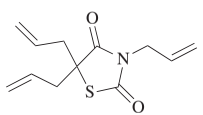
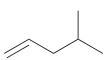
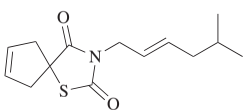
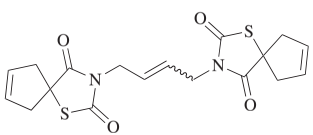
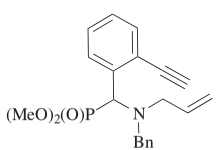
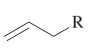
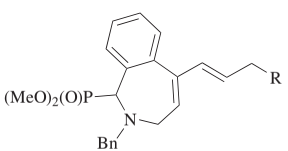
II

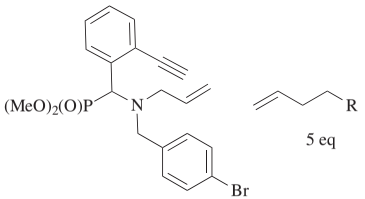
R^1	R^2	I	II
Boc	$PhCH_2$	(50)	(44)
Boc	Me	(66)	(39)
Boc	$CH_3S(CH_2)_2$	(14)	(0)
Boc	*i*-$Pr(CH_2)_2$	(59)	(30)
Fmoc	$PhCH_2$	(48)	(42)
Fmoc	H	(44)	(30)

554

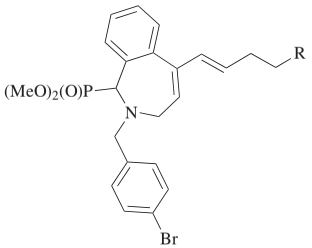
TABLE 3. CROSS-METATHESIS OF ALLYLIC AMINES (NOT INCLUDING AMINES WITH A SUBSTITUTED CARBON IN THE α-POSITION) (*Continued*)

C. TERTIARY AMINES (*Continued*)

Tertiary Amine	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{10}				
 (±)	 (±)	Gr II (0.1 eq), DCM, 50°, 3 h	 (84)	359
C_{12}				
	 5 eq	Hov II (0.02 eq), DCM, rt, 8 h	 (57) (*E*)/(*Z*) = 87:13 +  (14)	555
	 5 eq	Gr II (0.1 eq), DCM, reflux, 2 + 4 h	 R = TMS (74) (*E*)/(*Z*) = 66:34 R = $AcCH_2$ (68) (*E*)/(*Z*) = 67:33	556



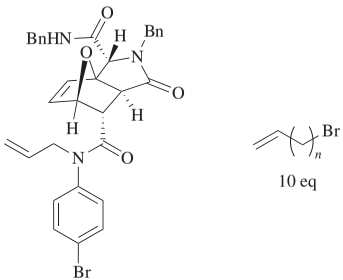
Gr II (0.1 eq),
DCM, reflux,
2 + 4 h



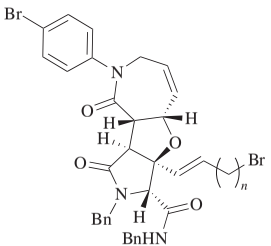
(*E*) only

R		
Br	(50)	556
Et	(70)	

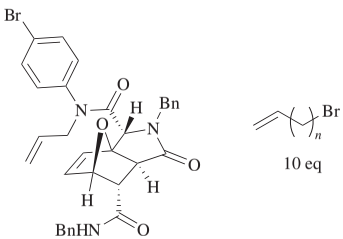
C_{13}



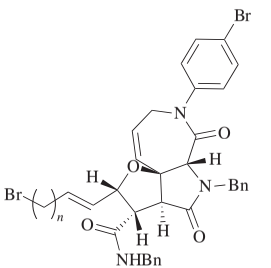
Gr II (0.1 eq),
DCM, rt, 3–12 h



n		(*E*)/(*Z*)	
2	(81)	60:40	557
3	(82)	67:33	



Gr II (0.1 eq),
DCM, rt, 3–12 h



n		(*E*)/(*Z*)	
2	(30)	50:50	557
3	(41)	55:45	

TABLE 3. CROSS-METATHESIS OF ALLYLIC AMINES (NOT INCLUDING AMINES WITH A SUBSTITUTED CARBON IN THE α-POSITION) (*Continued*)

C. TERTIARY AMINES (*Continued*)

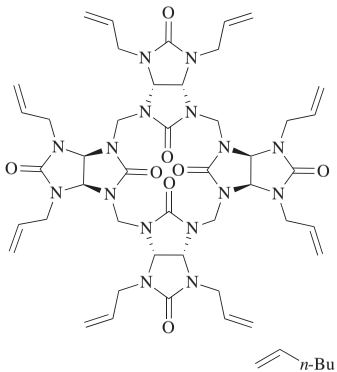
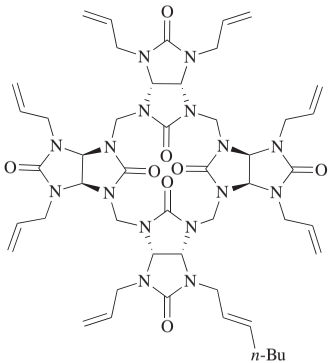
Tertiary Amine	Cross Partner	Conditions	Product(s) and Yield(s) (%)		Refs.
Please refer to the charts preceding the tables for the catalyst structures.					
C_{36} 	 *n*-Bu 2.5 eq	Gr II (0.1 eq), DCM		(20)	558

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES

A. ALLYLIC ALCOHOLS

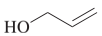
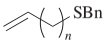
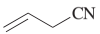
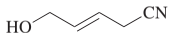
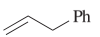
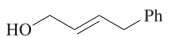
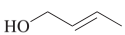
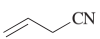
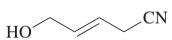
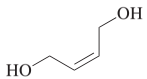
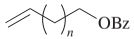
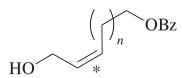
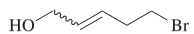
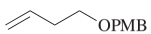
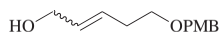
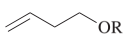
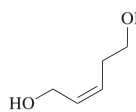
Allylic alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 10 eq		Hov II (0.06 eq), *t*-BuOH/H_2O (1:1), 32°, 3.5 h		*n* 0 (0) 1 (52) 2 (19) 3 (8)	559
10 eq		Hov II (0.06 eq), t-BuOH/H_2O (1:1), 32°, 3.5 h		(11)	559
2 eq		Gr II (0.05 eq), DCM, reflux, 2 h		(38) (*E*)/(*Z*) = 94:6	182
2 eq		Gr I (0.05 eq), DCM, reflux, 16 h		(72) (*E*)/(*Z*) = 75:25	156
C_4					
	 2 eq	Gr II (0.05 eq), DCM, reflux, 2 h		(46) (*E*)/(*Z*) = 94:6	182

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

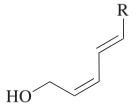
A. ALLYLIC ALCOHOLS (*Continued*)

Allylic alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 2 eq		Catalyst (0.05 eq), $AlCl_3$ (*x* eq), THF, rt, 6 h		560

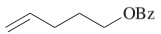
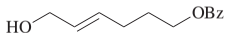
n	Catalyst	*x*		*(*E*)/(Z)
0	Ru cat **366**	0	(19)	80:20
0	Ru cat **366**	0.05	(84)	4:96
3	Ru cat **365**	0	(27)	88:12
3	Ru cat **366**	0	(35)	86:14
3	Ru cat **366**	0.05	(77)	10:90
3	Ru cat **367**	0	(30)	84:16
8	Ru cat **366**	0	(38)	89:11
8	Ru cat **366**	0.05	(63)	10:90

2 eq		Hov II (0.01 eq), DCM, 23°, 4 h		(97)	180
3 eq		Hov II (0.01 eq), DCM, rt, 4 h		(85)	561
2 eq		Ru cat **152** (0.05 eq), THF, 22°, 4 h			183

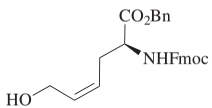
R		(*Z*)/(*E*)
TBS	(65)	93:7
4-$O_2NC_6H_4$	(74)	96:4

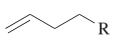
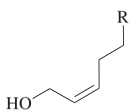
2 eq  Catalyst (0.05 eq), THF, 22°  183

R	Catalyst	Time (h)		(*Z*)(*E*)
MeO	Ru cat **152**	8	(63)	92:8
t-BuO_2C	Ru cat **152**	8	(56)	96:4
n-C_5H_{11}	Ru cat **152**	8	(54)	87:13
n-C_6H_{13}	Ru cat **152**	8	(66)	95:5
n-C_6H_{13}	Ru cat **215**	12	(53)	93:7

1 eq  Catalyst (0.025 eq), DCM, rt, 5 h  (*E*)/(*Z*) > 95:5

Catalyst		
Ru cat **41**	(75)	562
Ru cat **44**	(85)	
Ru cat **45**	(84)	

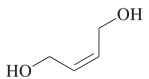
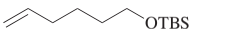
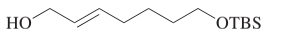
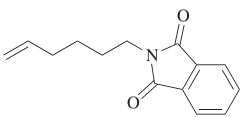
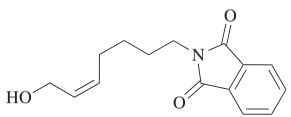
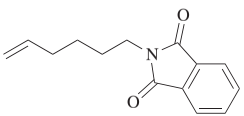
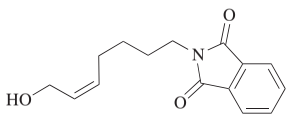
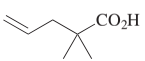
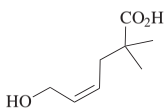
2 eq  Ru cat **152** (0.05 eq), THF, 22°, 4 h  (73) (*Z*)/(*E*) = 98:2 183

2 eq  Catalyst (0.05 eq), THF, 22°, 4 h  183

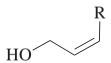
R	Catalyst		(*Z*)/(*E*)
BnO_2C	Ru cat **152**	(80)	98:2
HO_2CCH_2	Ru cat **152**	(70)	96:4
HO_2CCH_2	Ru cat **215**	(<2)	—
$OHC(CH_2)_6$	Ru cat **152**	(80)	94:6
$OHC(CH_2)_6$	Ru cat **215**	(30)	87:13
n-C_8H_{17}	Ru cat **152**	(72)	96:4

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

A. ALLYLIC ALCOHOLS (*Continued*)

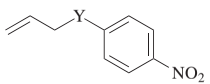
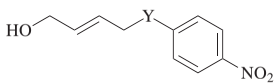
Allylic alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 2 eq		Ru cat **286** (0.02 eq), DCM, 40°, 8 h	 (39) (*E*)/(*Z*) = 91:9	161
2 eq		Ru cat **152** (0.05 eq), THF, 22°, 4 h	 (64) (*Z*)/(*E*) = 98:2	183
2 eq		Catalyst (0.05 eq), $AlCl_3$ (*x* eq), THF, rt, 6 h		560
2 eq		Ru cat **152** (0.05 eq), THF, 22°, 4 h	 (61) (*Z*)/(*E*) = 98:2	183

Catalyst	*x*		(*Z*)/(*E*)
Ru cat **365**	0	(13)	86:14
Ru cat **366**	0	(22)	83:17
Ru cat **366**	0.05	(87)	9:91
Ru cat **367**	0	(18)	80:20

2 eq  Ru cat **152** (0.05 eq), THF, 22°, 4 h  (*Z*)/(*E*) = 98:2

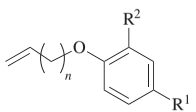
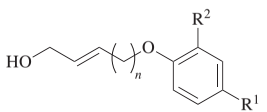
R		
	(59)	
	(63)	

183

2 eq  Catalyst (0.05 eq), $AlCl_3$ (*x* eq), THF, rt, 6 h 

560

Y	Catalyst	*x*		(*E*)/(*Z*)
HN	Ru cat **366**	0.05	(71)	95:5
O	Ru cat **365**	0	(19)	23:77
O	Ru cat **366**	0	(28)	21:79
O	Ru cat **366**	0.05	(88)	89:11
O	Ru cat **367**	0	(23)	30:70

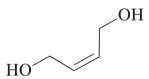
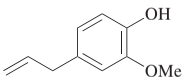
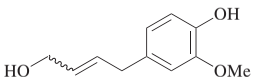
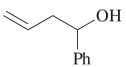
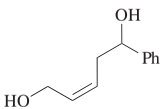
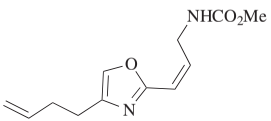
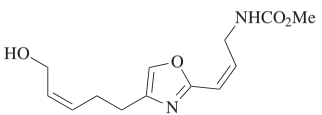
2 eq  Ru cat **366** (0.05 eq), $AlCl_3$ (0.05 eq), THF, rt, 6 h 

560

n	R^1	R^2		(*E*)/(*Z*)
2	NC–	H	(51)	79:21
5	H	Br	(75)	92:8

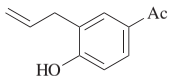
TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

A. ALLYLIC ALCOHOLS (*Continued*)

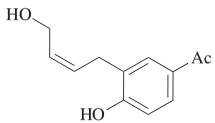
Allylic alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 6.3 eq		Gr II (0.02 eq), PE, rt, 23 h	 (86)	511
2 eq		Ru cat **152** (0.05 eq), THF, 22°, 4 h	 (64) $(Z)/(E)$ = 96:4	183
2 eq		Catalyst (0.05 eq), THF, 22°, 12 h	 (86)	183

Catalyst		$(Z)/(E)$
Ru cat **215**	(—)	61:39
Ru cat **151**	(55)	97:3
Ru cat **152**	(70)	98:2

2 eq



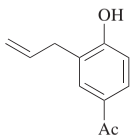
Catalyst (0.05 eq),
THF, 22°, 4 h



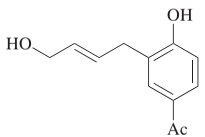
Catalyst		(*Z*)/(*E*)
Ru cat **215**	(50)	82:18
Ru car **152**	(68)	98:2

183

2 eq



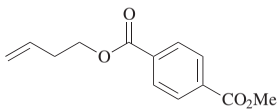
Ru cat **366** (0.05 eq),
$AlCl_3$ (0.05 eq),
THF, rt, 6 h



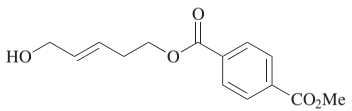
(51) (*E*)/(*Z*) = 93:7

560

2 eq



Ru cat **366** (0.05 eq),
$AlCl_3$ (0.05 eq),
THF, rt, 6 h



(66) (*E*)/(*Z*) = 94:6

560

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

A. ALLYLIC ALCOHOLS (*Continued*)

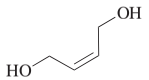
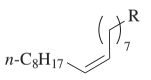
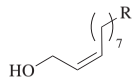
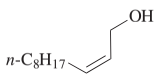
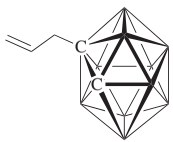
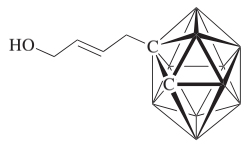
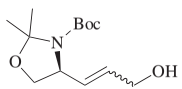
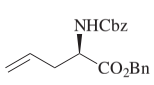
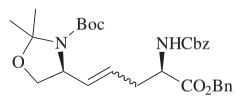
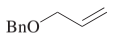
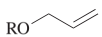
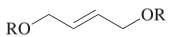
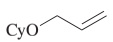
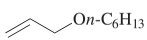
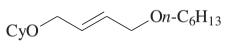
Allylic alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 2 eq		Ru cat **152** (0.05 eq), THF, 22°, 6 h	 **I** +  **II**	183
			R / **I** / (*Z*)/(*E*) **I** / **II** / (*Z*)/(*E*) **II** HO (62) 96:4 (59) 94:6 MeO_2C (65) 94:6 (60) 94:6	
6.3 eq		Gr II (0.014 eq), DCM, THF, reflux, 16 h	 (76) (*E*)/(*Z*) = 93:7	436
C_5				
 5 eq		Gr II (0.05 eq), toluene, reflux, 3 h	 (9)	563

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

B. ALLYLIC ETHERS

Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
	 10 eq	Hov II (0.06 eq), *t*-BuOH/H_2O (1:1), 32°, 3.5 h	 (31)	559
		Gr I (0.05 eq), benzene, 40°		564

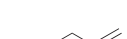
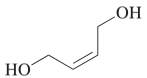
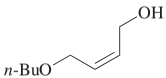
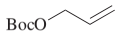
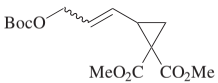
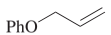
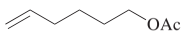
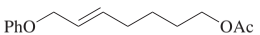
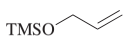
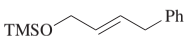
R	Time (min)		(*E*)/(*Z*)
Bn	5	(68)	81:19
Ph_3C	5	(23)	66:34
TBS	5	(35)	89:11
Bn	30	(66)	86:14
Ph_3C	30	(41)	75:25
TBS	30	(46)	91:9
Bn	240	(69)	88:12
Ph_3C	240	(66)	86:14
TBS	240	(59)	94:6
Bn	1440	(62)	88:12
Ph_3C	1440	(61)	89:11
TBS	1440	(51)	95:5

		Catalyst (0.025 eq), DCM, 3 h		565

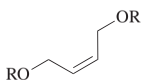
Catalyst	Temp (°)		(*E*)/(*Z*)
Gr II	40	(21)	86:14
Hov II	40	(18)	89:11
Ru cat **154**	40	(35)	89:11
Ru cat **155**	20	(10)	93:7

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

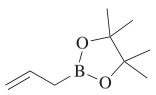
B. ALLYLIC ETHERS (*Continued*)

Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
	 2 eq	Ru cat **152** (0.05 eq), THF, 22°, 12 h	 (57) (*Z*)/(*E*) = 91:9	183
 1.4 eq		Gr II (0.01 eq), DCM, reflux	 (6)	407
		Catalyst (0.025 eq), DCM, 20°, 3 h		565
			Catalyst (47) (*E*)/(*Z*) Gr II (47) 88:12 Hov II (53) 83:17 Ru cat **155** (43) 90:10	
 2 eq		Gr I (0.05 eq), DCM, reflux, 16 h	 (79) (*E*)/(*Z*) = 67:33	156

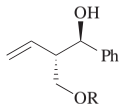
C_4



3 eq



1. Gr II (x eq), DCM, reflux, 2–12 h
2. PhCHO (1.5 eq), 23°, 12–48 h

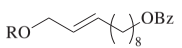


R	x		*anti/syn*[a]	
TBS	0.05	(44-67)	80:20	126
Bn	0.05	(60)	82:18	
Bn	0.02	(63)	76:24	

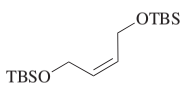
2 eq

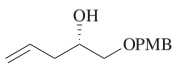


Gr I (0.05 eq), DCM, 45°

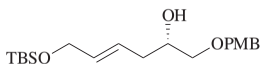


R		$(E)/(Z)$	
TBS	(77)	91:9	176
t-Bu	(90)	88:12	
Bn	(71)	90:10	



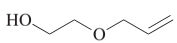


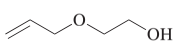
Gr II (0.1 eq), DCM, reflux, , 1 h



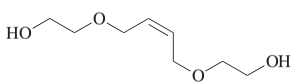
(50) $(E)/(Z)$ = 71:29 566

C_5





Catalyst (x eq), THF, 35°

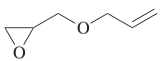
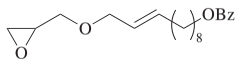
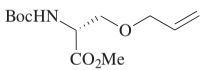
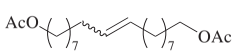
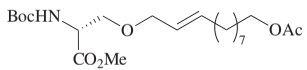
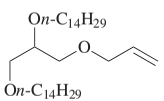
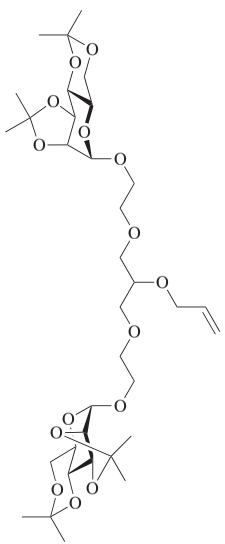
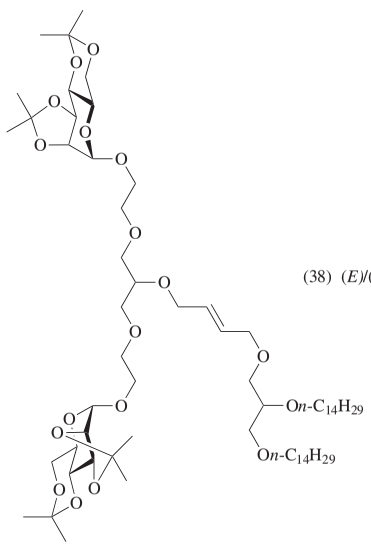


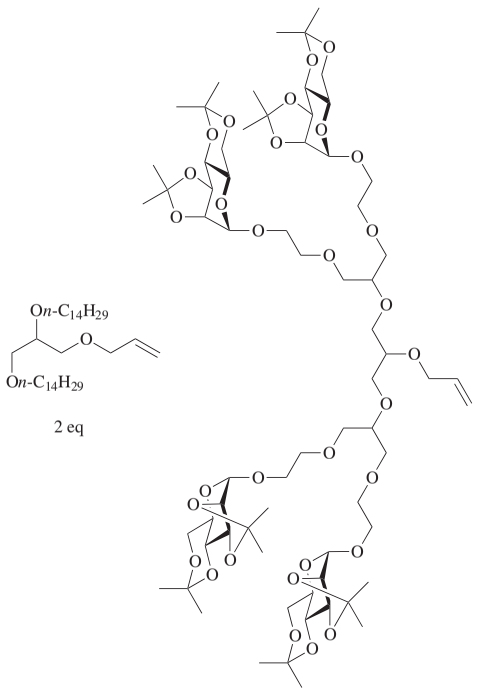
$(Z)/(E)$ = 67:33

Catalyst	x	Time (h)		
Ru cat **217**	0.02	1	(73)	84
Ru cat **215**	0.001	12	(30)	488

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

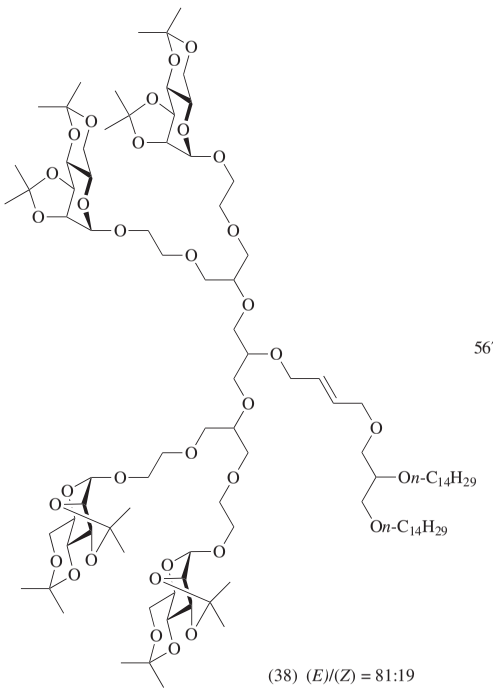
B. ALLYLIC ETHERS (*Continued*)

Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6				
		Gr I (0.05 eq), DCM, 45°, 12 h	 (61) (*E*)/(*Z*) = 75:25	124
	 2 eq	Gr I (0.05 eq), DCM, 45°	 (86) (*E*)/(*Z*) = 86:14	176
 2 eq		Gr II (0.1 eq), DCM, reflux, 14 h	 (38) (*E*)/(*Z*) = 73:27	567



2 eq

Gr II (0.1 eq),
DCM,
reflux, 22 h

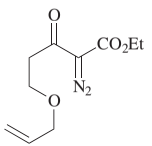
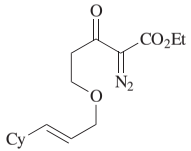
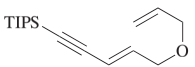
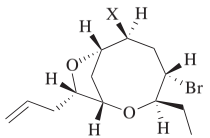
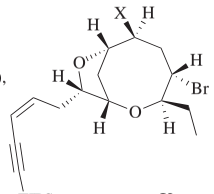
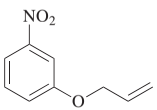
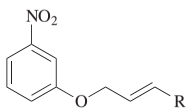
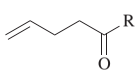
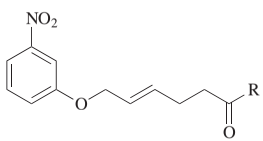


567

(38) (*E*)/(*Z*) = 81:19

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

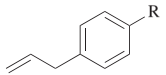
B. ALLYLIC ETHERS (*Continued*)

Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8 	 10 eq	Gr II (0.05 eq), DCM, reflux, 18 h	 (89) (*E*)/(*Z*) = 90:10	569
 5 × 1.5 eq		1. Hov II (5 × 0.07 eq), benzene, 70°, 6 h 2. DMSO, rt, 12 h		570
C_9  4 eq		Gr I (0.05 eq), DCM, 45°, 14 h		568
4 eq		Gr I (0.05 eq), DCM, 45°, 14 h		568

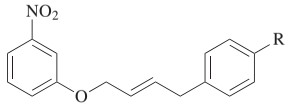
X	*x*		(*Z*)/(*E*)
Cl	0.07	(88)	79:21
Br	0.09	(75)	80:20

R		(*E*)/(*Z*)
$TBSOCH_2$	(47)	92:8
$Br(CH_2)_3$	(47)	77:23
Cy	(37)	(*E*) only
$Ph(CH_2)_2$	(79)	77:23

R		(*E*)/(*Z*)
Me	(51)	76:14
MeO	(57)	52:48

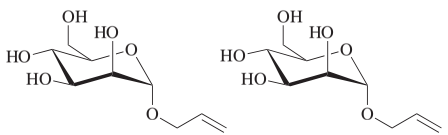
4 eq 

Gr I (0.05 eq),
DCM, 45°, 14 h

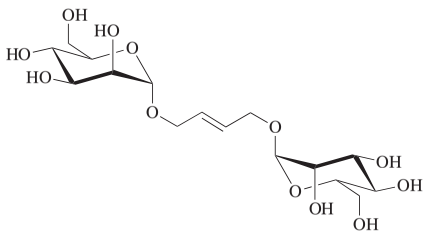


568

R		(*E*)/(*Z*)
H	(31)	82:18
MeO	(49)	85:15

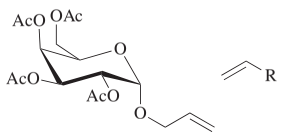


Gr I (0.1 eq),
DCM/MeOH (3:1)



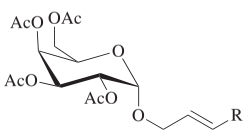
497

Temp (°)	Time (h)		(*E*)/(*Z*)
rt	8	(60)	63:37
40	18	(34)	58:42



4 eq

Gr I (0.07 eq),
DCM, reflux, 16 h



332

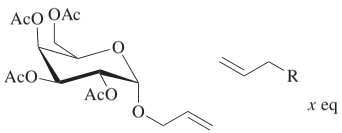
R		(*E*)/(*Z*)
n-C_6H_{13}	(74)	91:9
n-C_8H_{17}	(73)	87:13
n-$C_{10}H_{21}$	(77)	88:12
n-$C_{12}H_{25}$	(73)	89:11
n-$C_{14}H_{29}$	(77)	88:12
n-$C_{16}H_{33}$	(73)	86:14

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)
B. ALLYLIC ETHERS (*Continued*)

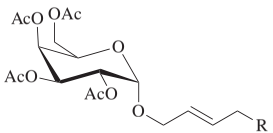
Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

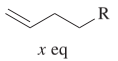
C_9



Gr I (*y* eq), DCM

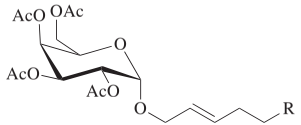


R	*x*	*y*	Temp	Time (h)		(*E*)/(*Z*)	
BocHN	2	0.2	reflux	6	(30)	80:20	571
BocHN	2	0.2	rt	15	(57)	80:20	571
CbzHN	2	0.2	reflux	6	(39)	80:20	571
CbzHN	2	0.2	rt	15	(65)	80:20	571
TBSO	2	0.2	reflux	6	(69)	95:5	571
BnO	4	0.07	reflux	16	(69)	87:13	332
PhO	4	0.07	reflux	16	(77)	80:20	332
Ph	4	0.07	reflux	16	(69)	84:16	332



x eq

Gr I (*y* eq),
DCM, reflux

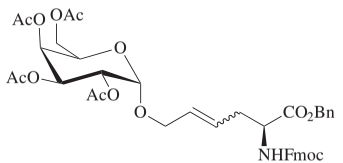


R	*x*	*y*	Time (h)		(*E*)/(*Z*)	
MeO_2C	2	0.2	6	(67)	67:33	571
Ph	4	0.07	16	(80)	87:13	332



x eq

Catalyst (0.2 eq),
DCM, 40°, 12 h

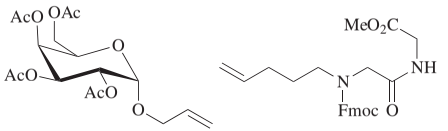
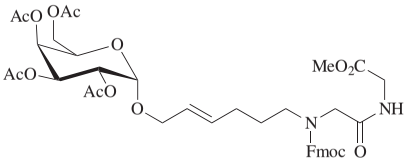
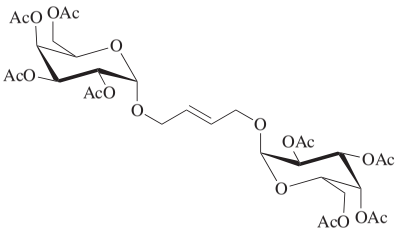
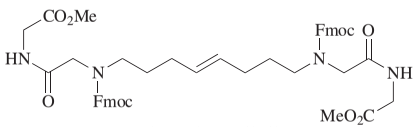
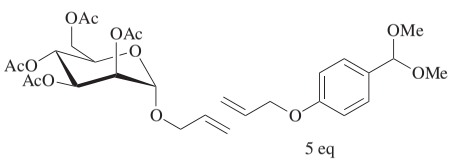
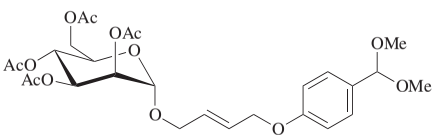


572

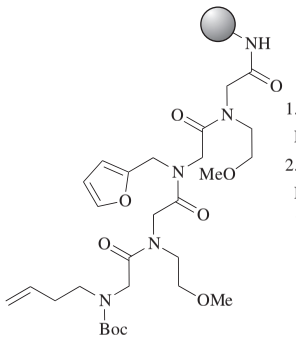
x	Catalyst	
2	Gr II	(26)
2	Gr I	(49)
5	Gr I	(70)

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

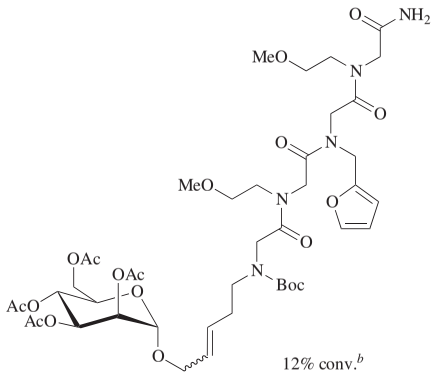
B. ALLYLIC ETHERS (*Continued*)

Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9		Gr I (0.1 eq), DCM, rt, 24 h	 (52) (*E*)/(*Z*) = 50:50 +  (20) (*E*)/(*Z*) = 57:43 +  (18) (*E*)/(*Z*) = 50:50	573
	 5 eq	Gr II (0.1 eq), DCM, reflux, 6 h	 (87) (*E*) only	574

20 eq

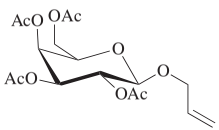


1. Hov II (0.05 eq), DCM, 40°, 8 h
2. TFA (92%), H_2O (5%), TIS (3%), 1–2 h



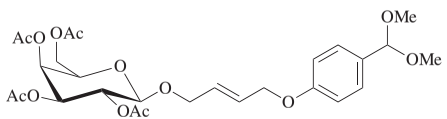
12% conv.[b]

12



5.54 eq

Gr II (0.1 eq), DCM, reflux, 6 h



(75) (*E*) only

574

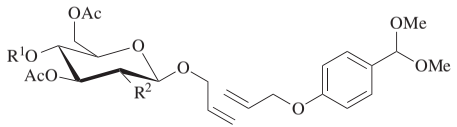
TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

B. ALLYLIC ETHERS (*Continued*)

Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

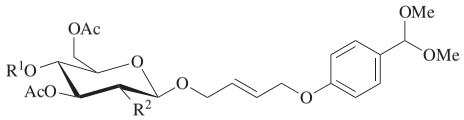
Please refer to the charts preceding the tables for the catalyst structures.

C_9



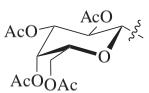
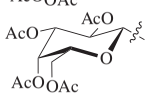
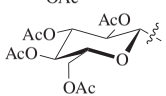
x eq

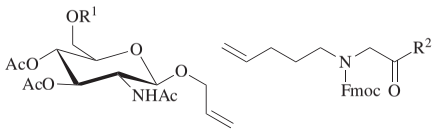
Catalyst (0.1 eq), DCM



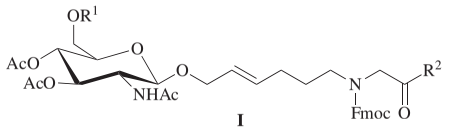
574

(*E*) only

x	R^1	R^2	Catalyst	Time (h)	Temp (°)	
5	Ac	AcO	Hov II	3	25	(36)
5	Ac	AcO	Hov II	3	40	(55)
5	Ac	AcO	Hov II	6	40	(92)
5	Ac	AcO	Hov II	12	40	(89)
5	Ac	AcO	Gr II	6	40	(54)
5	Ac	AcNH	Gr II	6	40	(81)
7.48		AcNH	Gr II	6	40	(12)
8		AcO	Gr II	6	40	(52)
8		AcO	Gr II	6	40	(46)

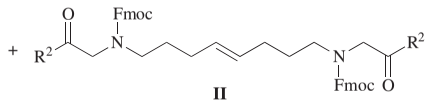


Gr I (0.1 eq),
DCM, rt, 24 h

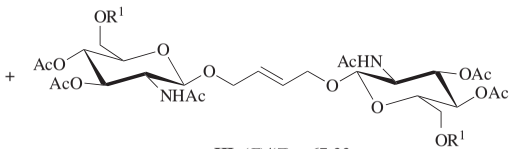


573

I



II



III (*E*)/(*Z*) = 67:33

R^1	R^2	**I**	(*E*)/(*Z*) **I**	**II**	(*E*)/(*Z*) **II**	**III**
Ac	HO	(41)	75:25	(10)	50:50	(10)
Tr	PfpO	(46)	50:50	(16)	50:50	(12)
Ac	MeO_2CCH_2HN	(49)	50:50	(27)	55:45	(11)

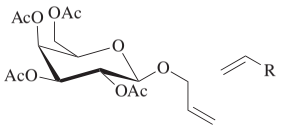
TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

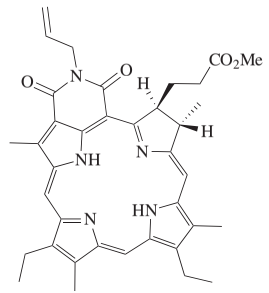
B. ALLYLIC ETHERS (*Continued*)

Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

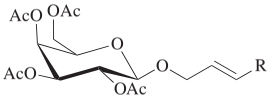
C_9





20 eq

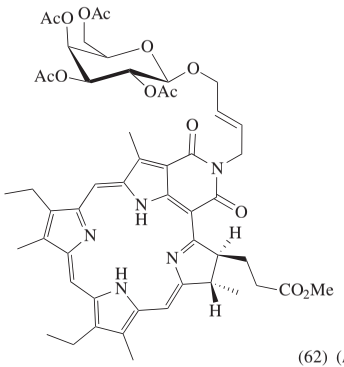
Gr I (0.07 eq),
DCM, reflux, 16 h



R		(*E*)/(*Z*)
n-$C_{12}H_{25}$	(62)	87:13
n-$C_{14}H_{29}$	(64)	88:12

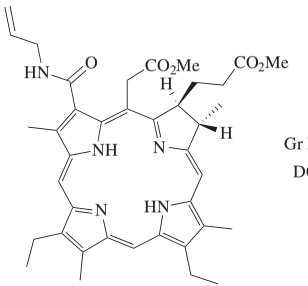
332

Gr II (1 eq),
DCM, reflux, 4 h



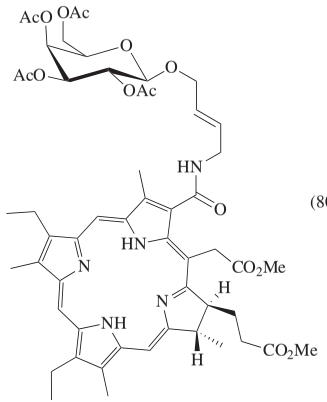
(62) (*E*)/(*Z*) = 86:14

575

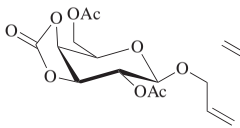


5 eq

Gr II (0.05 eq),
DCM, reflux, 4 h



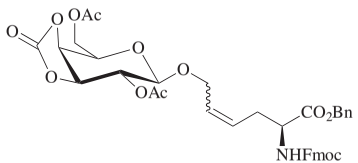
(80) (*E*)/(*Z*) = 83:17 575





5 eq

Gr I (0.2 eq),
DCM, 40°, 12 h



(66) 572

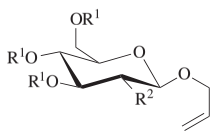
TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

B. ALLYLIC ETHERS (*Continued*)

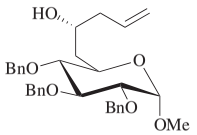
Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

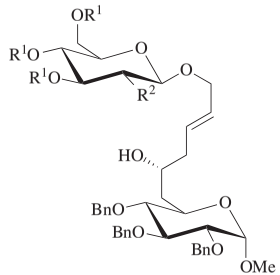
C_9



1.2 eq

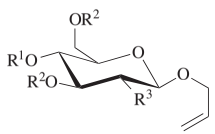


Hov II (0.1 eq), DCM, rt

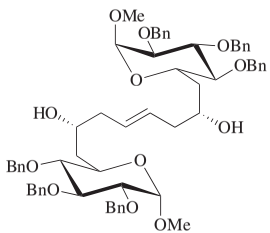


(*E*)/(*Z*) > 95:5

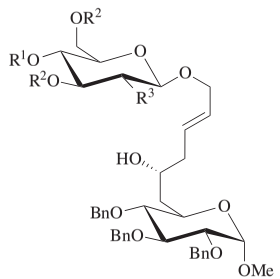
R^1	R^2		
Ac	N_3	(62)	498
Bn	BnO	(54)	



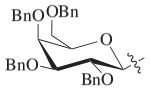
2 eq

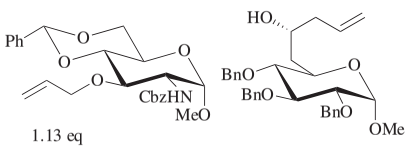


Hov II (0.1 eq), DCM, rt



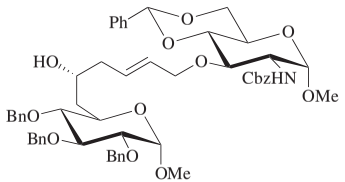
(*E*)/(*Z*) > 95:5 498

R^1	R^2	R^3	
Ac	Ac	N_3	(45)
Bn	Bn	BnO	(42)
	Bn	BnO	(40)



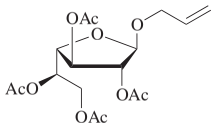
1.13 eq

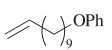
Hov II (0.1 eq),
DCM, rt



(41) $(E)/(Z) > 95:5$

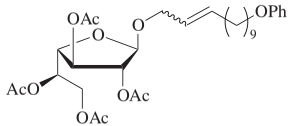
498





4 eq

Gr I (0.07 eq),
DCM, reflux, 14 h



(76)

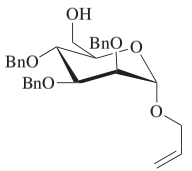
576

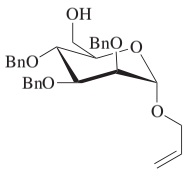
TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)
B. ALLYLIC ETHERS (*Continued*)

Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

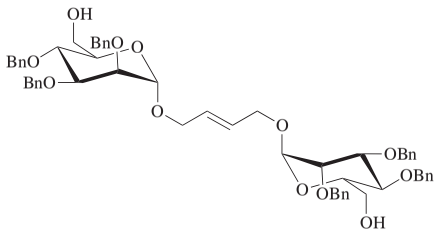
Please refer to the charts preceding the tables for the catalyst structures.

C_9



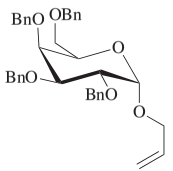


Gr I, DCM, reflux

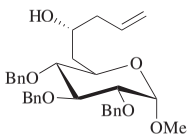


(84) (*E*)/(*Z*) = 80:20

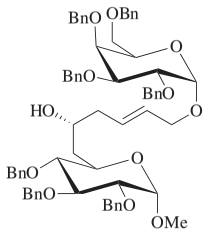
577



1.23 eq

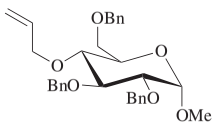


Hov II (0.1 eq),
DCM, rt

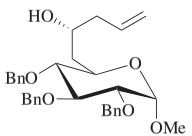


(45) (*E*)/(*Z*) > 95:5

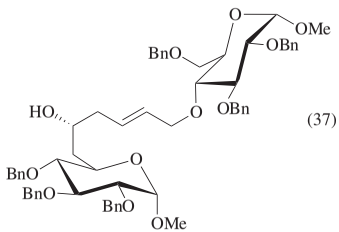
498



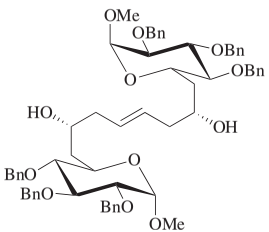
1.19 eq



Hov II (0.1 eq),
DCM, rt

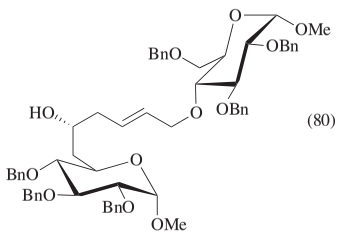


(37) (*E*)/(*Z*) > 95:5 498



2 eq

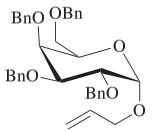
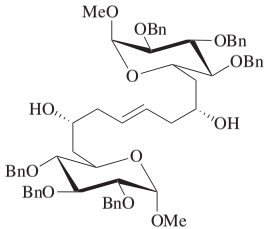
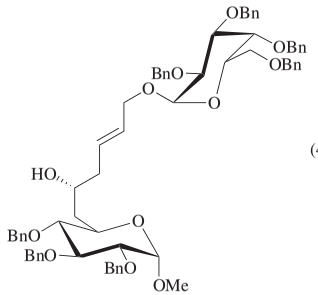
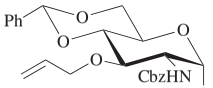
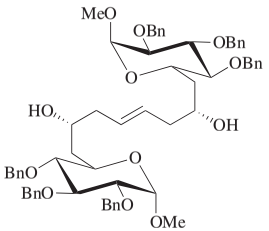
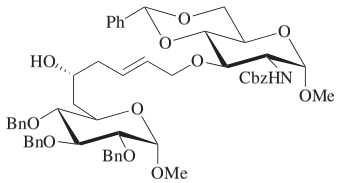
Hov II (0.1 eq),
DCM, rt

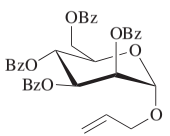


(80) (*E*)/(*Z*) > 95:5 498

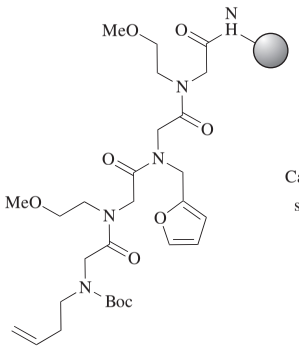
TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

B. ALLYLIC ETHERS (*Continued*)

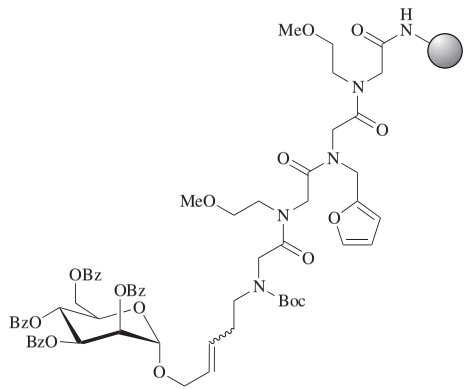
Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
	 2 eq	Hov II (0.1 eq), DCM, rt	 (40) (*E*)/(*Z*) > 95:5	498
	 2 eq	Hov II (0.1 eq), DCM, rt	 (34) (*E*)/(*Z*) > 95:5	498



20 eq



Catalyst (0.05 eq),
solvent



12

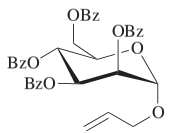
Catalyst	Solvent	Temp (°)	Time	Conv. (%)[b]
Gr I	DCM	40	8 h	10
Gr II	DCM	40	8 h	<5
Hov II	DCM	40	8 h	27
Gr I	DCB	MW	3 min	<5
Gr II	DCB	MW	3 min	<5
Hov II	DCB	MW	3 min	<5

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)
B. ALLYLIC ETHERS (*Continued*)

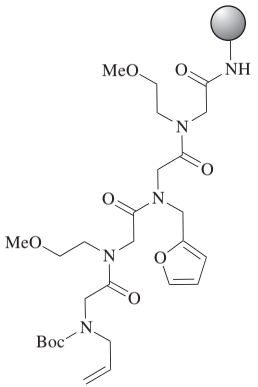
Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

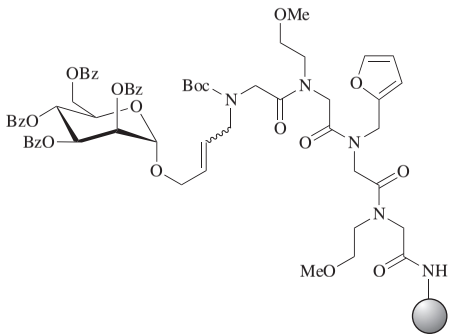
C_9



20 eq



Catalyst (0.05 eq),
solvent



12

Catalyst	Solvent	Temp (°)	Time	Conv. (%)[b]
Gr I	DCM	40	8 h	<5
Gr II	DCM	40	8 h	<5
Hov II	DCM	40	8 h	13
Gr I	DCB	MW	3 min	<5
Gr II	DCB	MW	3 min	<5
Hov II	DCB	MW	3 min	<5

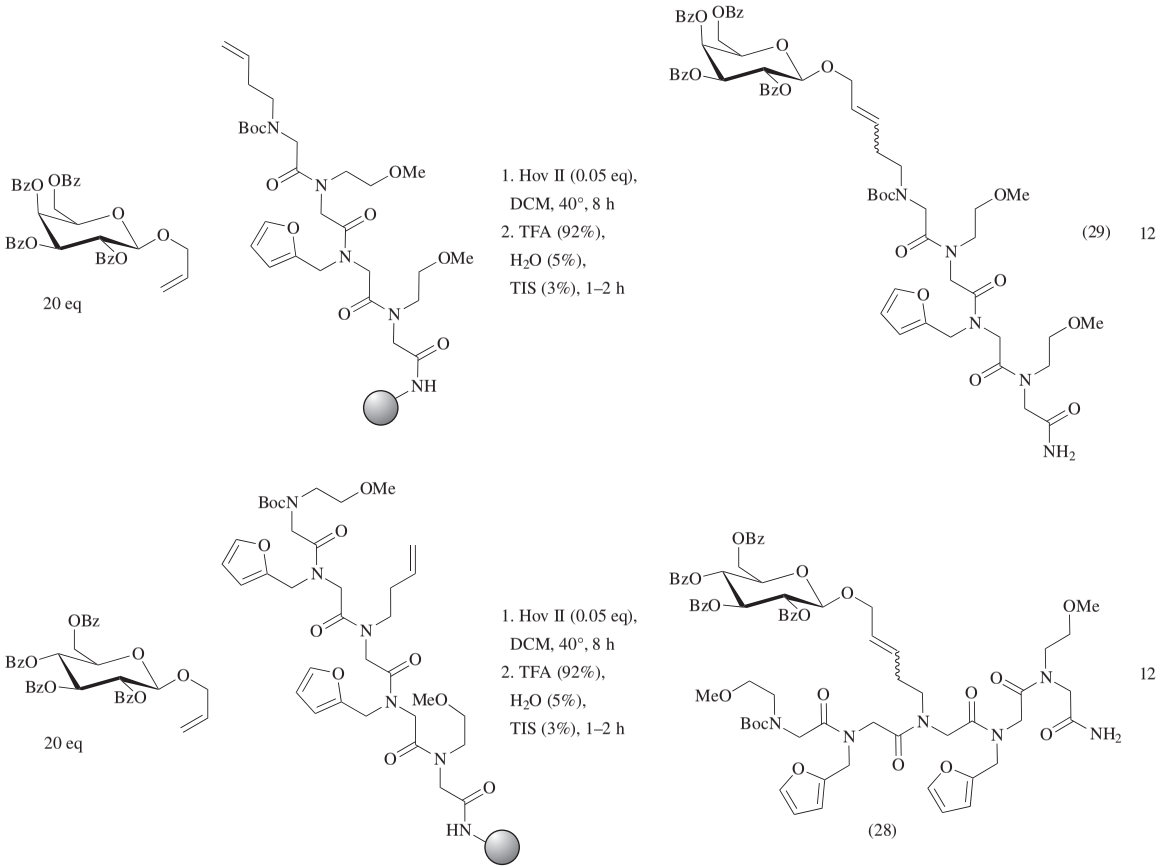
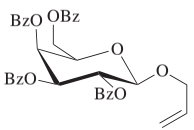
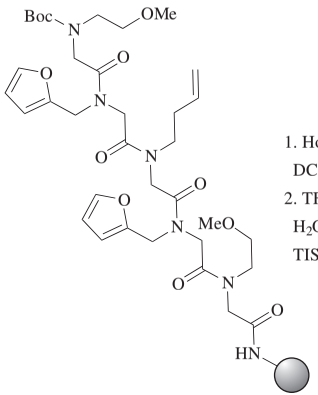
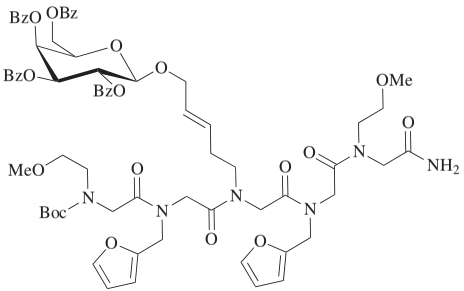
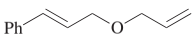
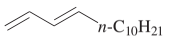
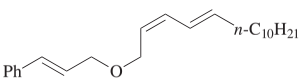
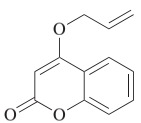
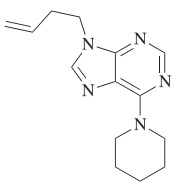
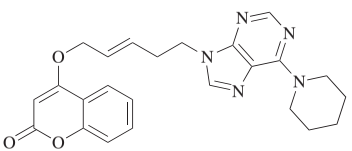
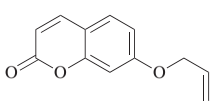

20 eq
1. Hov II (0.05 eq), DCM, 40°, 8 h
2. TFA (92%), H2O (5%), TIS (3%), 1–2 h
(29)
12
20 eq
1. Hov II (0.05 eq), DCM, 40°, 8 h
2. TFA (92%), H2O (5%), TIS (3%), 1–2 h
12
(28)

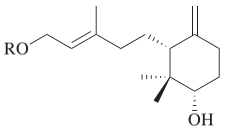
TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

B. ALLYLIC ETHERS (*Continued*)

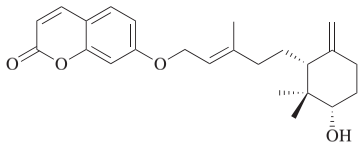
Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
 20 eq		1. Hov II (0.05 eq), DCM, 40°, 8 h 2. TFA (92%), H_2O (5%), TIS (3%), 1–2 h	 (27)	12
C_{12}				
	 1.5 eq	Ru cat **216** (0.03 eq) 50°, 24 h	 (82) (*Z*)/(*E*) > 95:5	538
	 3 eq	Gr II (0.1 + 0.04 eq), DCM, 100° (MW), 2 + 1 h	 (63) (*E*) only	499



3 eq



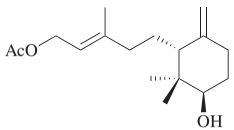
Catalyst (0.1 eq),
DCM, reflux, 48 h



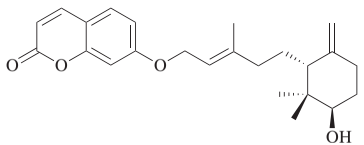
578

R	Catalyst		(*E*)/(*Z*)
H	Gr I	(0)	—
H	Gr II	(0)	—
Ac	Gr II	(19)	60:40

3 eq

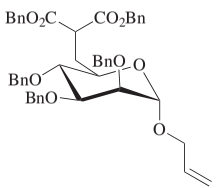


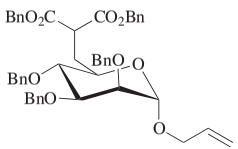
Gr II (0.1 eq),
DCM, reflux, 48 h



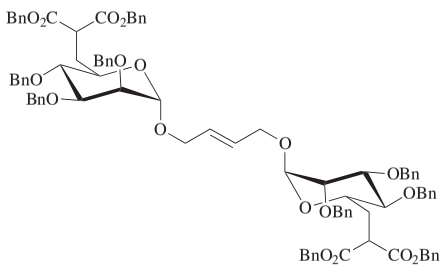
578

(19) (*E*)/(*Z*) = 60:40





Gr I, DCM, reflux

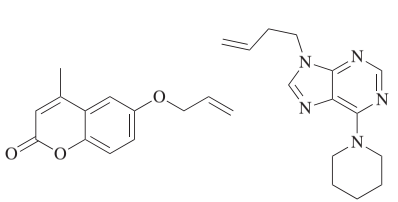
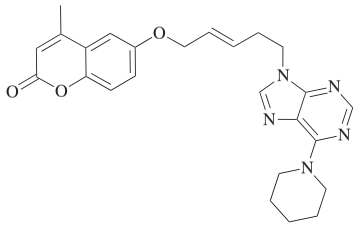
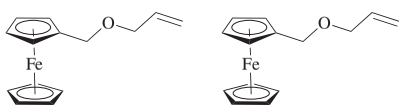
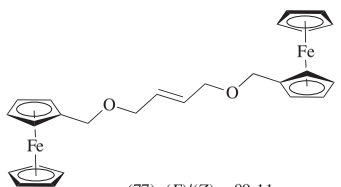
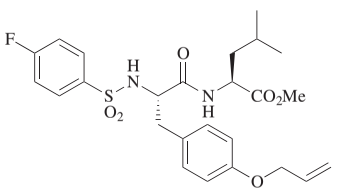
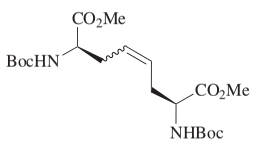
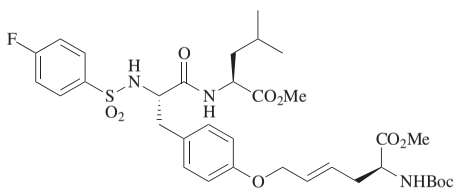


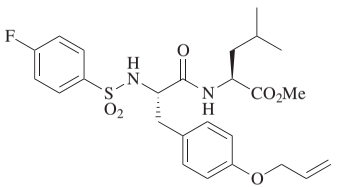
577

(67) (*E*)/(*Z*) = 80:20

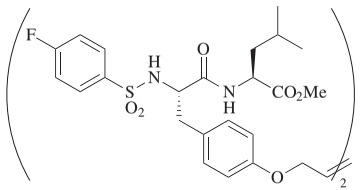
TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

B. ALLYLIC ETHERS (*Continued*)

Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{13} 	3 eq	Gr II (0.1 + 0.04 eq), DCM, 100° (MW), 2 + 1 h	 (58) (*E*) only	499
C_{14} 		Gr I (0.05 eq), DCM, 45°, 12 h	 (77) (*E*)/(*Z*) = 89:11	124
C_{18}  	2.25 eq	Gr II (1.25 eq), DCM, reflux, 18 h	 (33) (*E*)/(*Z*) = 92:8	579

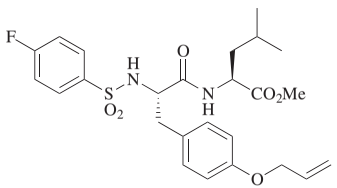


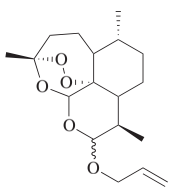
Gr II (4 x 0.04 eq),
BCl_2Cy_2 (0.15 eq),
DCM,
MW, 4 × 2 min

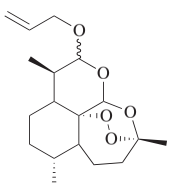


579

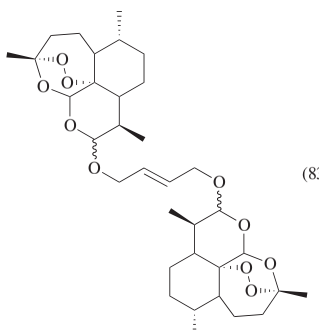
(87) (*E*)/(*Z*) = 81:19







Gr I (0.1 eq),
DCM, rt, 24 h



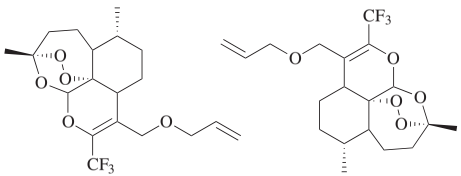
(83) (*E*)/(*Z*) > 90:10 195

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)
B. ALLYLIC ETHERS (*Continued*)

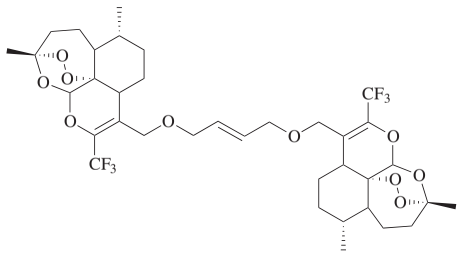
Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

C_{19}

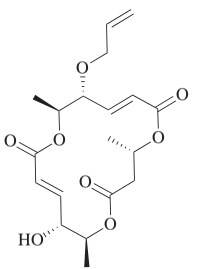


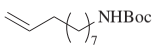
Catalyst (*x* eq), DCM



195

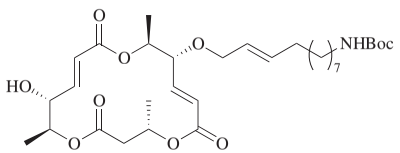
Catalyst	*x*	Temp	Time (h)	Conv. (%)[c]		(*E*)/(*Z*)
Gr I	0.05	rt	6	80	(—)	90:10
Gr I	0.1	rt	4	80	(—)	90:10
Gr I	0.05	reflux	1.5	100	(71)	90:10
Ru cat **35**	0.1	rt	24	90	(69)	(*E*) only





5 eq

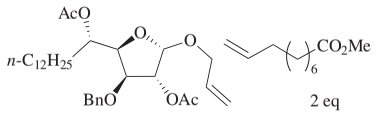
Gr II (0.1 eq), DCM, reflux, 0.5 h



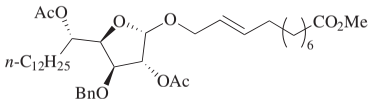
(52)

580

C_{20}



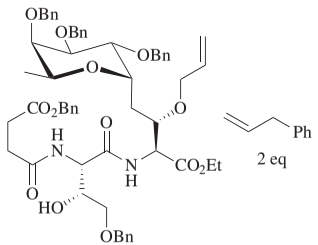
Gr I (0.25 eq),
DCM, 20°, 72 h



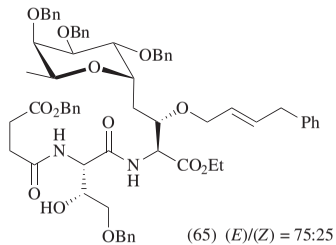
(60) (*E*) only

581

C_{21}

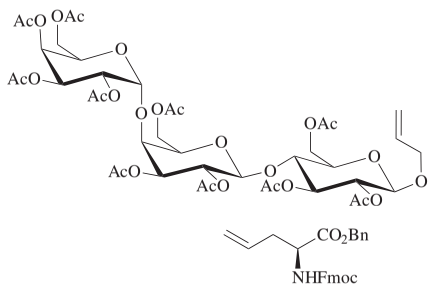


Gr I (0.05 eq),
DCM, reflux,
18–40 h

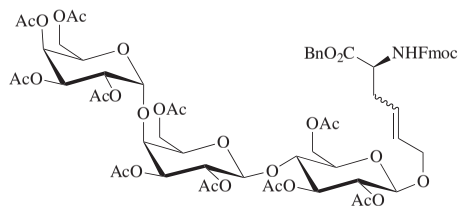


(65) (*E*)/(*Z*) = 75:25

582



Gr I (0.2 eq),
DCM, 40°, 12 h



(70)

572

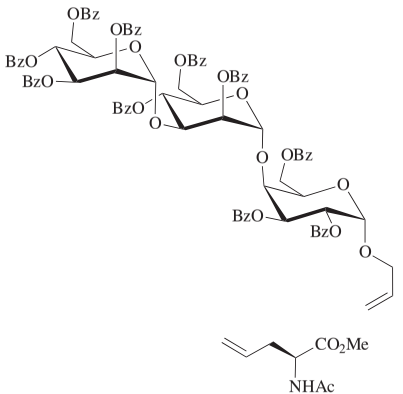
TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

B. ALLYLIC ETHERS (*Continued*)

Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

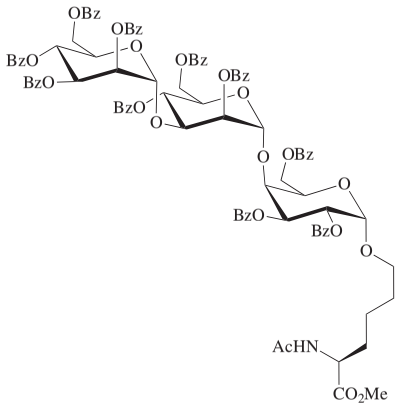
Please refer to the charts preceding the tables for the catalyst structures.

C_{21}



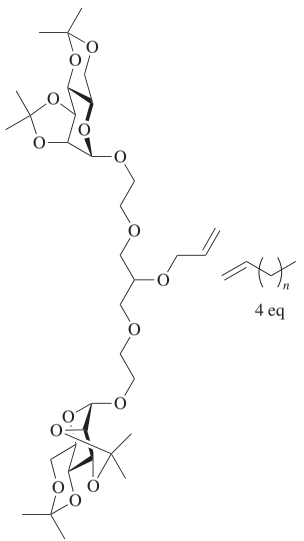
5 eq

1. Gr I (0.1 eq), DCM, reflux, 8 h
2. 10% Pd/C, MeOH, 60°



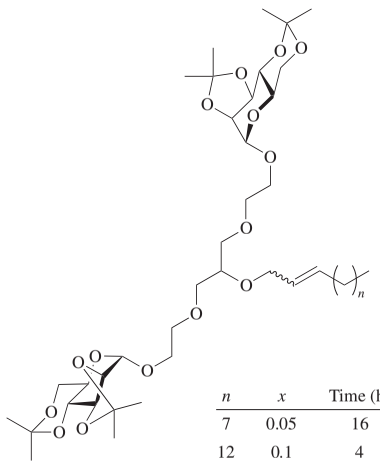
(60) 583

C_{22}



4 eq

Gr II (*x* eq),
DCM, reflux



n	*x*	Time (h)	
7	0.05	16	(81)
12	0.1	4	(64)

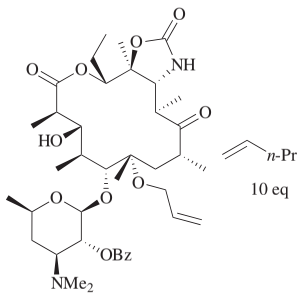
567

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)
B. ALLYLIC ETHERS (*Continued*)

Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

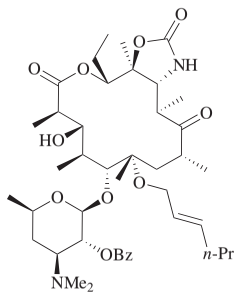
Please refer to the charts preceding the tables for the catalyst structures.

C_{24}



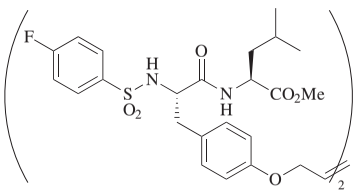
10 eq

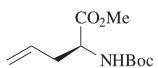
Gr I (0.1 eq),
DCM, 40°, 20 h



(84) (*E*)/(*Z*) = 64:36 584

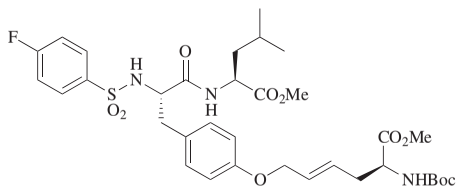
C_{34}





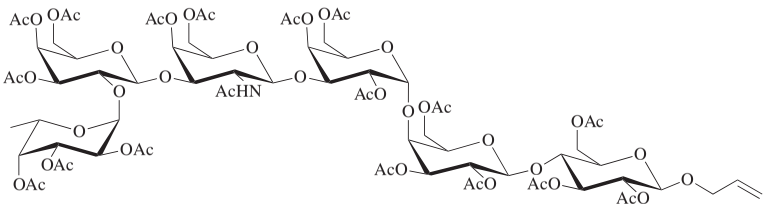
5.7 eq

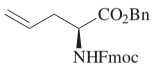
Gr II (0.09 eq),
DCM, reflux, 23 h



(51) (*E*)/(*Z*) = 87:13 579

C_{39}





5 eq

Gr I (0.2 eq),
DCM, 40°, 12 h

(69) 572

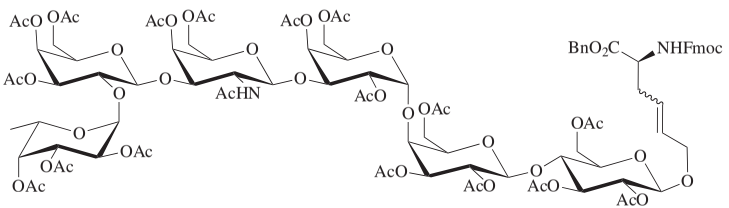
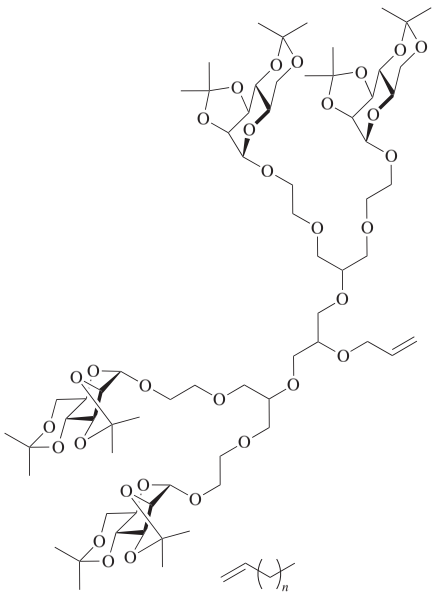


TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)
B. ALLYLIC ETHERS (*Continued*)

Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

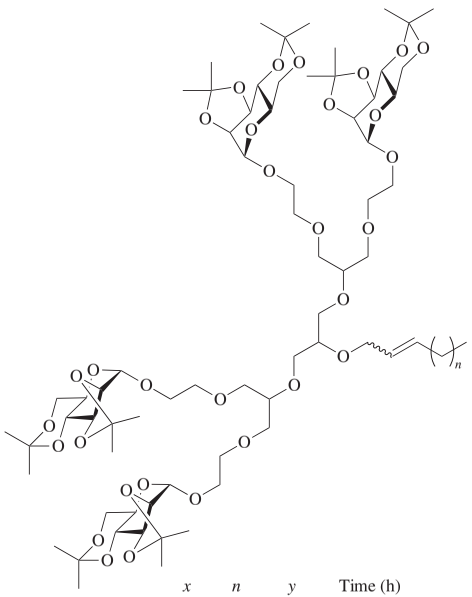
Please refer to the charts preceding the tables for the catalyst structures.

C_{44}



x eq

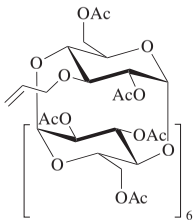
Gr II (*y* eq),
DCM, reflux



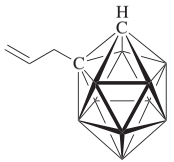
x	*n*	*y*	Time (h)	
2	7	0.1	16	(77)
4	12	0.05	5	(43)

567

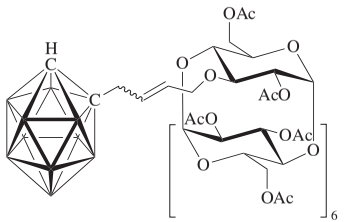
C_{45}



1.4 eq

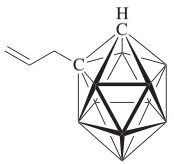


Hov II (0.1 eq),
toluene, 120°, 16 h

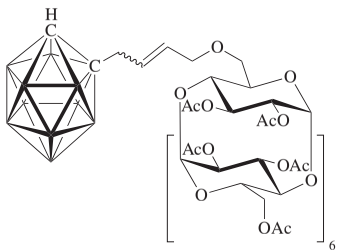


(17) 585

1.4 eq



Hov II (0.1 eq),
toluene, 120°, 16 h



(15) 585

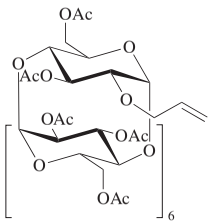
TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

B. ALLYLIC ETHERS (*Continued*)

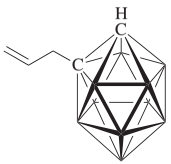
Allylic Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

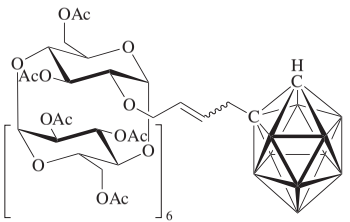
C_{45}



1.4 eq



Hov II (0.1 eq),
toluene, 120°, 16 h



(24) 585

[a] The ratios were determined by ^{1}H NMR spectroscopy.

[b] The conversion was determined by HPLC analysis.

[c] The conversion was determined by ^{1}H NMR analysis.

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

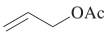
C. ALLYLIC ESTERS

Allylic ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

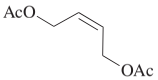
Please refer to the charts preceding the tables for the catalyst structures.

C_3



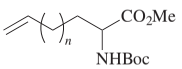


Catalyst (x eq), solvent

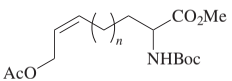


Catalyst	x	Solvent	Temp (°)	Time	Conv. (%)[a]		$(E)/(Z)$	
Ru cat **217**	0.02	THF	70	3 h	53	(—)	11:89	84
Ru cat **217**	0.02	THF	70	6 h	60	(—)	17:83	84
Ru cat **217**	0.02	THF	35	4 h	>95	(62)	11:89	84
Ru cat **215**	0.001	THF	35	12 h	8	(—)	5:95	488
Gr I	0.05	benzene	40	5 min	—	(16)	81:19	564
Gr I	0.05	benzene	40	0.5 h	—	(27)	82:18	564
Gr I	0.05	benzene	40	6 h	—	(34)	84:16	564
Gr I	0.05	benzene	40	24 h	—	(58)	85:15	564

5 eq



Catalyst (0.075 eq), additive (2 mM), H_2O/t-BuOH (x/y) THF, 40°, 4 h



401

n	Catalyst	Additive	x/y		$(Z)/(E)$
0	Ru cat **215**	—	—	(40)	88:12
0	Ru cat **215**	—	1:1	(38)	90:10
0	Ru cat **215**	LiCl	1:1	(31)	76:24
0	Ru cat **215**	$MgCl_2$	1:1	(30)	72:28
0	Ru cat **216**	—	—	(42)	90:10
0	Ru cat **216**	—	1:1	(36)	92:8
0	Ru cat **216**	LiCl	1:1	(31)	84:16
0	Ru cat **216**	$MgCl_2$	1:1	(34)	83:17
1	Ru cat **215**	—	—	(56)	90:10
1	Ru cat **215**	—	1:1	(53)	90:10
1	Ru cat **215**	LiCl	1:1	(48)	84:16
1	Ru cat **215**	$MgCl_2$	1:1	(44)	79:21
1	Ru cat **216**	—	—	(55)	95:5
1	Ru cat **216**	—	1:1	(51)	93:7
1	Ru cat **216**	LiCl	1:1	(50)	87:13
1	Ru cat **216**	$MgCl_2$	1:1	(46)	84:16

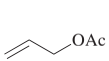
TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

C. ALLYLIC ESTERS (*Continued*)

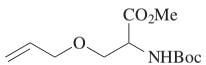
Allylic ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

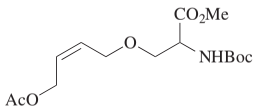
C_3



5 eq



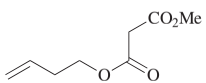
Catalyst (0.075 eq), additive (2 mM), H_2O/*t*-BuOH (*x*/y), THF, 40°, 4 h



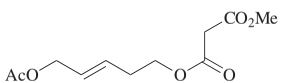
401

Catalyst	Additive	*x*/*y*		(*Z*)/(*E*)
Ru cat **215**	—	—	(63)	88:12
Ru cat **215**	—	1:1	(64)	87:13
Ru cat **215**	LiCl	1:1	(54)	67:33
Ru cat **215**	$MgCl_2$	1:1	(56)	63:37
Ru cat **216**	—	—	(66)	92:8
Ru cat **216**	—	1:1	(67)	93:7
Ru cat **216**	LiCl	1:1	(61)	79:21
Ru cat **216**	$MgCl_2$	1:1	(61)	84:16

5 eq



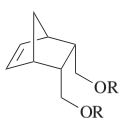
Gr II (0.05 eq), DCM, reflux, 22 h



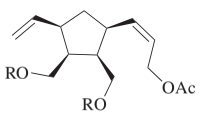
(56) (*E*)/(*Z*) = 90:10

586

7 eq

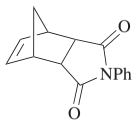
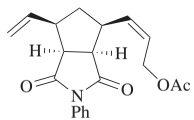
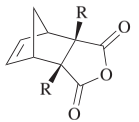
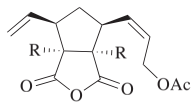
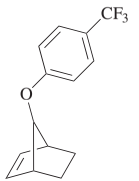
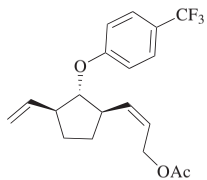
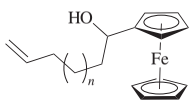
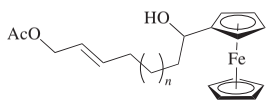


Ru cat **215** (0.01 eq), THF, 23°, 1 h



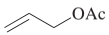
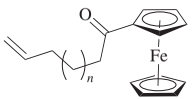
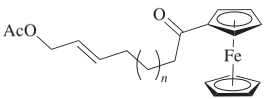
R		(*Z*)/(*E*)	er
Ac	(45)	97:3	91.0:9.0
Bn	(64)	95:5	93.0:7.0

417

7 eq		Ru cat **215** (0.01 eq), THF, 23°, 1 h		(63) (*Z*)/(*E*) = 94:6, er 60.0:40.0 417
7 eq		Ru cat **215** (0.01 eq), THF, 23°, 1 h		R (58) (*Z*)/(*E*) 98:2 er 75.0:25.0 417 H Me (65) 96:4 95.0:5.0
7 eq		Ru cat **215** (0.01 eq), THF, 23°, 1 h		(40) (*Z*)/(*E*) = 70:30 417 er (*Z*) 95.0:5.0 er (*E*) 95.0:5.0
2 eq		Gr I (0.19 eq), DCM, reflux, 17–24 h		587

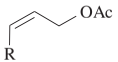
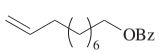
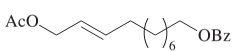
n		(*E*)/(*Z*)
1	(70)	75.0:25.0
2	(63)	75.0:25.0

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)
C. ALLYLIC ESTERS (*Continued*)

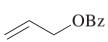
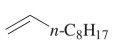
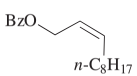
Allylic ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 2 eq		Gr I (0.19 eq), DCM, reflux, 17–24 h		587

n		(*E*)/(*Z*)
1	(58)	70.0:30.0
2	(68)	75.0:25.0

$C_{3–4}$

					Refs.
 *x* eq		Gr I (0.05 eq), solvent, 45°, 12 h			176

R	*x*	Solvent		(*E*)/(*Z*)
H	4	DCM	(81)	75:25
H	2	DCM	(80)	80:20
H	1	DCM	(59)	85:15
$AcOCH_2$	55	—	(91)	75:25
$AcOCH_2$	2	DCM	(89)	82:18
$AcOCH_2$	1	DCM	(77)	83:17

					Refs.
	 5 eq	Ru cat **216** (0.02 eq), THF, 35°		(71) (*Z*)/(*E*) > 95:5	551

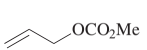
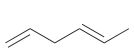
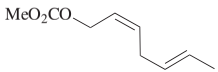
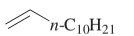
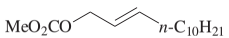
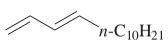
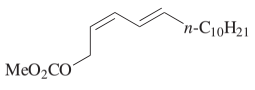
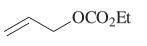
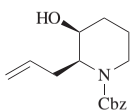
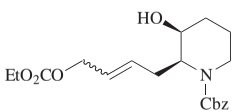
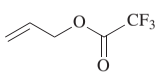
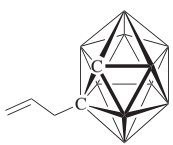
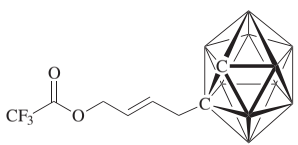
	 9 eq	Ru cat **216** (0.01 eq), THF, rt, 5 h		(79) (*Z*)/(*E*) > 95:5	437
	 5 eq	Hov II (0.05 eq), DCM, 40°		(68) (*E*)/(*Z*) = 91:9	551
	 1.5 eq	Ru cat **216** (0.04 eq) 50°, 24 h		(42) (*Z*)/(*E*) > 95:5	538
 2 eq		Gr II (0.1 eq), DCM, reflux, 24 h		(72)	441
 6 eq		Gr II (0.02 eq), DCM, reflux, 5 h		(77) (*E*)/(*Z*) > 95:5	436

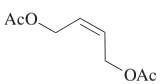
TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

C. ALLYLIC ESTERS (*Continued*)

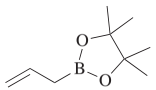
Allylic ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

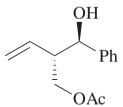
C_4



x eq



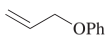
1. Gr II (*y* eq), DCM, 40°, 2–12 h
2. PhCHO (*z* eq), 23°, 12–48 h



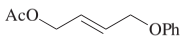
126

x	*y*	*z*		*anti/syn*[b]
3	1.5	0.05	(32)	64:36
3	1.5	0.05	(75)	82:18
3	1.5	0.02	(75)	82:18
0.5	1.5	0.05	(57)	82:18
3	0.75	0.05	(75)	82:18

2 eq



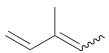
Catalyst (0.025 eq), DCM, 20°, 3 h



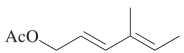
Catalyst		(*E*)/(*Z*)
Gr II	(76)	92:8
Hov II	(75)	92:8
Ru cat **155**	(67)	92:8

565

2 eq



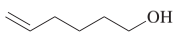
Gr II (0.05 eq), DCM, reflux, 12 h



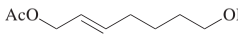
(82) (*E*) only

132

2 eq



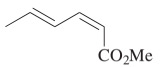
Ru cat **143** (0.05 eq), H_2O, 30°, 12 h



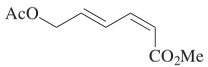
(76) (*E*)/(*Z*) = 90:10

588

— eq



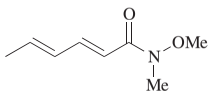
Gr II (0.075 eq), DCM, 40°, 8 h



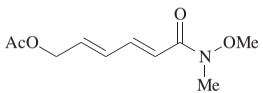
(68) (*E*) only

589

5 eq



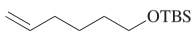
Hov II (0.1 eq), DCM, rt, 24 h



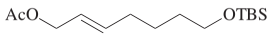
(42) (*E*)/(*Z*) = 83:17

549

2 eq

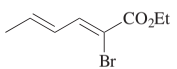


Catalyst (*x* eq), solvent

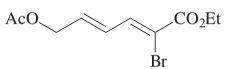


Catalyst	*x*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
Ru cat **158**	0.01	DCM	25	2	(90)	93:7	590
Ru cat **157**	0.005	DCM	25	2	(93)	93:7	590
Ru cat **316**	0.02	toluene	80	3.5	(59)	86:14	591
Ru cat **286**	0.02	DCM	40	8	(71)	91:9	161
Ru cat **88**	0.025	DCM	25	5	(67)	89:11	171

3 eq



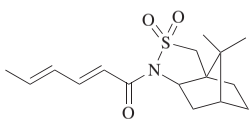
Gr II (0.1 eq), DCM, reflux, 12 h



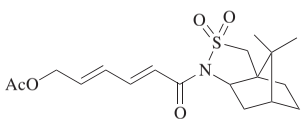
(70) (*E*)/(*Z*) = 88:12

132

5 eq



Hov II (0.1 eq), DCM, rt, 24 h

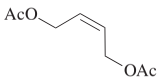
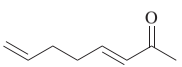
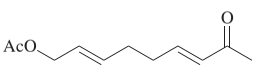
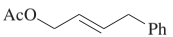


(40) (*E*)/(*Z*) = 83:17

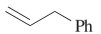
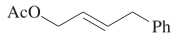
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TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

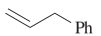
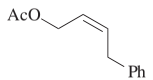
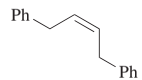
C. ALLYLIC ESTERS (*Continued*)

Allylic ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 2 eq		Gr I (0.1 eq), DCM, 40°, 12 h	 (78) (*E*)/(*Z*) = 82:18	36
2 eq		Catalyst (0.01 eq), DCM, N_2, rt		

Catalyst	Time (h)	Conv. (%)[a]	(*E*)/(*Z*)	
Ind II	1	50	52:48	77
Ru cat **294**	1	96	88:12	77
Ru cat **295**	1	97	90:10	77
Ru cat **296**	1	97	91:9	77
Ru cat **285**	1	75	89:11	77
Ru cat **297**	1	97	90.5:9.5	77
Ru cat **343**	20	>99	64:36	77
Ru cat **339**	20	67	76:24	77
Ru cat **342**	20	55	65:35	77
Ru cat **344**	5	89	56.5:43.5	77
Ind II	2.5	98	75:25	489
Ru cat **282**	20	97	71:29	489
Ru cat **284**	20	90	64:36	489
Ru cat **283**	20	61	69:31	489
Ru cat **285**	2.5	95	89:11	489
Ru cat **286**	2.5	97	84:16	489

2 eq  Catalyst (0.01 eq), toluene, N_2, 80° 

Catalyst	Time (h)	Conv. (%)[a]	(*E*)/(*Z*)	
Ru cat **343**	1	98	85:15	77
Ru cat **343**	20	99	87.5:12.5	77
Ru cat **339**	1	98	74:26	77
Ru cat **339**	20	99	84:16	77
Ru cat **342**	1	>99	77:23	77
Ru cat **342**	20	99	84.5:15.5	77
Ru cat **344**	5	>99	69:31	77
Ru cat **344**	20	>99	70:30	77
Ru cat **283**	1	100	80:20	489
Ru cat **283**	20	100	87.5:12.5	489

2 eq  Catalyst (*x* eq), THF  +  488

I **II**

Catalyst	*x*	Temp (°)	Time (h)	Conv. **I** (%)[c]	(*Z*)/(*E*) **I**	Conv. **II** (%)[c]	(*Z*)/(*E*) **II**
Ru cat **217**	0.05	70	9	37	89:11	26	96:4
Ru cat **217**	0.05	35	6	50	86:14	19	>95:5
Ru cat **218**	0.05	70	6	48	82:18	33	91:9
Ru cat **218**	0.05	35	9	45	87:13	23	>95:5
Ru cat **220**	0.05	70	3	57	75:25	42	94:6
Ru cat **220**	0.05	35	6	64	79:21	22	>95:5
Ru cat **219**	0.05	35	7	54	83:17	17	>95:5
Ru cat **215**	0.01	35	9	58	91:9	28	>95:5

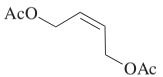
TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

C. ALLYLIC ESTERS (*Continued*)

Allylic ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

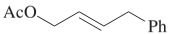
C_4



2 eq



Catalyst (*x* eq), DCM

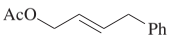


Catalyst	*x*	Temp (°)	Time (h)	Conv. (%)		(*E*)/(*Z*)	
Ru cat **327**	0.025	30	20	—	(80)	89:11	592, 593
Ru cat **328**	0.025	30	20	—	(74)	90:10	592, 593
Ind II	0.025	30	20	—	(74)	92:8	592, 593
Ru cat **14**	0.025	40	16	—	(47)	86:14	594
Gr II	0.03	40	12	—	(80)	88:12	36
Gr I	0.03	40	12	—	(80)	76:24	36
Ru cat **288**	0.025	25	24	—	(79)	87:13	595
Ru cat **289**	0.025	25	23	—	(76)	86:14	595
Ru cat **107**	0.01	25	5	—	(63)	85:15	596
Ru cat **247**	0.01	40	1	61	(—)	80:20	597
Ru cat **247**	0.01	40	5	62	(—)	80:20	

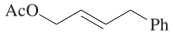
2 eq



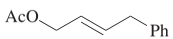
Catalyst (0.02 eq),
2-MeTHF, 70°, 0.5 h



Catalyst		(*E*)/(*Z*)	
Ru cat **103**	(72)	86:14	598
Ru cat **104**	(70)	85:15	
Ru cat **105**	(70)	88:12	
Hov II	(73)	87:13	

2 eq  Catalyst (0.01 eq), benzene, 23°  599

Catalyst	Time (min)	Conv. (%)[c]	(*E*)/(*Z*)
Ru cat **271**	5	87	90.5:9.5
Hov II	5	87	91:9
Ru cat **187**	5	97	86:14
Ru cat **272**	15	74	77:23
Ru cat **145**	25	70	76:24
Ru cat **203**	240	78	73:27
Ru cat **273**	30	78	78:22
Ru cat **204**	75	80	75:25
Ru cat **205**	60	75	76:24
Ru cat **146**	15	72	86:14
Ru cat **206**	45	73	75:25
Ru cat **147**	10	83	85:15
Ru cat **274**	120	74	80:20
Ru cat **207**	90	71	75:25

2.4 eq  Catalyst (0.025 eq), DCM, ethylene, 12 h  600

Catalyst	Temp (°)	Conv. (%)[c]	(*E*)/(*Z*)
Ru cat **228**	60	75	50:50
Ru cat **227**	23	80	86:14
Ru cat **223**	23	80	86:14
Ru cat **224**	23	75	71:29

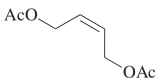
TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

C. ALLYLIC ESTERS (*Continued*)

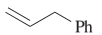
Allylic ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

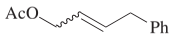
C_4



2.4 eq



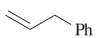
Gr II (*x* eq), solvent, 25°, 3 h



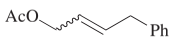
601

x	Solvent	Conv. (%)[c]
0.005	DCM	64
0.005	methyl decanoate	79
0.005	neat	82
0.025	DCM	87
0.025	methyl decanoate	95
0.025	neat	86
0.001	neat	55

2 eq

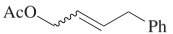


Hov II (*x* eq), solvent, 25°, 3 h

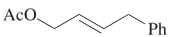


601

x	Solvent	Conv. (%)[c]
0.005	DCM	88
0.025	DCM	91
0.025	methyl decanoate	91
0.025	neat	91
0.001	DCM	15
0.005	methyl decanoate	72
0.005	neat	88
0.001	neat	85

2 eq  Ru cat **89** (*x* eq), solvent, 25°, 3 h  601

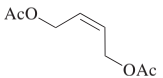
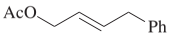
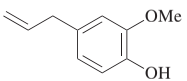
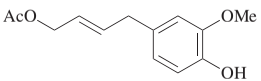
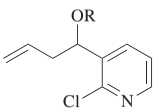
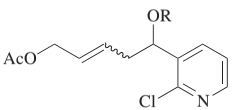
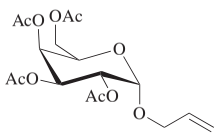
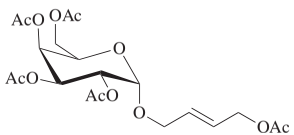
x	Solvent	Conv. (%)[c]
0.005	DCM	72
0.005	methyl decanoate	79
0.001	methyl decanoate	36
0.005	none	89
0.001	none	82
0.025	DCM	92
0.025	methyl decanoate	90
0.025	none	90

2 eq  Catalyst (*x* eq), additive (*y* eq), solvent 

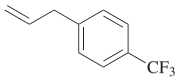
Catalyst	*x*	Additive	*y*	Solvent	Temp (°)	Time (h)	Conv. (%)[c]		(*E*)/(*Z*)	
Ru cat **281**	0.02	C_2Cl_6	0.08	toluene	80	24	—	(65)	80:20	602
Hov II	0.01	—	—	DCM	40	2	63	(—)	90:10	526
Ru cat **194**	0.01	TMSCl	0.1	DCM	40	2	55	(—)	90:10	526
Ru cat **195**	0.01	TMSCl	0.1	DCM	40	2	81	(—)	90:10	526
Ru cat **196**	0.01	TMSCl	0.1	DCM	40	2	52	(—)	83:17	526
Ru cat **150**	0.005	—	—	toluene	70	0.25	—	(84)	90:10	448
Ru cat **150**	0.005	—	—	toluene	70	0.5	—	(87)	90:10	448

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

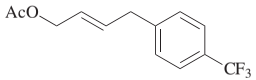
C. ALLYLIC ESTERS (*Continued*)

Allylic ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 2 eq		Ru cat **109** (0.02 eq), H_2O, 22°, 12 h	 (84) (*E*)/(*Z*) = 93:7	341
		Catalyst (0.01 eq), DCM, rt, 5 h	 (*E*)/(*Z*) = 91:9	Catalyst: Ru cat **41** (80); Ru cat **44** (78); Ru cat **45** (86)	562
3 eq		Hov II (0.1 eq), DCM, 50°, 24 h		R: H (79); Ac (80); TBS (71)	603
2 eq		Gr I (0.2 eq), DCM, reflux, 6 h	 (70) (*E*)/(*Z*) = 83:17		571

3 eq

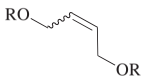


Catalyst (0.01 eq), toluene, 80°, 20 h

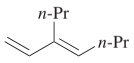


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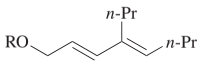
Catalyst		(*E*)/(*Z*)
Hov II	(82)	85:15
Ru cat **359**	(79)	77:23
Ru cat **360**	(84)	86:14
Ru cat **361**	(83)	86:14
Ru cat **362**	(77)	75:25



2 eq

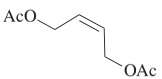


Gr II (0.05 eq), solvent, 12 h

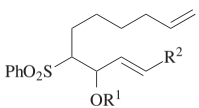


132

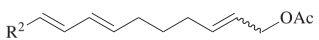
R	Solvent	Temp (°)		(*E*)/(*Z*)
Ac	DCM	40	(51)	—
Ac	benzene	60	(72)	—
Ac	benzene	80	(63)	—
Bz	DCM	reflux	(79)	(*E*) only



5 eq

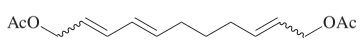


1. Gr II (0.05 eq), solvent, temp, 6 h
2. DMPU (5.0 eq), SmI_2 (3.0 eq), –78°, 1 h



I

\+



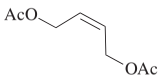
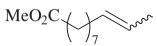
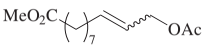
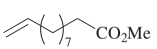
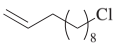
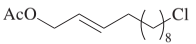
II

604

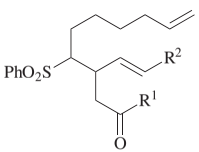
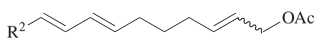
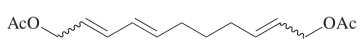
R^1	R^2	Solvent	Temp (°)	**I + II**	**I/II**
Ac	H	DCM	rt	(65)	>91:9
Bz	H	toluene	80	(67)	83:17
Bz	Me	toluene	80	(70)	>91:9
Bz	n-C_5H_{11}	toluene	80	(64)	>91:9
Bz	Ph	toluene	80	(68)	>91:9

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

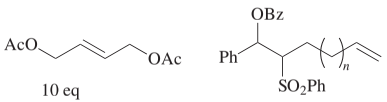
C. ALLYLIC ESTERS (*Continued*)

Allylic ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
		Hov II (0.01 eq), DCM, rt, 4 h	 (90)	605
10 eq				
4 eq		Ru cat **246** (0.00025 eq), toluene, 60°, 10 min	 68% conv.[a] (*E*)/(*Z*)= 70:30	606
3 eq		Catalyst (0.01 eq), toluene, 80°, 20 h		491

Catalyst		(*E*)/(*Z*)
Hov II	(90)	85:15
Ru cat **359**	(85)	87:13
Ru cat **360**	(85)	84:16
Ru cat **361**	(82)	77:23
Ru cat **362**	(73)	74:16

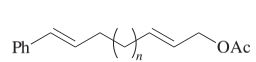
5 eq		1. Gr II (0.05 eq), toluene, 80°, 6 h 2. 5% Na in Hg (5.5 eq), NaH_2PO_4 (6.4 eq), MeOH, THF, rt, 1 h	 **I** +  **II**	604

R^1	R^2	**I + II**	**I/II**
Me	H	(74)	65:35
Me	Me	(80)	>91:9
Me	n-C_5H_{11}	(83)	>91:9
Me	Ph	(72)	>91:9
Ph	Ph	(74)	>91:9



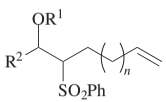
10 eq

1. Gr II (0.1 eq), toluene, 60°, 12 h
2. SmI_2 (x eq), solvent, –78°



445

n	x	Solvent	Time (h)		$(E,E)/(Z,E)$
2	2	HMPA (6 eq), THF	0.5	(72)	88:12
3	2	HMPA (6 eq), THF	0.5	(68)	90:10
3	3	THF/DMPU (4:1)	1	(61)	90:10



10 eq

1. Gr II (0.1 eq), toluene, 60°, 12 h
2. Na/Hg (5%), NaH_2PO_4, THF, MeOH, rt

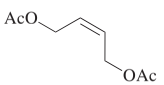
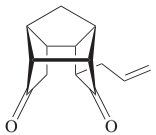
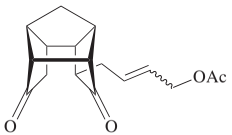
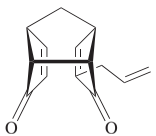
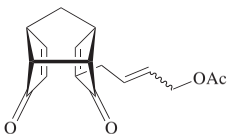
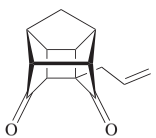
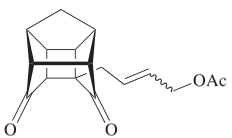
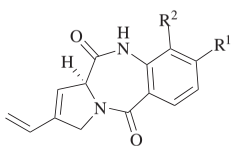
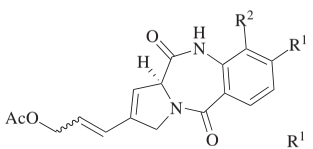
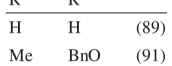


445

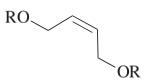
n	R^1	R^2		$(E,E)/(Z,E)$
2	Ac	n-C_6H_{13}	(85)	88:12
2	Bz	n-C_6H_{13}	(83)	90:10
3	Bz	Ph	(70)	88:12

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

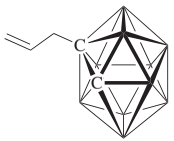
C. ALLYLIC ESTERS (*Continued*)

Allylic ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 2 eq		Ru cat **271** (0.05–0.07 eq), toluene, reflux, 12 h	 (62)	607
2 eq		Ru cat **271** (0.05–0.07 eq), toluene, reflux, 12 h	 (63)	607
2 eq		Ru cat **271** (0.05–0.07 eq), toluene, reflux, 12 h	 (64)	607
10 eq		Gr II (0.15 eq), DCM, reflux, 2 h	 	608

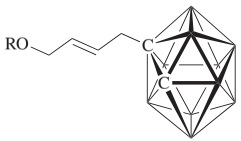
R^1	R^2	
H	H	(89)
Me	BnO	(91)



x eq

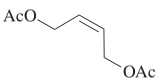


Gr II (0.021 eq), DCM, reflux

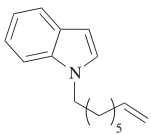


436

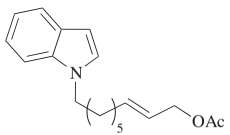
R	*x*	Time (h)		(*E*)/(*Z*)
Ac	4.1	24	(84)	94:6
Bz	4.2	25	(79)	88:12



3 eq



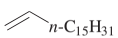
Ru cat **360** (0.01 eq), toluene, 80°, 8 h



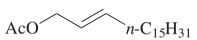
(90) (*E*)/(*Z*) = 69:31

491

2 eq



Ru cat **143** (0.05 eq), H_2O, 30°, 12 h



(68) (*E*)/(*Z*) = 90:10

588

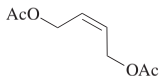
TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

C. ALLYLIC ESTERS (*Continued*)

Allylic ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

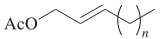
Please refer to the charts preceding the tables for the catalyst structures.

C_4





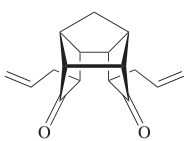
Catalyst (*y* eq), DCM



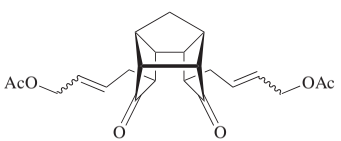
x eq

x	*n*	Catalyst	*y*	Temp (°)	Time (h)		(*E*)/(*Z*)	
2	14	Ru cat **88**	0.03	28	3	(85)	88:12	609
2	14	Ru cat **88**	0.01	25	2	(55)	88:12	609
2	14	Ru cat **130**	0.01	25	3	(38)	88:12	609
2	14	Ru cat **116**	0.01	25	2	(97)	88:12	609
2	14	Ru cat **116**	0.003	25	0.5	(73)	88:12	609
2	14	Ru cat **117**	0.01	25	2	(64)	88:12	609
—	15	Hov II	0.01	24	6	(37)	—	610
—	15	Ru cat **88**	0.01	24	6	(89)	—	610
2	14	Ru cat **175**	0.02	22	0.5	(73)	91:9	611
2	14	Ru cat **174**	0.02	22	0.5	(69)	91:9	611
2	14	Ru cat **177**	0.02	22	0.5	(64)	91:9	611
2	14	Ru cat **176**	0.02	22	0.5	(55)	91:9	611
2	14	Ru cat **178**	0.02	22	0.5	(36)	91:9	611
2	14	Ru cat **197**	0.02	22	0.5	(70)	91:9	611

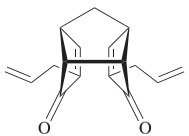
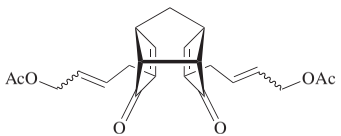
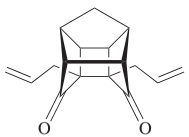
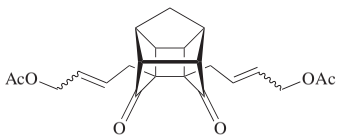
2 eq



Ru cat **271** (0.05–0.07 eq), toluene, reflux, 12 h



(55) 607

2 eq		Ru cat **271** (0.05–0.07 eq), toluene, reflux, 12 h		(40)	607
2 eq		Catalyst (0.05–0.07 eq), toluene, reflux, 12 h			607

Catalyst	
Gr II	(0)
Hov II	(24)
Ru cat **271**	(57)

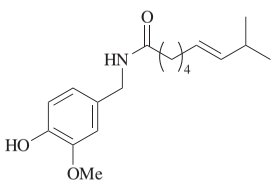
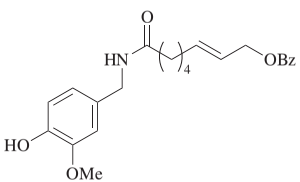
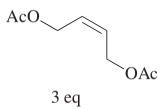
5 eq		Hov II (0.05 eq), DCM, 40°		(64) (*E*)/(*Z*) = 86:14	551

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)
C. ALLYLIC ESTERS (*Continued*)

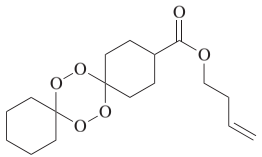
Allylic ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

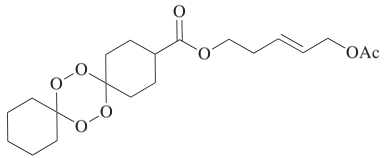
C_4



3 eq

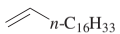


Ru cat **88** (0.03 eq), DCM, 45°, 2 h

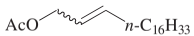


(89) (*E*)/(*Z*) = 80:20

193

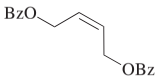


Catalyst (0.01 eq), toluene

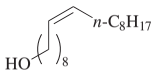


610

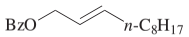
Catalyst	Temp (°)	Time (h)	
Ru cat **182**	55	5	(56)
Ru cat **182**	55	24	(78)
Ru cat **184**	24	5	(63)
Ru cat **184**	24	24	(85)
Ru cat **183**	55	5	(35)
Ru cat **183**	55	24	(52)
Ru cat **164**	90	47	(64)
Ru cat **165**	90	42	(57)
Ru cat **179**	24	24	(19)
Ru cat **180**	24	24	(53)



5 eq



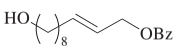
Hov II (0.05 eq), DCM, 40°



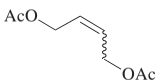
(62) (*E*)/(*Z*) = 88:12

551

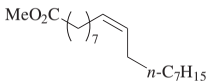
\+



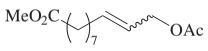
(63) (*E*)/(*Z*) = 89:11



10 eq



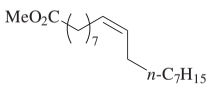
Hov II (0.01 eq), DCM, rt, 4 h



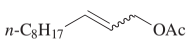
(80)

1214

x eq

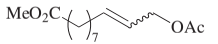


Ind II (0.01 eq), tetradecane (0.6 eq), solvent, 5 h



I

\+



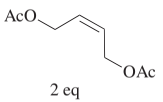
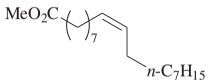
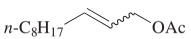
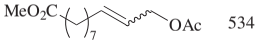
II

534

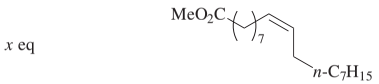
x	Solvent	Temp (°)	Conv. (%)[e]	Selectivity (%) **I**/**II**[e]	**I**[e]	**II**[e]
2	toluene	25	7	100:100	(7)	(7)
2	toluene	50	72	86:83	(62)	(58)
2	toluene	80	80	80:77	(64)	(61)
2	DCE	50	67	80:78	(54)	(52)
3	—	50	67	80:78	(54)	(52)

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

C. ALLYLIC ESTERS (*Continued*)

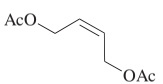
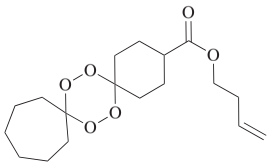
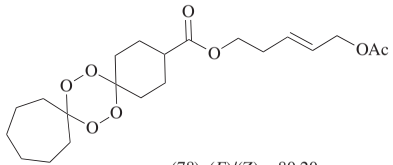
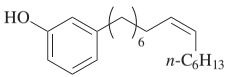
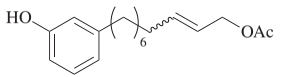
Allylic ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 2 eq		Catalyst (0.01 eq), tetradecane (0.6 eq), toluene, 50°	 **I** +  **II**	534

Catalyst	Conv. (%)[e] (1 h)	Selectivity **I/II**[e] (1 h)	**I**[e] (1 h)	**II**[e] (1 h)	Conv. (%)[e] (5 h)	Selectivity **I/II**[e] (5 h)	**I**[e] (1 h)	**II**[e] (1 h)
Ind II	43	85:75	(36)	(32)	72	86:83	(62)	(58)
Ru cat **283**	35	86;91	(30)	(32)	58	86:82	(50)	(48)
Ru cat **331**	58	80:76	(46)	(44)	77	82:79	(63)	(61)
Ru cat **297**	56	83:80	(46)	(45)	75	87:82	(65)	(62)
Ru cat **330**	50	84:82	(42)	(41)	70	84:82	(59)	(57)
Ru cat **319**	30	81:77	(24)	(23)	41	83:78	(34)	(32)
Ru cat **282**	8	100:100	(8)	(8)	34	78:77	(27)	(26)
Ru cat **326**	66	88:89	(58)	(59)	70	90:83	(63)	(58)
Ru cat **325**	71	81:75	(56)	(53)	73	82:76	(60)	(55)
Ru cat **327**	51	81:83	(41)	(42)	55	89:84	(49)	(46)
Ru cat **329**	40	91:92	(36)	(37)	44	90:87	(40)	(35)
Ru cat **294**	0	—	(0)	(0)	26	83:81	(22)	(21)
Ru cat **328**	16	89:87	(14)	(15)	16	100:100	(16)	(16)
Ru cat **315**	5	100:100	(5)	(5)	13	85:83	(11)	(10)
Gr II	63	83:86	(52)	(54)	65	80:84	(52)	(55)
Hov II	47	85:87	(40)	(41)	49	83:87	(41)	(42)



x	Catalyst	*y*	*z*	Temp (°)	Time (h)	Conv. (%)[c]	**I**	**II**	**III**	**IV**
5	Gr I	0.01	—	50	5	14	(3)	(4)	(6)	(5)
5	Gr II	0.01	—	50	5	48	(29)	(28)	(10)	(10)
5	Ind I	0.01	—	50	5	15	(4)	(4)	(6)	(6)
5	Ind II	0.01	—	50	5	42	(24)	(26)	(9)	(10)
5	Ru cat **304**	0.01	100	50	5	84	(53)	(52)	(16)	(16)
5	Ru cat **307**	0.01	100	50	5	90	(59)	(58)	(16)	(15)
5	Ru cat **307**	0.001	100	50	5	15	(1)	(2)	(7)	(7)
5	Ru cat **307**	0.005	100	50	5	32	(6)	(6)	(12)	(13)
5	Ru cat **307**	0.015	100	50	5	94	(66)	(65)	(15)	(14)
5	Ru cat **307**	0.02	100	50	5	96	(64)	(63)	(15)	(15)
2	Ru cat **307**	0.015	100	50	5	96	(45)	(45)	(25)	(26)
4	Ru cat **307**	0.015	100	50	5	92	(54)	(54)	(19)	(18)
8	Ru cat **307**	0.015	100	50	5	96	(76)	(78)	(10)	(9)
10	Ru cat **307**	0.015	100	50	5	96	(77)	(79)	(10)	(10)
8	Ru cat **307**	0.015	100	50	1	94	(58)	(61)	(18)	(17)
8	Ru cat **307**	0.015	100	50	3	94	(67)	(71)	(13)	(14)
8	Ru cat **307**	0.015	100	50	7	93	(73)	(78)	(10)	(10)
8	Ru cat **307**	0.015	100	50	9	93	(79)	(71)	(11)	(10)

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)
C. ALLYLIC ESTERS (*Continued*)

Allylic ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 3 eq		Ru cat **88** (0.03 eq) DCM, 45°, 2 h	 (78) (*E*)/(*Z*) = 80:20	193
5 eq		Catalyst (*x* eq), toluene, 60°		387

Catalyst	*x*	Time (h)	Conv. (%)[d]
Gr II	0.02	1	90
Gr II	0.02	2	91
Gr II	0.02	5	91
Ru cat **8**	0.02	1	74
Ru cat **8**	0.02	2	75
Ru cat **8**	0.02	5	81
Ru cat **8**	0.002	1	42
Ru cat **8**	0.002	2	47
Ru cat **8**	0.002	5	54
Ru cat **89**	0.02	1	98
Ru cat **89**	0.02	2	99
Ru cat **89**	0.02	5	99
Ru cat **90**	0.02	1	95
Ru cat **90**	0.02	2	96
Ru cat **90**	0.02	5	96
Ru cat **90**	0.002	1	60
Ru cat **90**	0.002	2	63
Ru cat **90**	0.002	5	66

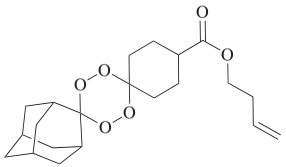
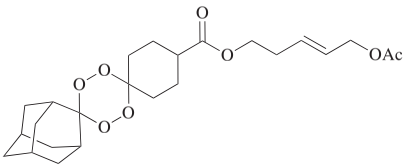
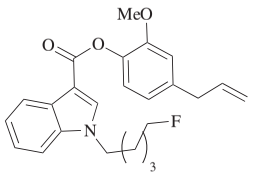
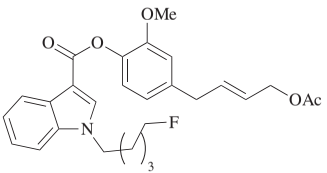
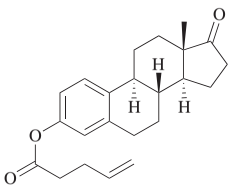
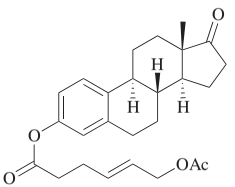
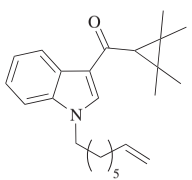
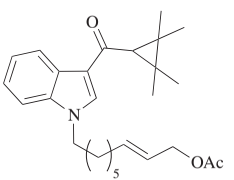
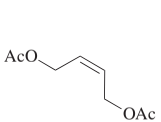
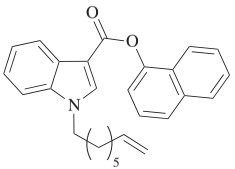
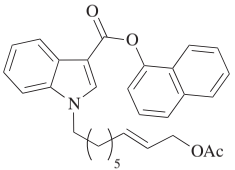
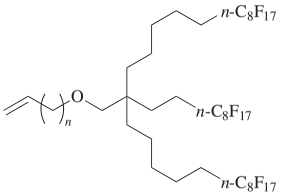
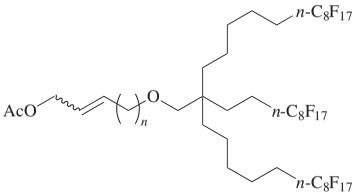
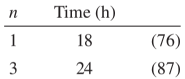
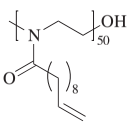
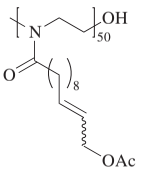
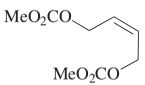
3 eq		Ru cat **88** (0.03 eq) DCM, 45°, 2 h	 (90%) (*E*)/(*Z*) = 89:11		193
3 eq		Ru cat **360** (0.01 eq), toluene, 80°, 8 h	 (92) (*E*)/(*Z*) = 77:23		491
10 eq		Ru cat **143** (0.05 eq), H_2O, 30°, 12 h		(75) (*E*)/(*Z*) = 90:10	588
3 eq		Ru cat **360** (0.01 eq), toluene, 80°, 8 h		(85) (*E*)/(*Z*) = 80:20	491

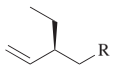
TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

C. ALLYLIC ESTERS (*Continued*)

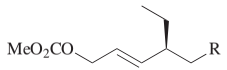
Allylic ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4  3 eq		Ru cat **360** (0.01 eq), toluene, 80°, 8 h	 (90) (*E*)/(*Z*) = 67:33	491
4 eq		Hov II (0.02 eq), Et_2O, reflux	 	613
10 eq		Hov II (0.05 eq), DCM, 40°, 2 h	 (88)	614



2 eq



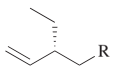
Gr II (0.03 eq),
DCM, reflux, 20 h



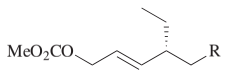
615

R		(*E*)/(*Z*)
BnO	(65)	90:10
$BnOCH_2$	(67)	90:10
$Ph(CH_2)_2$	(61)	87:13

2 eq



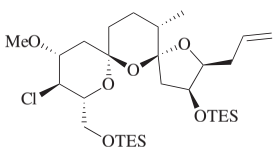
Gr II (0.03 eq),
DCM, reflux, 20 h



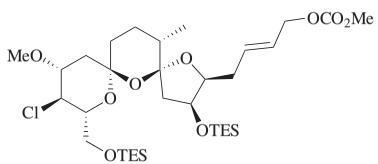
615

R		(*E*)/(*Z*)
BnO	(65)	90:10
$BnOCH_2$	(69)	90:10
$Ph(CH_2)_2$	(63)	87:13

2 eq



Gr II (0.05 eq),
DCM, 40°, 3 h



(95) (*E*)/(*Z*) = 87.5:12.5

616

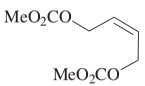
TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

C. ALLYLIC ESTERS (*Continued*)

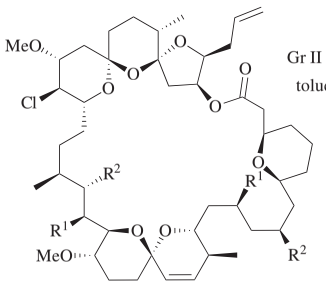
Allylic ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

C_4



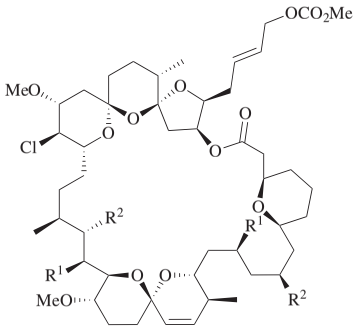
15 eq



R^1–R^2 =



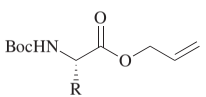
Gr II (0.2 eq), toluene, 80°, 16 h



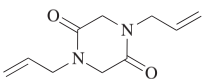
(58) (*E*)/(*Z*) = 86:14

616

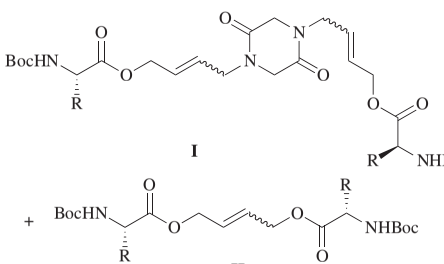
$C_{6–12}$



3 eq



Gr II (0.10 eq), $CHCl_3$, reflux, 10 h



I

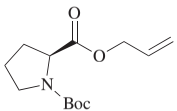
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II

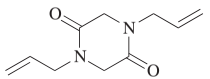
R	I	II
Me	(40)	(42)
$MeS(CH_2)_2$	(0)	(0)
Bn	(37)	(38)

554

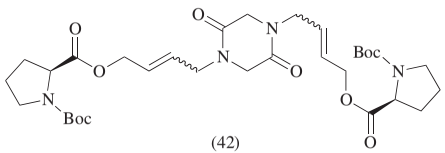
C_8



3 eq



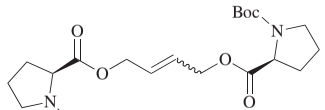
Gr II (0.10 eq),
$CHCl_3$, reflux, 10 h



(42)

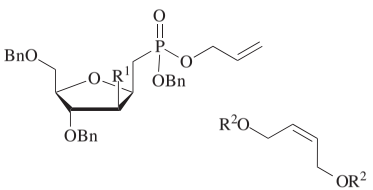
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+



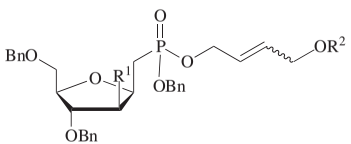
(31)

C_9



x eq

1. Gr I (0.2 eq),
DCM, reflux, 3 h
2. $Pb(OAc)_4$,
rt, overnight

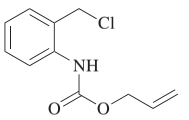
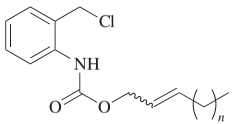
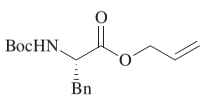
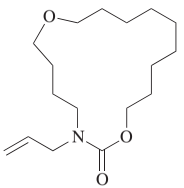
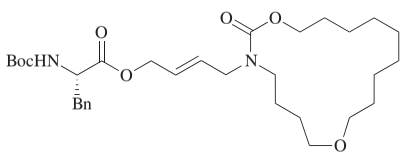
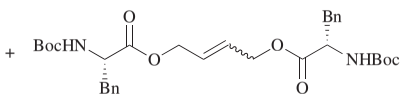


617

R^1	R^2	*x*	
BnO	*n*-C_7H_{15}	3	(55)
BnO	*n*-C_8H_{17}	3	(63)
BnO	*n*-C_9H_{19}	4	(57)
BnO	*n*-$C_{10}H_{21}$	4	(51)
BnO	*n*-$C_{12}H_{25}$	4	(66)
BnO	*n*-$C_{16}H_{33}$	4	(62)

TABLE 4. CROSS-METATHESIS OF PRIMARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

C. ALLYLIC ESTERS (*Continued*)

Allylic ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{11} 		Hov II (0.05 + 0.02 eq), DCM, 40°, 16 h	 *n*: 3 (49); 5 (62)	618
C_{12}  2 eq 		Gr II (0.05 eq), $CHCl_3$, reflux, 21 h	 (48) (*E*)/(*Z*) = 55:45 +  (45)	386

[a] The conversion was determined by ^{1}H NMR analysis.

[b] The ratios were determined by ^{1}H NMR spectroscopy.

[c] The conversion was determined by GC analysis.

[d] The conversion was determined by HPLC analysis.

[e] The conversion, selectivity and yield were determined by GC analysis.

TABLE 5. CROSS-METATHESIS OF PRIMARY ALLYLIC HALIDES AND 1,4-DIHALOBUT-2-ENES

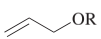
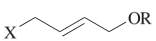
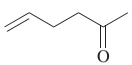
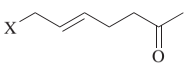
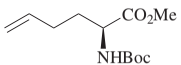
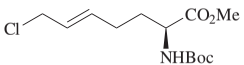
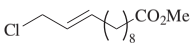
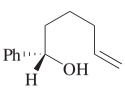
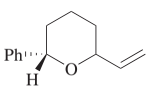
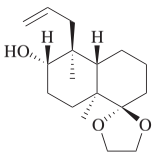
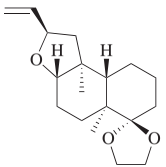
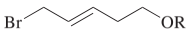
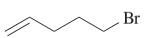
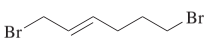
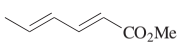
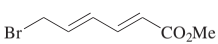
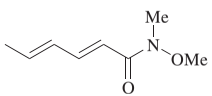
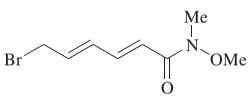
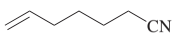
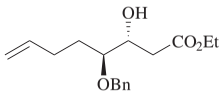
Allyl Halide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3  2 eq		Hov II (0.02 eq), DCM, rt, 3–8 h		197
			X R (39) (*E*)/(*Z*) Cl TBS (39) 95:5 Br TBS (35) 76:24 Cl Bn (65) 89:11 Br Bn (58) 86:14	
2 eq		Hov II (0.02 eq), DCM, rt, 3–8 h		197
			X (*E*)/(*Z*) Cl (49) 93:7 Br (46) 80:20	
 3.5 eq		Gr II (0.1 eq), DCM, 40°, 14 h	 (67) (*E*)/(*Z*) = 86:14	619
6 eq		Ru cat **139** (0.02 eq), DCM, reflux, 5 h	 (80) (*E*)/(*Z*) = 89:11	620
 3 eq		1. Gr II (0.1 eq), DCM, reflux, time 1 2. Toluene, reflux, time 2		621
			X Time 1 (h) Time 2 (h) (66) dr (*cis:trans*) Cl 16 — (66) 67:33 Cl 3 12 (79) 67:33 Br 2 10 (78) 67:33	

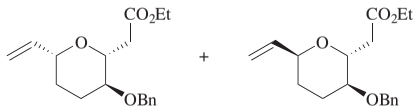
TABLE 5. CROSS-METATHESIS OF PRIMARY ALLYLIC HALIDES AND 1,4-DIHALOBUT-2-ENES (*Continued*)

Allyl Halide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
3 + 3 eq		Gr II (4 x 0.05 eq), DCM, reflux, 30 h	 (53)	622
 2 eq		Hov II (0.02 eq), DCM, rt, 3–8 h	 R (*E*)/(*Z*) H (37) 83:17 Bz (49) 78:22	197
2 eq		Hov II (0.02 eq), DCM, rt, 3–8 h	 (51) (*E*)/(*Z*) = 85:15	197
5 eq		Hov II (0.02 eq), DCM, rt, 48 h	 (48) (*E*)/(*Z*) = 95:5	549, 131 623
5 eq		Hov II (0.05 eq), DCM, rt, 14 h	 (39) (*E*)/(*Z*) = 95:5	549
2 eq		Hov II (0.02 eq), DCM, rt, 3–8 h	 (30) (*E*)/(*Z*) = 83:17	197

10 eq



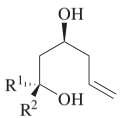
1. Gr II (0.1 eq),
DCM, 40°, 5 h
2. Toluene, 100°, 10 h



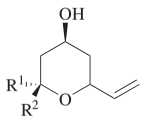
I **I** + **II** (71), **I**/**II** = 75:25 **II**

624

3 eq



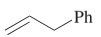
1. Gr II (0.1 eq),
DCM, reflux, 2 h
2. Toluene, reflux



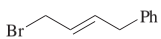
621

R^1	R^2	Time (h)		dr (*cis:trans*)
$BnO(CH_2)_2$	H	3–10	(95)	80:20
i-Pr	H	3–10	(80)	75:25
$BnOCH_2C(Me)_2$	H	3–10	(85)	80:20
Ph	H	3	(83)	83:17
Ph	Ph	12	(29)	72:28

2 eq



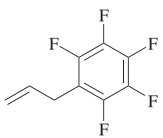
Gr I (0.05 eq),
DCM, reflux, 16 h



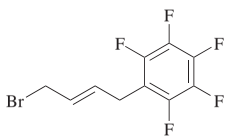
(65) (*E*)/(*Z*) = 77:23

156

2 eq



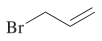
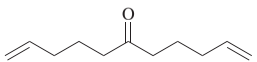
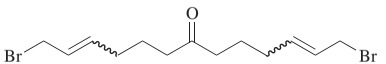
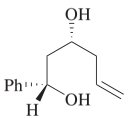
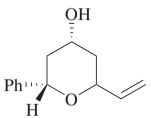
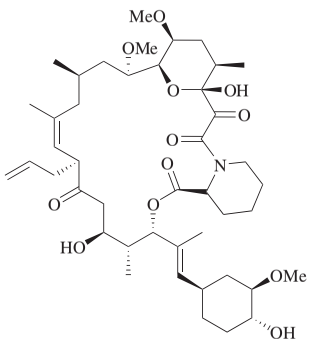
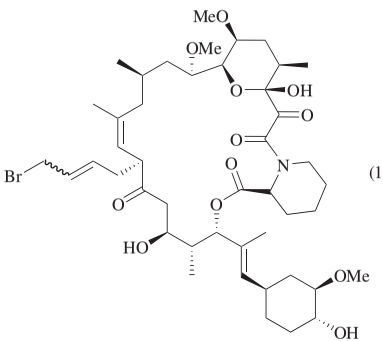
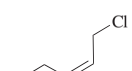
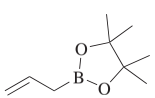
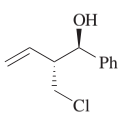
Hov II (0.02 eq),
DCM, rt, 3–8 h



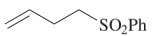
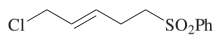
(39) (*E*)/(*Z*) = 75:25

197

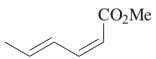
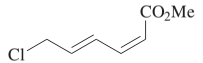
TABLE 5. CROSS-METATHESIS OF PRIMARY ALLYLIC HALIDES AND 1,4-DIHALOBUT-2-ENES (*Continued*)

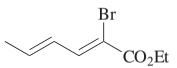
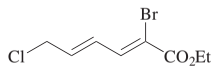
Allyl Halide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 6 eq		Ru cat **190** (2 x 0.025 eq), DCM, rt, 192 h	 (35)	231
3 eq		1. Gr II (0.1 eq), DCM, reflux, 3 h 2. Toluene, reflux, 10 h	 (62) dr (*cis:trans*) = 67:33	621
20 eq		Gr II (0.1 eq), DCB, 150° (MW), 5 min	 (11)	432
C_4				
 3 eq		1.Gr II (*x* eq), DCM, reflux, 2–12 h 2. PhCHO (1.5 eq), 23°, 12–48 h		126

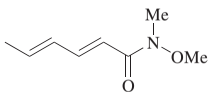
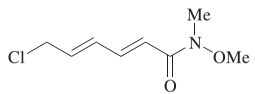
x		*anti/syn*[a]
0.05	(78)	83:17
0.02	(79)	82:18

2 eq  Catalyst (*x* eq), DCM, 25°  (*E*)/(*Z*) = 90:10 609

Catalyst	*x*	Time (h)	
Hov II	0.01	1	(100)
Hov II	0.002	3	(67)
Ru cat **115**	0.002	3	(82)
Ru cat **115**	0.003	4	(89)

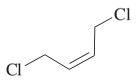
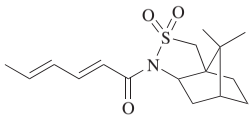
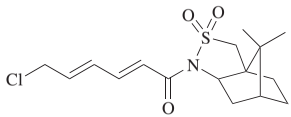
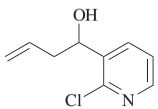
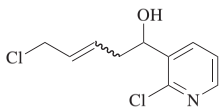
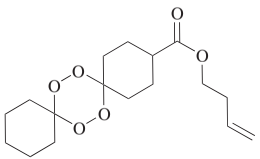
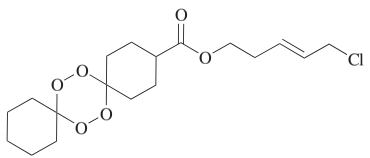
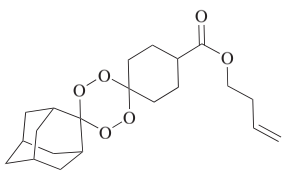
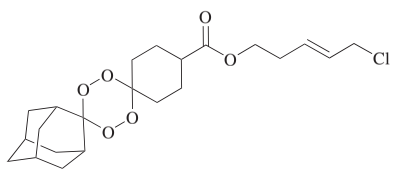
 Gr II (0.05 eq), DCM, 40°, 8 h  (63) (*E*) only 589

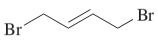
2 eq  Gr II (0.05 eq), DCM, reflux, 12 h  (48) (*E*)/(*Z*) = 86:14 132

5 eq  Hov II (*x* eq), DCM, rt  549

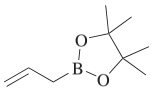
x	Time (h)		(*E*)/(*Z*)
0.1	24	(70)	95:5
0.05	0.5	(59)	99:1

TABLE 5. CROSS-METATHESIS OF PRIMARY ALLYLIC HALIDES AND 1,4-DIHALOBUT-2-ENES (*Continued*)

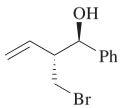
Allyl Halide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 5 eq		Hov II (0.1 eq), DCM, rt, 24 h	 (57) (*E*)/(*Z*) = 94:6	549
3 eq		Hov II (0.1 eq), DCM, 50°, 24 h	 (38)	603
3 eq		Ru cat **88** (0.03 eq) DCM, 45°, 2 h	 (89) (*E*)/(*Z*) = 86:14	193
3 eq		Ru cat **88** (0.03 eq) DCM, 45°, 2 h	 (87) (*E*)/(*Z*) = 86:14	193



3 eq



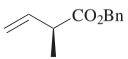
1.Gr II (*x* eq),
DCM, reflux, 2–12 h
2. PhCHO (1.5 eq),
23°, 12–48 h



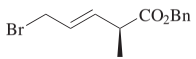
x		*anti/syn*[a]
0.05	(73)	79:21
0.02	(72)	78:22

126

2 eq



Hov II (0.05 eq),
2,6-Cl_2-BQ (0.1 eq),
DCM, 40°, 16 h



(73) (*E*) only

555

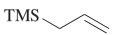
[a] The ratios were determined by ^{1}H NMR spectroscopy.

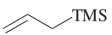
TABLE 6. CROSS-METATHESIS OF ALLYLSILANES

Allylsilane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

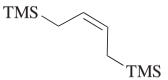
Please refer to the charts preceding the tables for the catalyst structures.

C_3





Catalyst (0.02 eq), THF, 35°



(*Z*)/(*E*) = 95:5

Catalyst	Time (h)		
Ru cat **217**	3	(54)	84
Ru cat **215**	9	(14)	488

2 eq



Mo cat **1** (0.02 eq), DME, rt, 4 h

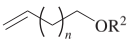


I + **II** 208

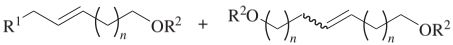
R	*n*	**I**	(*E*)/(*Z*) **I**	**II**
NC–	0	(34)	80:20	(0)
NC–	1	(37)	81:19	(15)
NC–	2	(62)	83:17	(14)
BnO_2C	1	(61)	75:25	(30)
Br	1	(45)	74:26	(12)
Br	2	(60)	76:24	(19)



2 eq



Mo cat **1** (0.02 eq), DME, rt, 4 h



I + **II** 208

R^1	R^2	*n*	**I**	(*E*)/(*Z*) **I**	**II**
TMS	TBS	1	(62)	76:24	(23)
TMS	TBS	2	(54)	79:21	(10)
TMS	TBS	3	(56)	74:26	(19)
TMS	Bn	1	(67)	79:21	(8)
TMS	Bn	2	(60)	82:18	(26)
TMS	Bn	3	(66)	72:28	(6)
TMS	Ph	2	(72)	72:28	(5)
TMS	Ph	3	(72)	72:28	(—)
TIPS	Ph	3	(77)	88:12	(—)

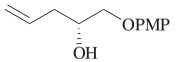
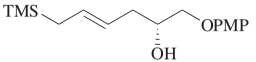
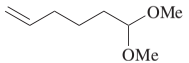
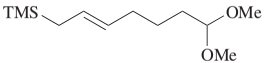
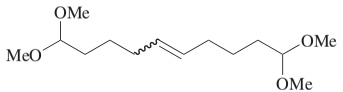
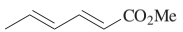
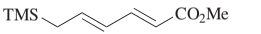
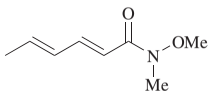
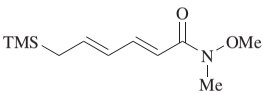
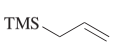
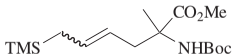
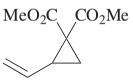
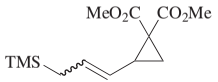
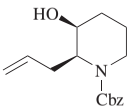
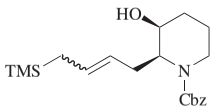
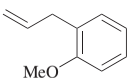
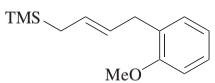
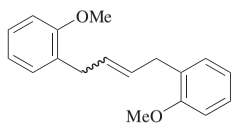
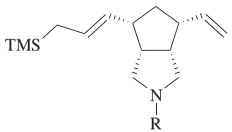
 0.9 eq		Hov II (0.025 eq), DCM, rt, 36 h		(76) (*E*)/(*Z*) = 75:25	626
2 eq		Mo cat **1** (0.02 eq), DME, rt, 4 h	 + 	(55) (*E*)/(*Z*) = 73:27 (5)	208
5 eq		Hov II (0.05 eq), DCM, rt, 48 h	 + 	(61) (*E*)/(*Z*) = 83:17 (10)	549
5 eq		Hov II (0.1 eq), DCM, rt, 24 h		(45) (*E*)/(*Z*) = 80:20	549

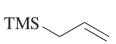
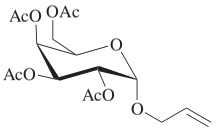
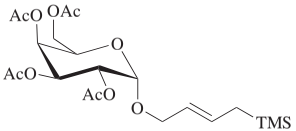
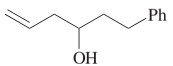
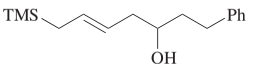
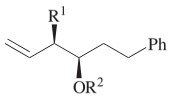
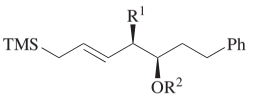
TABLE 6. CROSS-METATHESIS OF ALLYLSILANES (*Continued*)

Allylsilane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 4 eq		Gr II (0.05 eq), toluene, rt, 17 h	 (70)	457
1.4 eq		Gr II (0.01 eq), DCM, reflux	 (7)	407
2 eq		Gr II (0.1 eq), DCM, reflux, 24 h	 (70)	441
2 eq		Mo cat **1** (0.02 eq), DME, rt, 4 h	 (73) (*E*)/(*Z*) = 76:24	208
			+  (7)	

2 eq  Catalyst (*x* eq), solvent  96

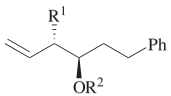
R	Catalyst	*x*	Solvent	Temp (°)	Time (h)	Conv. (%)[a]	(*E*)/(*Z*)	er
Tos	Ru cat **32**	0.03	DCM	rt	12	>99	40:60	87.5:12.5
Tos	Ru cat **32**	0.03	MTBE	rt	12	>99	67:33	79.0:21.0
Tos	Ru cat **32**	0.03	THF	rt	12	>99	50:50	81.5:18.5
Tos	Ru cat **32**	0.03	benzene	rt	12	>99	67:33	76.5:23.5
Tos	Ru cat **32**	0.03	toluene	rt	12	>99	67:33	78.5:21.5
Tos	Ru cat **32**	0.03	$C_6H_5CF_3$	rt	12	92	60:40	84.5:15.5
Tos	Ru cat **32**	0.025	DCM	40	1	>99	40:60	87.5:12.5
Tos	Ru cat **32**	0.025	DCM	rt	2	>99	40:60	87.5:12.5
Tos	Ru cat **32**	0.025	DCM	0	2	>99	33:67	89.5:10.5
Tos	Ru cat **32**	0.025	DCM	–10	48	>99	33:67	89.5:10.5
Tos	Ru cat **229**	0.025	DCM	rt	18	>99	50:50	86.5:13.5
Tos	Ru cat **24**	0.025	DCM	rt	2	>99	75:24	67.0:33.0
CF_3CO	Ru cat **32**	0.025	DCM	rt	2	>99	67:33	90.0:10.0
CF_3CO	Ru cat **32**	0.025	DCM	0	6	>99	67:33	91.0:9.0

TABLE 6. CROSS-METATHESIS OF ALLYLSILANES (*Continued*)

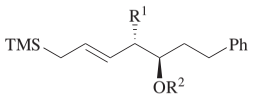
Allylsilane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 2 eq		Gr I (0.2 eq), DCM, reflux, 6 h	 (94) (*E*)/(*Z*) = 80:20	571
4 eq		Gr II (0.05 eq), DCM, reflux, 4 h	 (84) (*E*)/(*Z*) = 70:30	627
4 eq		Gr II (0.05 eq), DCM, reflux		627

R^1	R^2	Time (h)	Conv. (%)[a]		(*E*)/(*Z*)
Me	H	4	—	(81)	80:20
EtO_2C	H	4	—	(74)	80:20
EtO_2C	TMS	24	33–45	(—)	92:8

4 eq



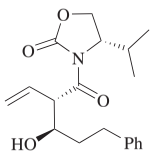
Gr II (0.05 eq),
DCM, reflux



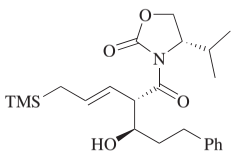
627

R^1	R^2	Time (h)	Conv. (%)[a]		(*E*)/(*Z*)
Me	H	4	—	(86)	92:8
EtO_2C	H	4	—	(67)	92:8
EtO_2C	TMS	24	33–45	(—)	89:11

4 eq

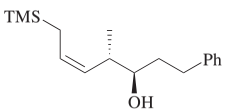


Gr II (0.05 eq),
DCM, reflux, 4 h

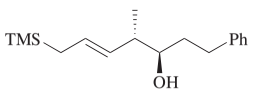


(75) (*E*)/(*Z*) > 95:5 627

4 eq

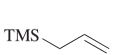
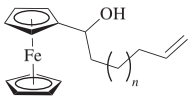
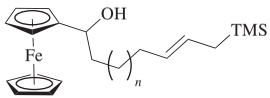
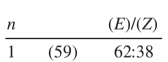
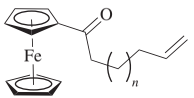
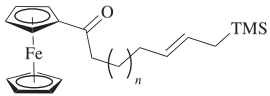
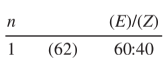
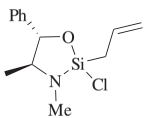
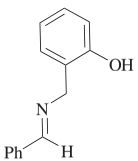
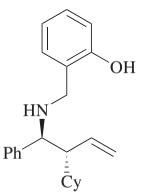


Gr II (0.05 eq),
DCM, reflux, 18 h



(—) (*E*)/(*Z*) = 54:46 627

TABLE 6. CROSS-METATHESIS OF ALLYLSILANES (*Continued*)

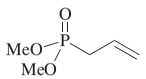
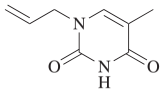
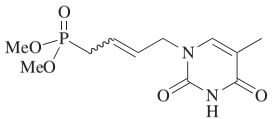
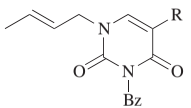
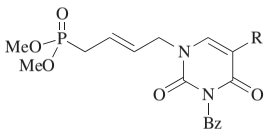
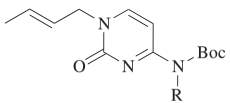
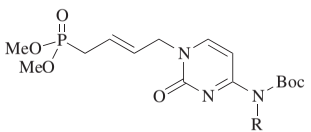
Allylsilane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 2 eq		Gr I (0.19 eq), DCM, reflux, 17–24 h		 587
2 eq		Gr I (0.19 eq), DCM, reflux, 17–24 h		 587
 1.5 eq	 7.5 eq +  **I**	1. Gr II (0.026 eq), DCM, reflux, 7 h 2. **I**, reflux, 14 h		(58) dr > 95:5, er = 99.5:0.5 211

n		(*E*)/(*Z*)
1	(59)	62:38
2	(45)	63:37

n		(*E*)/(*Z*)
1	(62)	60:40
2	(58)	58:42

[a] The conversion was determined by ^{1}H NMR analysis.

TABLE 7. CROSS-METATHESIS OF ALLYLIC ORGANOPHOSPHORUS COMPOUNDS
A. ALLYLPHOSPHONATES

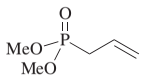
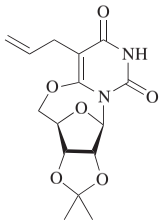
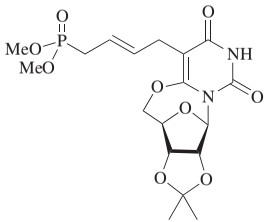
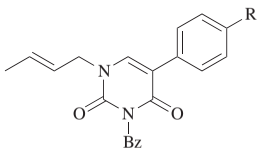
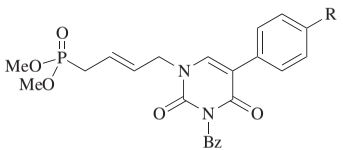
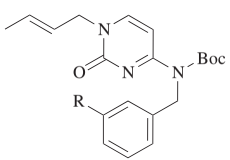
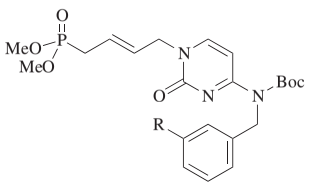
Allylphosphonate	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 5 eq		Ru cat **35** (0.1 eq), DCM, 40°, 5 h	 (0)	628
4 eq		Gr II (0.05 eq), DCM, reflux, 16 h		629
6 eq		Ru cat **35** (0.05 eq), DCM, 60°, 12 h		630

R		(*E*)/(*Z*)
H	(87)	80:20
Cl	(87)	83:17
Br	(74)	83:17
PhS	(74)	83:17

R		(*E*)/(*Z*)
n-C_4H_9	(59)	95:5
n-C_5H_{11}	(53)	95:5
Cy	(66)	95:5
n-C_9H_{19}	(46)	95:5

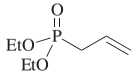
TABLE 7. CROSS-METATHESIS OF ALLYLIC ORGANOPHOSPHORUS COMPOUNDS (*Continued*)

A. ALLYLPHOSPHONATES (*Continued*)

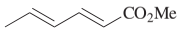
Allylphosphonate	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 5 eq		Ru cat **35** (0.06 eq), DCM, reflux, 7 h	 (90) (*E*) only	631
4 eq		Gr II (0.05 eq), DCM, reflux, 16 h		629
6 eq		Ru cat **35** (0.05 eq), DCM, 60°, 12 h		630

R		(*E*)/(Z)
H	(94)	83:17
F	(81)	83:17
MeO	(92)	83:17

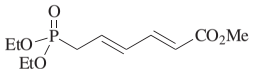
R		(*E*)/(Z)
H	(52)	95:5
Cl	(67)	95:5
F	(67)	95:5



5 eq

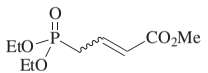


Hov II (0.05 eq),
DCM, rt, 48 h



I (*E*,*E*)/(*E*,*Z*) = 85:15

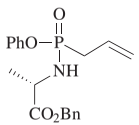
\+

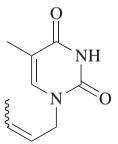


II

I + **II** (56), **I/II** = 80:20

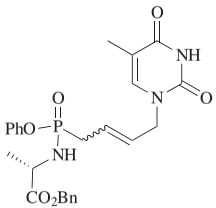
549



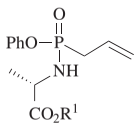


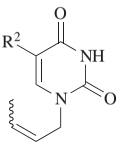
2 eq

Gr II (3 x 0.06 eq),
H_2O, PTS (*x* eq),
ultrasound, 55°, 20 h



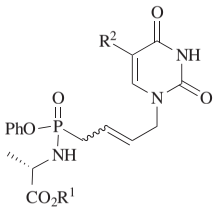
x		
0	(41)	632
0.025	(40)	





2 eq

Gr II (3 x 0.06 eq),
H_2O, PTS (0.025 eq),
ultrasound, 55°, 20 h



R^1	R^2		
Me	Me	(41)	632
i-Pr	Me	(44)	
Bn	F	(36)	
Bn	Cl	(35)	

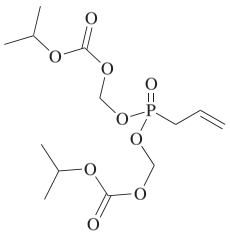
TABLE 7. CROSS-METATHESIS OF ALLYLIC ORGANOPHOSPHORUS COMPOUNDS (*Continued*)

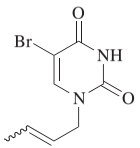
A. ALLYLPHOSPHONATES (*Continued*)

Allylphosphonate	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

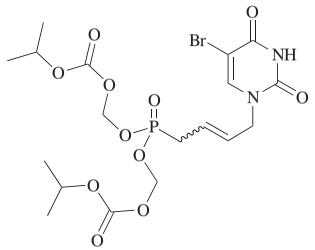
C_3





1.3 eq

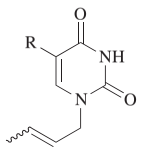
Catalyst (0.05 eq), DCM



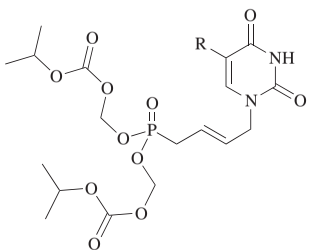
219

Catalyst	Temp (°)	Time (h)	
Ru cat **35**	rt	24	(tr)
Ru cat **282**	rt	24	(tr)
Ind II	rt	24	(tr)
Ru cat **38**	rt	0.5	(44)
Ru cat **286**	rt	0.5	(46)
Ru cat **285**	rt	0.5	(46)
Ru cat **35**	40	18	(36)
Ru cat **282**	40	18	(59)
Ind II	40	18	(29)
Ru cat **285**	40	18	(23)

1.3 eq



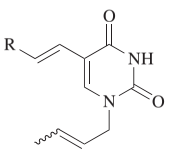
Ru cat **285** (0.05 eq), DCM, rt



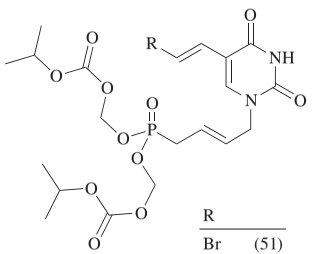
219

R	Time (min)		(*E*)/(*Z*)
H	45	(46)	85:15
F	60	(52)	85:15
Cl	40	(53)	85:15
Br	30	(56)	85:15
CH_3	30	(47)	85:15

1.3 eq



Ru cat **285** (0.05 eq), DCM, rt, 3.5 h



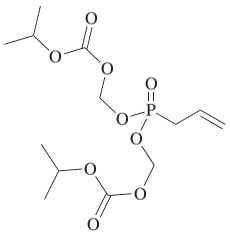
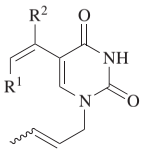
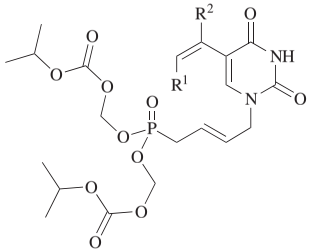
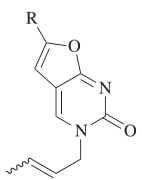
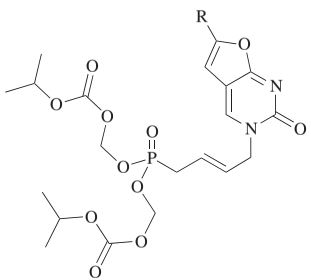
(*E*) only

633

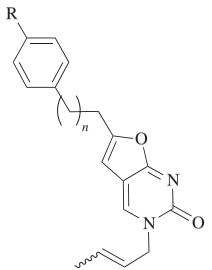
R	
Br	(51)
I	(47)

TABLE 7. CROSS-METATHESIS OF ALLYLIC ORGANOPHOSPHORUS COMPOUNDS (*Continued*)

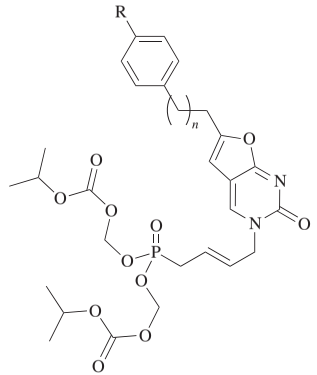
A. ALLYLPHOSPHONATES (*Continued*)

Allylphosphonate	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 1.3 eq		Ru cat **285** (0.05 eq), DCM, rt, 3.5 h		(*E*) only 633
			R^1 R^2 I I (51); I Br (40); I Cl (45); Br Br (48)	
1.3 eq		Ru cat **285** (0.05 eq), DCM, reflux, 16 h		(*E*) only 633
			R: *n*-C_3H_7 (51); *n*-C_5H_{11} (49); *n*-C_8H_{17} (51)	

1.3 eq

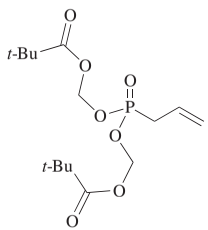


Ru cat **285** (0.05 eq),
DCM, reflux, 16 h

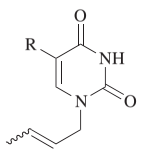


(*E*) only 633

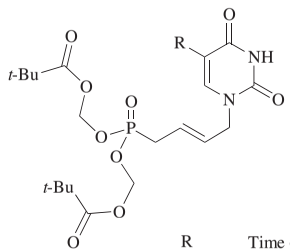
R	*n*	
H	1	(58)
Me	1	(52)
Me	3	(55)



1.3 eq



Ru cat **285** (0.05 eq),
DCM, 40°



(*E*)/(*Z*) = 85:15 219

R	Time (h)	
H	1	(56)
F	0.75	(60)
Cl	1	(53)
Me	0.5	(63)

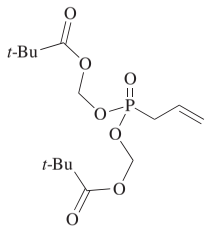
TABLE 7. CROSS-METATHESIS OF ALLYLIC ORGANOPHOSPHORUS COMPOUNDS (*Continued*)

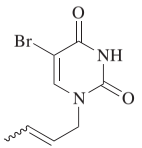
A. ALLYLPHOSPHONATES (*Continued*)

Allylphosphonate	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

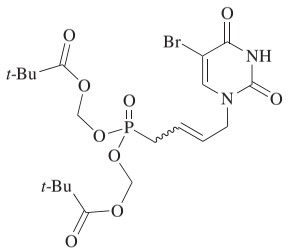
C_3





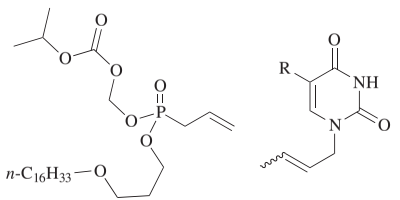
1.3 eq

Catalyst (0.05 eq), DCM



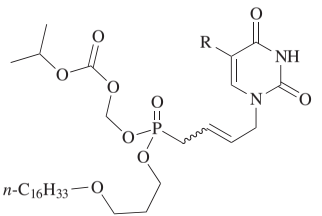
219

Catalyst	Temp (°)	Time (h)		(*E*)/(*Z*)
Gr I	rt	24	(0)	—
Ind I	rt	24	(0)	—
Ru cat **35**	rt	24	(tr)	—
Ru cat **282**	rt	24	(tr)	—
Ind II	rt	24	(tr)	—
Ru cat **38**	rt	1	(50)	—
Ru cat **286**	rt	1.5	(54)	—
Ru cat **285**	rt	1	(47)	—
Gr I	40	24	(0)	—
Ind I	40	24	(0)	—
Ru cat **35**	40	0.3	(69)	—
Ru cat **282**	40	4	(74)	—
Ind II	40	3	(71)	—
Ru cat **285**	40	1	(36)	—
Ru cat **285**	40	0.5	(69)	85:15



1.3 eq

Catalyst (0.05 eq),
DCM, rt



219

R	Catalyst	Time (min)	
H	Ru cat **285**	35	(41)
F	Ru cat **285**	35	(45)
Cl	Ru cat **35**	—	[a]
Cl	Ru cat **282**	—	(tr)
Cl	Ru cat **38**	30	(47)
Cl	Ru cat **286**	45	(50)
Cl	Ru cat **285**	30	(48)
Cl	Ru cat **285**	35	(47)
Br	Ru cat **285**	35	(48)
Me	Ru cat **285**	35	(44)

[a] The reaction resulted in low conversion.

TABLE 7. CROSS-METATHESIS OF ALLYLIC ORGANOPHOSPHORUS COMPOUNDS (*Continued*)

B. ALLYL PHOSPHINE OXIDES

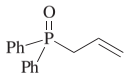
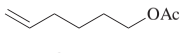
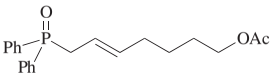
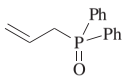
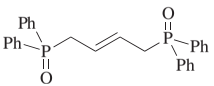
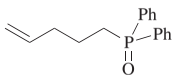
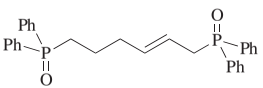
Allyl Phosphine Oxide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
	 3 eq	Gr II (0.02–0.06 eq), DCM, 40°, 20–48 h	 (70) (*E*)/(*Z*) = 80:20	214
— eq		Gr II (0.02 eq), DCM, 40°, 20–48 h	 (96) (*E*) only	214
3 eq		Gr II (0.04 eq), DCM, 40°, 20–48 h	 (94) (*E*) only	214

TABLE 7. CROSS-METATHESIS OF ALLYLIC ORGANOPHOSPHORUS COMPOUNDS (*Continued*)

C. ALLYL PHOSPHINE BORANES

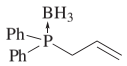
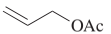
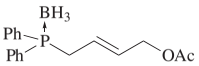
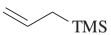
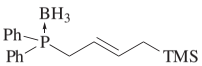
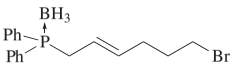
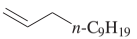
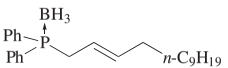
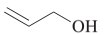
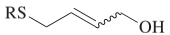
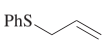
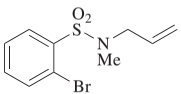
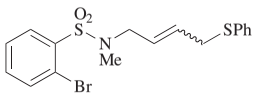
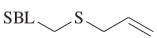
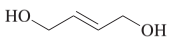
Allyl Phosphine Borane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
	 3 eq	Gr II (0.08 eq), DCM, reflux, 96 h		(0) 213
	 3 eq	Gr II (0.04 eq), DCM, reflux, 24 h		(85) (*E*)/(*Z*) = 83:17 213
	 3 eq	Gr II (0.08 eq), DCM, reflux, 48 h		(41) (*E*) only 213
	 3 eq	Gr II (0.04 eq), DCM, reflux, 24 h		(60) (*E*)/(*Z*) = 90:10 213

TABLE 8. CROSS-METATHESIS OF PRIMARY ALLYLIC ORGANOSULFUR AND ORGANOSELENIUM COMPOUNDS

A. ALLYLIC SULFIDES AND SELENIDES

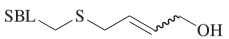
Sulfide or Selenide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
	 10 eq	Hov II (0.06 eq), *t*-BuOH/H_2O (1:1), 32°, 3.5 h	 R: Ph (28); Bn (52)	559
 3 eq		Gr II (0.05 eq), DCM, 40°, 3 h	 (72)	634
	 *x* eq	Hov II (*y* eq), additive (*z* eq), 30% *t*-BuOH/H_2O, pH 8.0		

R	*x*	*y*	Additive	*z*	Time (h)	Temp (°)	Conv. (%)[a]	
HO	9250	187.5	—	—	5	rt	0	559
HO	9250	187.5	$MgCl_2$•$6H_2O$	8750	5	rt	>90	559
HO	9259	187.5	NaCl	8750	5	rt	0	559
HO	10,000	~200	$MgCl_2$•$6H_2O$	10,000	2	rt	>95	226
AcHN	5009	~210	$MgCl_2$•$6H_2O$	10,600	1	37	0	226
$Cl^-Me_3N^+$	5009	~210	$MgCl_2$•$6H_2O$	10,600	1	37	0	226
$Cl^-HMeN^+(CH_2)_2O$	5009	~210	$MgCl_2$•$6H_2O$	10,600	1	37	0	226

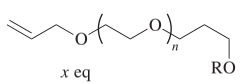


10,000 eq

Hov II (~200 eq),
$MgCl_2 \bullet 6H_2O$ (10,000 eq),
30% *t*-BuOH/H_2O,
pH 8.0, rt, 2 h

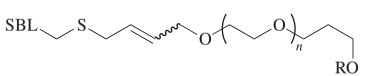


28% conv.[a] 226

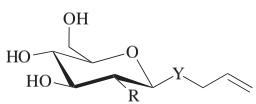


x eq

Hov II (~210 eq),
$MgCl_2 \bullet 6H_2O$ (10,600 eq),
30% *t*-BuOH/H_2O,
pH 8.0, rt + 37°

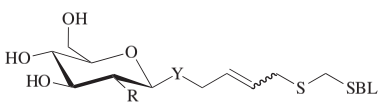


n	R	*x*	Time (h)	Conv. (%)[a]	
2	Me	5400	2 + 1	55	559
3	H	5400	2 + 1	60	559
3	H	5009	2 + 0.5	65	226



x eq

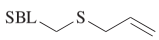
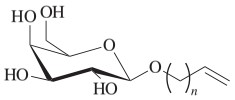
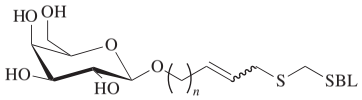
Hov II (*y* eq),
$MgCl_2 \bullet 6H_2O$ (*z* eq),
30% *t*-BuOH/H_2O, pH 8.0



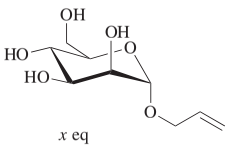
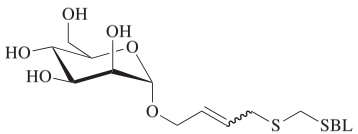
R	Y	*x*	*y*	*z*	Temp (°)	Time (h)	Conv. (%)[a]	
HO	O	2750	~183	7500	rt + 37	1 + 4	50	559
HO	O	4971	~200	10,000	37	1	30	226
AcHN	O	5009	~210	10,800	rt + 37	2	0	226
AcHN	S	5009	~210	10,800	rt + 37	1	0	226

TABLE 8. CROSS-METATHESIS OF PRIMARY ALLYLIC ORGANOSULFUR AND ORGANOSELENIUM COMPOUNDS (*Continued*)

A. ALLYLIC SULFIDES AND SELENIDES (*Continued*)

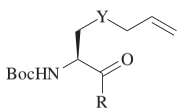
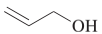
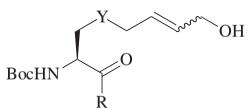
Sulfide or Selenide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
	 5009 eq	Hov II (~200 eq), $MgCl_2 \cdot 6H_2O$ (10,130 eq), 30% *t*-BuOH/H_2O, pH 8.0, 37°, 1 h		226

n	Conv. (%)[a]
1	30
4	>95

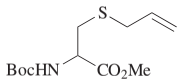
	 *x* eq	Hov II (~210 eq), $MgCl_2 \cdot 6H_2O$ (10,600 eq), 30% *t*-BuOH/H_2O, pH 8.0		

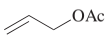
x	Temp (°)	Time (h)	Conv. (%)[a]	
10,600	rt + 37	1 + 4	60	559
5009	37	1	30	226

C_6

	 10 eq	Hov II (*x* eq), *t*-BuOH/H_2O (*y*/*z*), 32°		

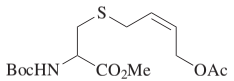
R	Y	*x*	*y*/*z*	Time (h)	Conv. (%)[a]	
H_2N	S	0.08	1:1	3.5	56	559
H_2N	S	0.08	3:7	3.5	68	559
H_2N	S	0.06	1:1	2.5	56	226
H_2N	Se	0.06	1:1	2.5	72	226
MeO	S	2 x 0.1	1:1	2.5	72	227





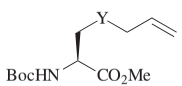
5 eq

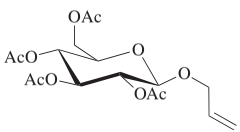
Catalyst (0.075 eq),
additive (2 mM),
H_2O/*t*-BuOH (*x*/*y*)
THF, 40°, 4 h



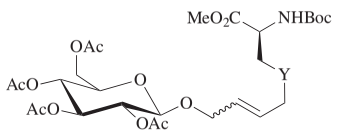
401

Catalyst	Additive	*x*/*y*		(*Z*)/(*E*)
Ru cat **215**	—	—	(62)	88:12
Ru cat **215**	—	1:1	(63)	86:14
Ru cat **215**	LiCl	1:1	(55)	74:26
Ru cat **215**	$MgCl_2$	1:1	(58)	76:24
Ru cat **216**	—	—	(61)	90:10
Ru cat **216**	—	1:1	(67)	92:8
Ru cat **216**	LiCl	1:1	(60)	88:12
Ru cat **216**	$MgCl_2$	1:1	(60)	82:18





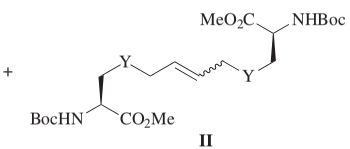
Hov II (0.06 eq),
t-BuOH/H_2O (1:1),
$MgCl_2$, 32°, 2.5 h



I

226

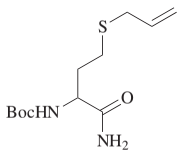
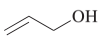
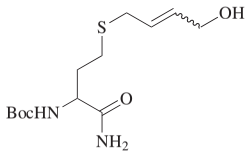
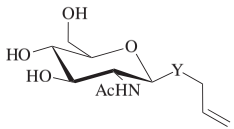
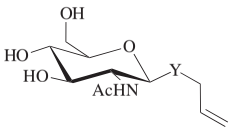
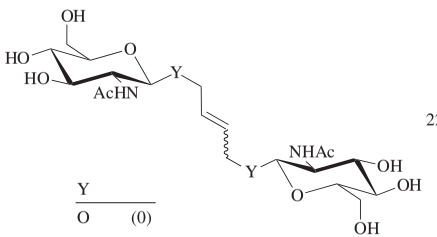
Y	**I**	**II**
S	(45)	(0)
Se	(53)	(20)

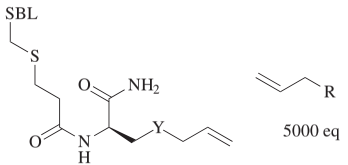


II

TABLE 8. CROSS-METATHESIS OF PRIMARY ALLYLIC ORGANOSULFUR AND ORGANOSELENIUM COMPOUNDS (*Continued*)

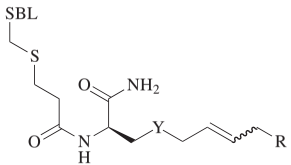
A. ALLYLIC SULFIDES AND SELENIDES (*Continued*)

Sulfide or Selenide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_7 	 10 eq	Hov II (0.08 eq), *t*-BuOH/H_2O (1:1), 32°, 3.5 h	 (67)	559
C_9 		Hov II (0.06 eq), *t*-BuOH/H_2O (1:1), 32°, 2.5 h	 Y: O (0), S (59)	226



5000 eq

Hov II (~200 eq),
$MgCl_2 \bullet 6H_2O$ (x eq),
30% t-BuOH/H_2O, pH 8.0



226

Y	R	x	Time (h)	Temp (°)	Conv. (%)[a]
S	AcHN	9794	0.5	37	0
S	$Cl^-Me_3N^+$	9794	1	37	0
Se	AcHN	9794	0.5	37	90
Se	$Cl^-Me_3N^+$	9794	1	37	0
S	HO	9770	0.5	rt	>95
Se	HO	9770	0.25	rt	>95
S	$Cl^-HMeN^+(CH_2)_2O$	9770	0.5	37	29
Se	$Cl^-HMeN^+(CH_2)_2O$	9770	0.5	37	>95

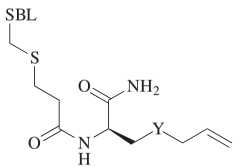
TABLE 8. CROSS-METATHESIS OF PRIMARY ALLYLIC ORGANOSULFUR AND ORGANOSELENIUM COMPOUNDS (*Continued*)

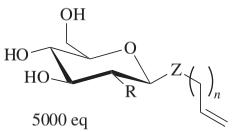
A. ALLYLIC SULFIDES AND SELENIDES (*Continued*)

Sulfide or Selenide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

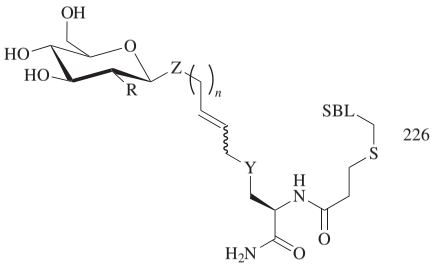
C_9





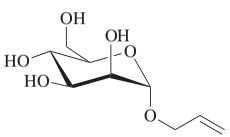
5000 eq

Hov II (~200 eq),
$MgCl_2 \cdot 6H_2O$ (9770 eq),
30% *t*-BuOH/H_2O, pH 8.0



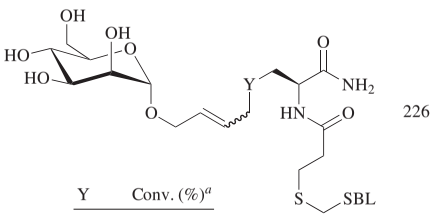
226

Y	R	Z	*n*	Temp (°)	Time (h)	Conv. (%)[a]
S	HO	O	1	37	1	>95
Se	HO	O	1	37	1	>95
S	HO	O	4	rt	0.5	>95
Se	HO	O	4	rt	0.5	>95
S	AcHN	O	1	37	2	53
S	AcHN	S	1	37	1	0
Se	AcHN	O	1	37	1	>95
Se	AcHN	S	1	rt	1	0



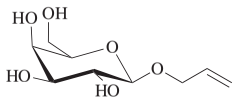
5000 eq

Hov II (~200 eq),
$MgCl_2 \cdot 6H_2O$ (9770 eq),
30% *t*-BuOH/H_2O,
pH 8.0, rt, 1 h



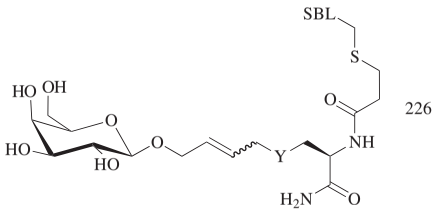
226

Y	Conv. (%)[a]
S	>95
Se	>95



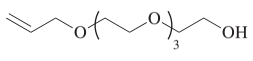
5000 eq

Hov II (~200 eq),
$MgCl_2 \cdot 6H_2O$ (9770 eq),
30% *t*-BuOH/H_2O,
pH 8.0, 37°, 1 h



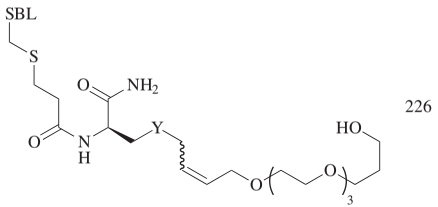
226

Y	Conv. (%)[a]
S	>95
Se	>95



5000 eq

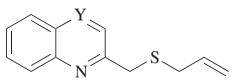
Hov II (~200 eq),
$MgCl_2 \cdot 6H_2O$ (9770 eq),
30% *t*-BuOH/H_2O, pH 8.0, rt

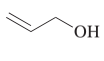


226

Y	Time (h)	Conv. (%)[a]
S	2	>95
Se	1	>95

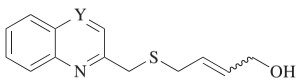
C_{12}





20 eq

Hov II (2 × 0.1 eq),
t-BuOH/H_2O (1:1),
32°, 2.5 h

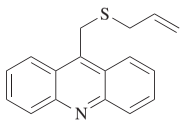
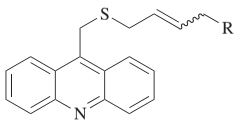
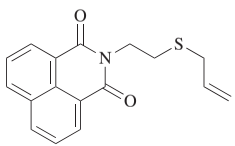
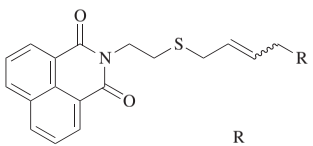
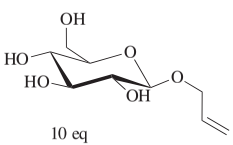
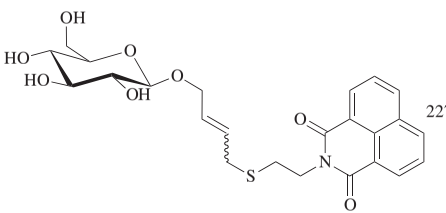


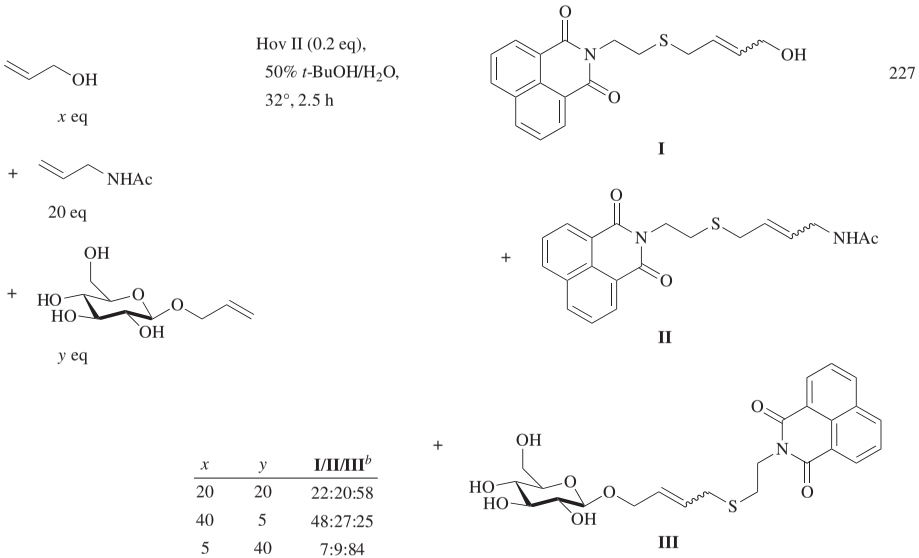
227

Y	
N	(31)
CH	(53)

TABLE 8. CROSS-METATHESIS OF PRIMARY ALLYLIC ORGANOSULFUR AND ORGANOSELENIUM COMPOUNDS (*Continued*)

A. ALLYLIC SULFIDES AND SELENIDES (*Continued*)

Sulfide or Selenide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{17}				
	 *x* eq	Hov II (2 x 0.1 eq), *t*-BuOH/H_2O (1:1), 32°, 2.5 h		227
			R *x* AcHN 10 (30) HO 20 (65)	
	 10 eq	Hov II (2 x 0.1 eq), *t*-BuOH/H_2O (1:1), 32°, 2.5 h		227
			R AcHN (96) HO (94)	
	 10 eq	Hov II (2 x 0.1 eq), *t*-BuOH/H_2O (1:1), 32°, 2.5 h	 (90)	227



x	*y*	**I/II/III**[b]
20	20	22:20:58
40	5	48:27:25
5	40	7:9:84

[a] The conversion was determined by LC-MS analysis.

[b] The ratio was determined by LC-MS analysis.

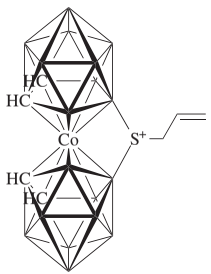
TABLE 8. CROSS-METATHESIS OF PRIMARY ALLYLIC ORGANOSULFUR AND ORGANOSELENIUM COMPOUNDS (*Continued*)

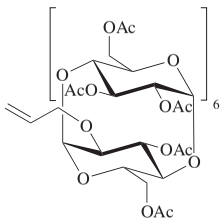
B. SULFONIUM SALTS

Sulfonium Salt	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

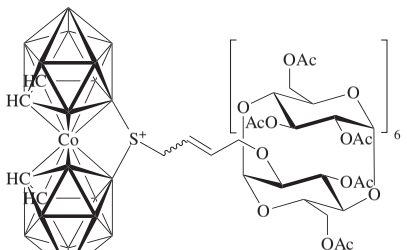
C_{25}





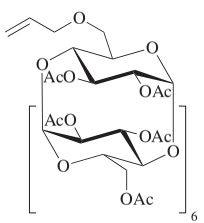
1.4 eq

Hov II (0.1 eq), toluene, 120°, 16 h



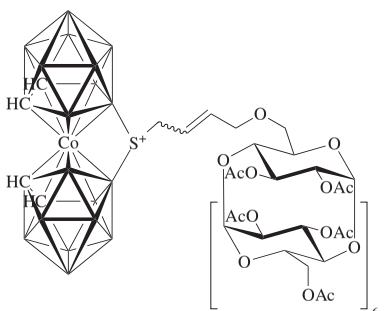
(20)

585



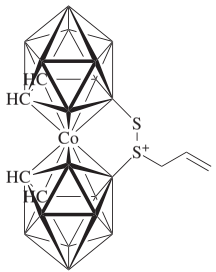
1.4 eq

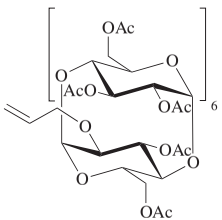
Hov II (0.1 eq), toluene, 120°, 16 h



(19)

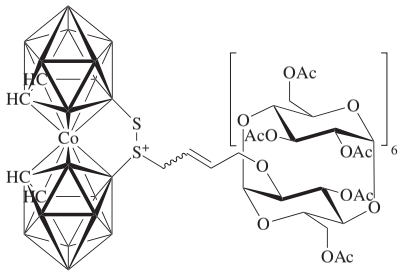
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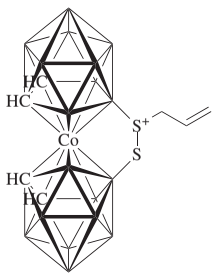
1.4 eq

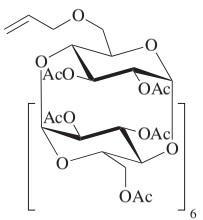
Hov II (0.1 eq),
toluene, 120°, 16 h



(18)

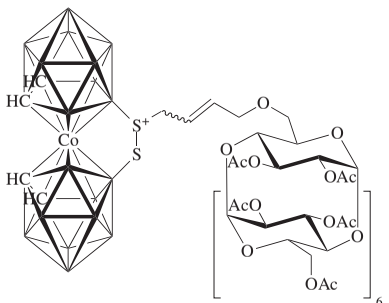
585





1.4 eq

Hov II (0.1 eq),
toluene, 120°, 16 h



(20)

585

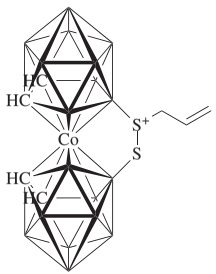
TABLE 8. CROSS-METATHESIS OF PRIMARY ALLYLIC ORGANOSULFUR AND ORGANOSELENIUM COMPOUNDS (*Continued*)

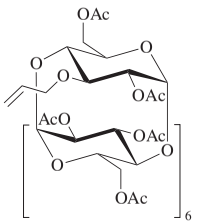
B. SULFONIUM SALTS (*Continued*)

Sulfonium Salt	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

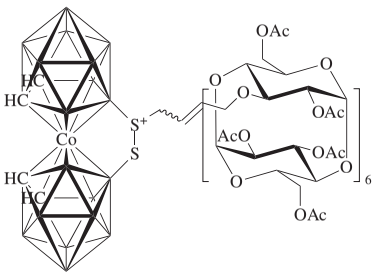
C_{25}





1.4 eq

Hov II (0.1 eq),
toluene, 120°, 16 h

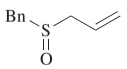
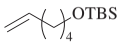
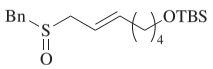
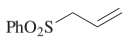
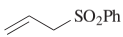
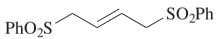
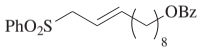
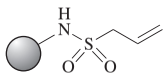
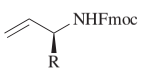
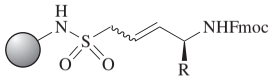


(19)

585

TABLE 8. CROSS-METATHESIS OF PRIMARY ALLYLIC ORGANOSULFUR AND ORGANOSELENIUM COMPOUNDS (*Continued*)

C. ALLYLIC SULFOXIDES, SULFONES AND SULFONAMIDES

Sulfur Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
	 1.5 eq	Gr II (0.1 eq), $(PhO)_3B$ (*x* eq), solvent, 70°, 6 h	 (*E*) only	*x* Solvent — toluene (9) 0.1 toluene (12) — C_6F_6 (31)	229
		Gr I (0.05 eq), DCM, 45°		(37) (*E*)/(*Z*) = 89:11	124
2 eq		Gr I (0.025 eq), DCM, 45°, 4 h		(90) (*E*)/(*Z*) = 89:11	124
	 *x* eq	Catalyst (*y* eq), additive, solvent			154

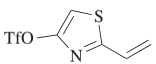
R	*x*	Catalyst	*y*	Additive	Solvent	Temp (°)	Time (h)	Loading (%)
H	5	Gr II	0.5	—	DCM	40	16	17
H	10	Gr II	1	—	DCM	40	16	11
H	5	Gr II	0.5	—	DCM/MeOH	40	16	0
H	5	Hov II	0.5	—	DCM/MeOH	40	16	11
H	5	Gr II	0.2	—	DCM	150 (MW)	0.5	16
H	5	Gr II	0.2	—	toluene	150 (MW)	0.5	32
H	5	Gr II	0.2	Cy_2BCl	toluene	150 (MW)	0.5	21
H	5	Gr II	0.2	Cy_2BCl	toluene	80	16	19
H	5	Hov II	0.2	Cy_2BCl	toluene	80	16	35
Bn	5	Hov II	0.2	Cy_2BCl	toluene	80	16	13
Bn	5	Hov II	0.5	Cy_2BCl	toluene	80	16	26

TABLE 9. CROSS-METATHESIS OF VINYL-SUBSTITUTED HETEROAROMATIC COMPOUNDS

Heteroaromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

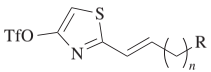
C_5





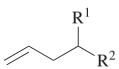
x eq

Catalyst (*y* eq), DCM, 40°



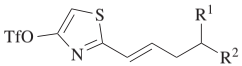
147

R	*n*	*x*	Catalyst	*y*	Time (h)		(*E*)/(*Z*)
TMS	1	3	Gr II	0.1	2	(89)	83:17
TMS	1	3	Hov II	0.05	12	(83)	83:17
$(EtO)_2P(O)$	1	1.5	Gr II	0.1	24	(43)	83:17
$(EtO)_2P(O)$	1	1.5	Hov II	0.05	24	(37)	87:13
AcO	2	1.5	Gr II	0.1	18	(63)	89:11
AcO	2	1.5	Hov II	0.05	24	(58)	87:13
Me	2	3	Gr II	0.1	4	(82)	>95:5
Me	2	3	Hov II	0.05	8	(79)	>95:5



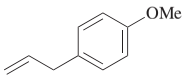
1.5 eq

Catalyst (*x* eq), DCM, 40°



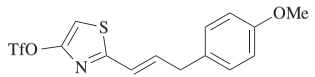
147

R^1	R^2	Catalyst	*x*	Time (h)		(*E*)/(*Z*)
MeO_2C	MeO_2C	Gr II	0.1	24	(46)	80:20
MeO_2C	MeO_2C	Hov II	0.05	24	(54)	75:25
TBSO	$TBSOCH_2$	Gr II	0.1	18	(57)	>95:5
TBSO	$TBSOCH_2$	Hov II	0.05	8	(51)	>95:5
HO	Ph	Gr II	0.1	24	(22)	80:20
HO	Ph	Hov II	0.05	24	(19)	75:25
TBSO	Ph	Gr II	0.1	12	(65)	>95:5
TBSO	Ph	Hov II	0.05	24	(83)	>95:5



1.5 eq

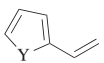
Catalyst (*x* eq),
DCM, 40°

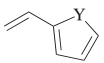


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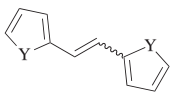
Catalyst	*x*	Time (h)		(*E*)/(*Z*)
Gr II	0.1	12	(89)	>95:5
Hov II	0.05	24	(86)	>95:5

C_6



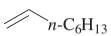


Catalyst (0.05 eq),
toluene, rt, 17 h



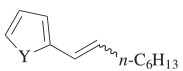
636

Y	Catalyst	Gas	Conv. (%)
O	Gr I	O_2	0
O	Gr I	N_2	0
O	Mo cat **1**	N_2	2
S	Gr I	O_2	0
S	Gr I	N_2	0
S	Mo cat **1**	N_2	4



6 eq

Catalyst (0.05 eq),
toluene, rt, 17 h



636

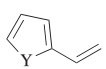
Y	Catalyst	Gas	
O	Gr I	N_2	(50)
O	Mo cat **1**	N_2	(78)
S	Gr I	O_2	(50)
S	Gr I	N_2	(51)
S	Mo cat **1**	N_2	(98)

TABLE 9. CROSS-METATHESIS OF VINYL-SUBSTITUTED HETEROAROMATIC COMPOUNDS (*Continued*)

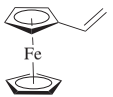
Heteroaromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

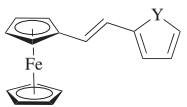
C_6



1 eq

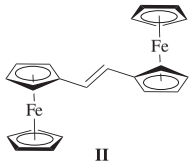


Mo cat **1**
(0.017–0.01 eq),
rt, 15 h



I

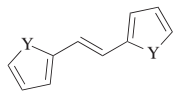
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II

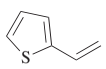
637

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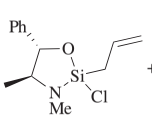


III

Y	**I**	**I/II/III**	(*E*)/(*Z*)
S	(51)	91:0:9	(*E*) only
O	(65)	79:7:14	(*E*) only

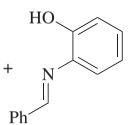


7.5 eq



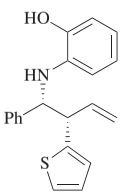
1.5 eq

+



1 eq

1. Gr II (0.026 eq),
DCE, reflux, 3.5 h
2. Imine, reflux, 14 h



(54) dr 83:17, er 97.0:3.0

211

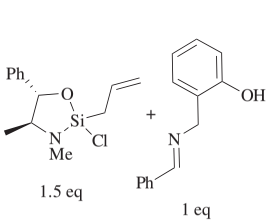
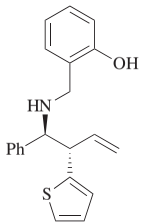
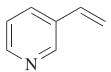
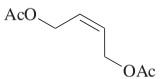
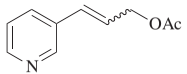
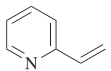
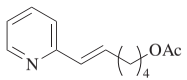
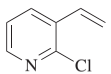
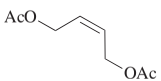
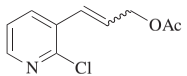
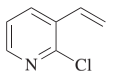
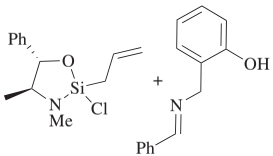
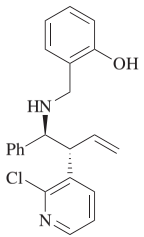
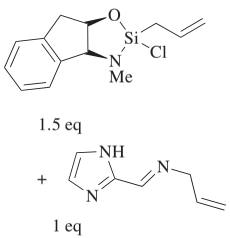
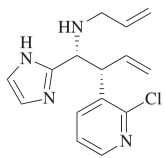
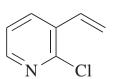
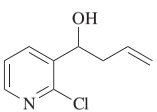
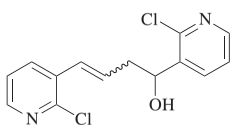
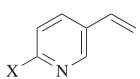
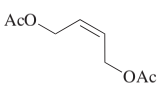
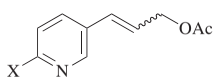
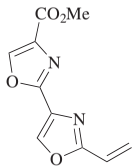
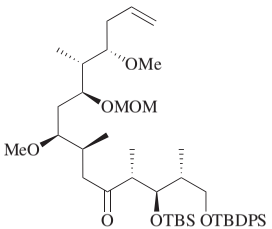
	7.5 eq	 1.5 eq 1 eq	1. Gr II (0.026 eq), $CHCl_3$, reflux, 5 h 2. Imine, reflux, 14 h		(65) dr > 95:5, er 98.5:1.5	211
		 10 eq	Gr II (0.02 eq), DCM, 45°, 3 h		(85)	638
		 2 eq	Gr II (0.05 eq), DCM, reflux, 12 h		(45) (*E*)/(*Z*) > 95:5	145
C_7		 3 eq	Hov II (0.1 eq), DCM, 50°, 24 h		(56)	603

TABLE 9. CROSS-METATHESIS OF VINYL-SUBSTITUTED HETEROAROMATIC COMPOUNDS (*Continued*)

Heteroaromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_7				
 7.5 eq	 1.5 eq 1 eq	1. Gr II (0.026 eq), $CHCl_3$, reflux, 5 h 2. Imine, reflux, 14 h	 (54) dr > 95:5, er 97.5:2.5	211
7.5 eq	 1.5 eq 1 eq	1. Hov II (0.036 eq), benzene, reflux, 2 h 2. Imine, rt, 14 h	 (58) dr 92:8, er 93.5:6.5	211
 3 eq		Hov II (0.1 eq), DCM, 50°, 24 h	 (55)	603
 3 eq		Hov II (0.1 eq), DCM, 50°, 24 h	 X: F (22), Cl (61), Br (65)	603

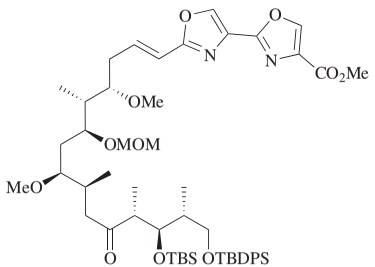
C_9





2 eq

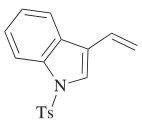
Gr II (0.15 eq),
DCM, 40°, 16 h
sealed tube



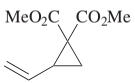
639

(57) (*E*)/(*Z*) = 95:5

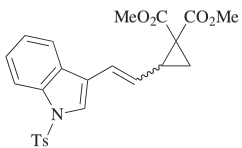
C_{10}



1.4 eq



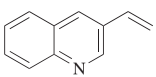
Gr II (0.01 eq),
DCM, reflux



(5)

407

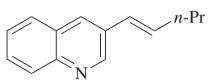
C_{11}





10 eq

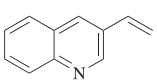
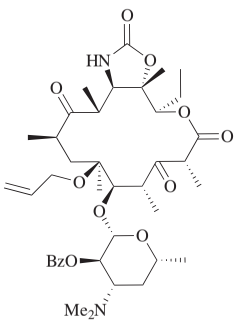
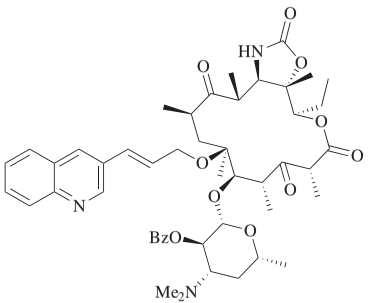
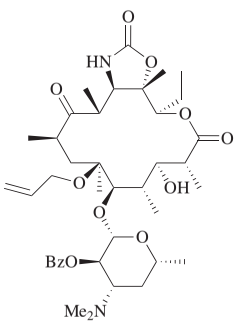
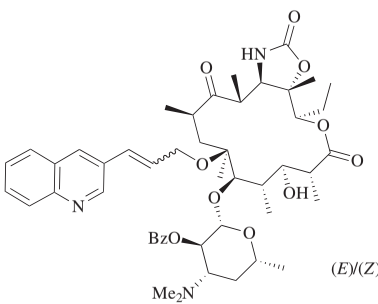
Gr I (0.1 eq),
DCM, 40°, 20 h



(73) (*E*)/(*Z*) = 95:5

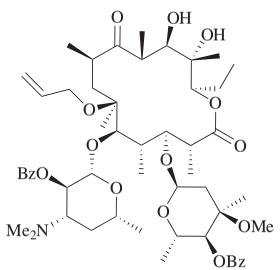
584

TABLE 9. CROSS-METATHESIS OF VINYL-SUBSTITUTED HETEROAROMATIC COMPOUNDS (*Continued*)

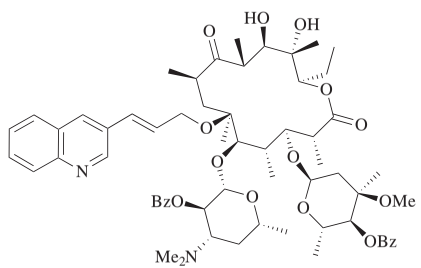
Heteroaromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{11}				
 3 eq		Gr I (0.1 eq), DCM, 40°, 20 h	 (39) (*E*)/(Z) > 95:5	584
x eq	 *y* eq	Gr I (*z* eq), DCM	 (*E*)/(Z) > 95:5	584

x	*y*	*z*	Temp (°)	Time (h)	Conv. (%)[a]
2	1	0.1	rt	20	5
2	1	0.1	40	20	35
2	1	0.1	40	65	59
2	1	0.1	40	91	65
2	1	0.1	40	168	71
2	1	0.05	40	20	27
2	1	0.25	40	20	49
2	1	0.25	40	65	75
1	1	0.25	40	20	45
1	3	0.1	40	20	64
1	3	0.1	40	65	79
5	1	0.1	40	20	23

3 eq



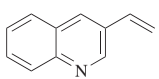
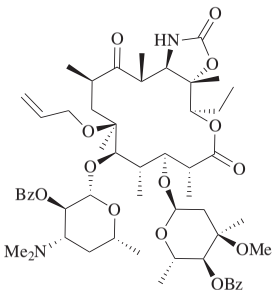
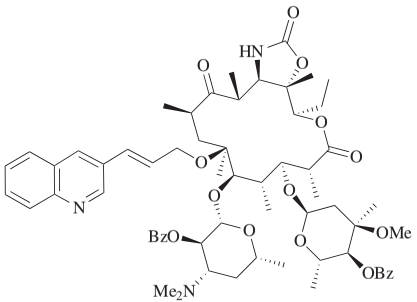
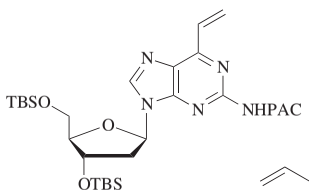
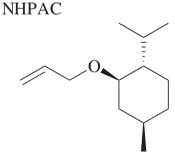
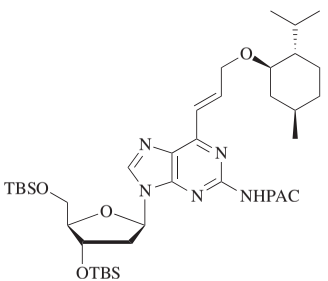
Gr I (0.1 eq),
DCM, 40°, 20 h



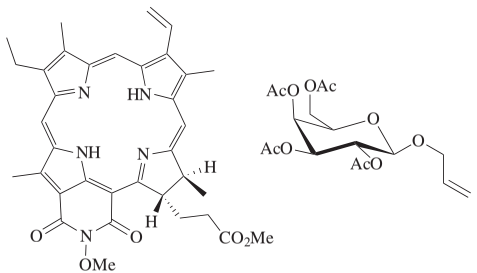
584

(86) (*E*)/(*Z*) > 95:5

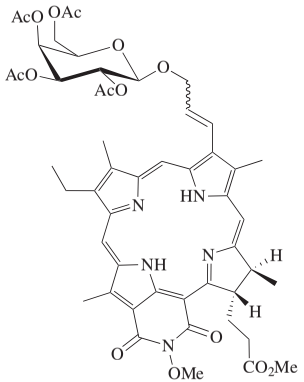
TABLE 9. CROSS-METATHESIS OF VINYL-SUBSTITUTED HETEROAROMATIC COMPOUNDS (*Continued*)

Heteroaromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{11}  3 eq		Gr I (0.1 eq), DCM, 40°, 20 h	 (64) (*E*)/(*Z*) > 95:5	584
C_{12} 	 5 eq	Gr II (0.1 eq), DCM, 45°, 2 h	 (22) (*E*) only	640

C_{33}



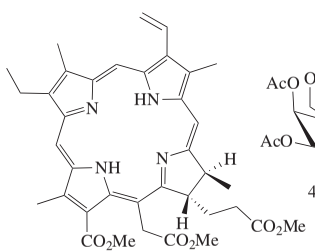
Gr II (0.25 eq),
DCM, reflux

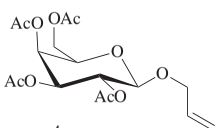


(0)

575

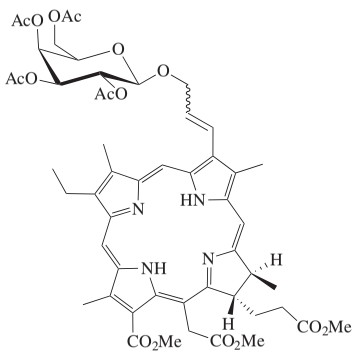
C_{34}





4 eq

Gr II (0.25 eq),
DCM, reflux, 16 h



(40)

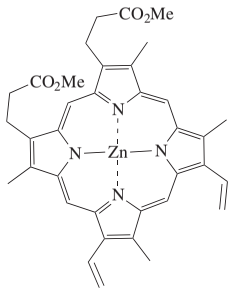
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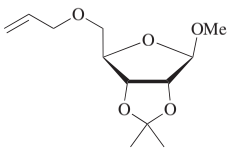
TABLE 9. CROSS-METATHESIS OF VINYL-SUBSTITUTED HETEROAROMATIC COMPOUNDS (*Continued*)

Heteroaromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

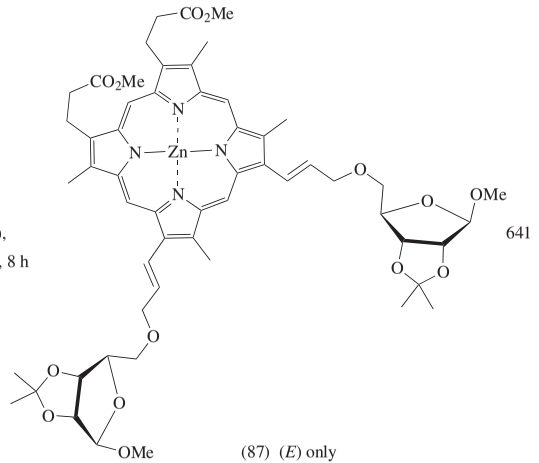
C_{34}





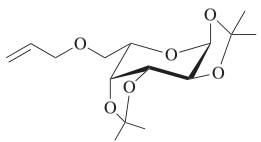
2 eq

Gr II (0.25 eq),
DCM, reflux, 8 h



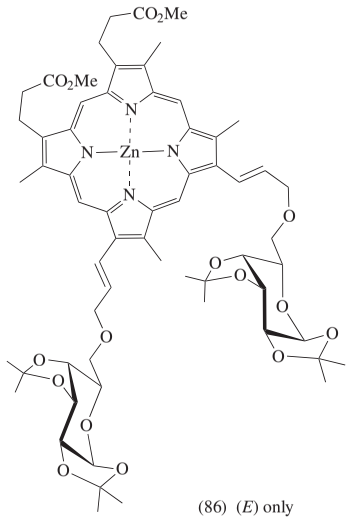
641

(87) (*E*) only



2 eq

Gr II (0.25 eq),
DCM, reflux, 8 h



(86) (*E*) only

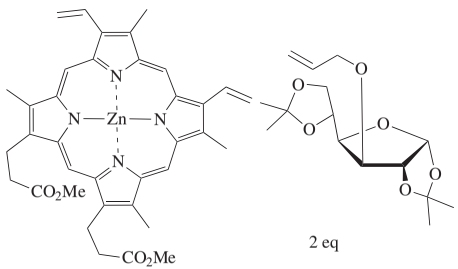
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TABLE 9. CROSS-METATHESIS OF VINYL-SUBSTITUTED HETEROAROMATIC COMPOUNDS (*Continued*)

Heteroaromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

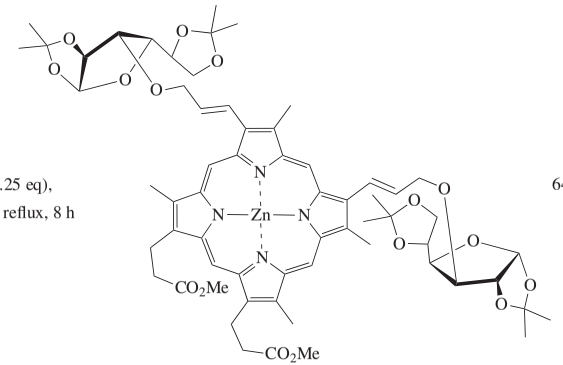
Please refer to the charts preceding the tables for the catalyst structures.

C_{34}



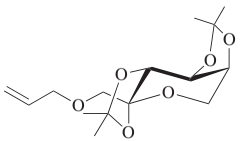
2 eq

Gr II (0.25 eq),
DCM, reflux, 8 h



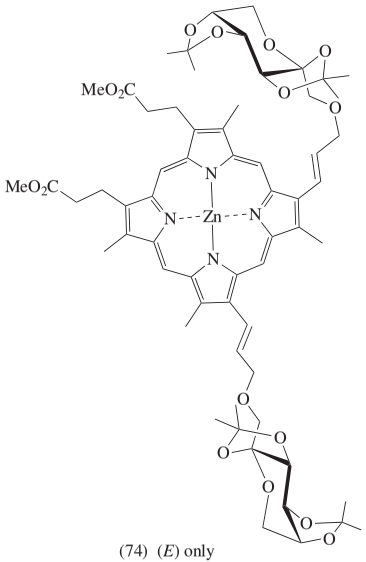
(84) (*E*) only

641



2 eq

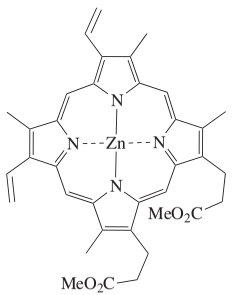
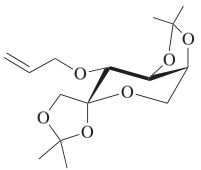
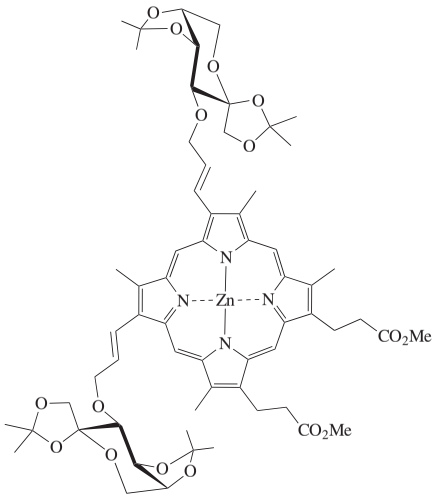
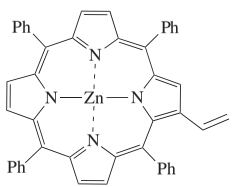
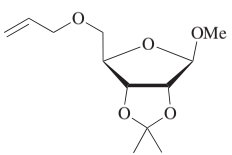
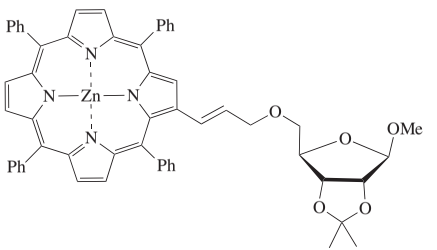
Gr II (0.25 eq),
DCM, reflux, 8 h

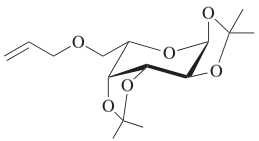


(74) (*E*) only

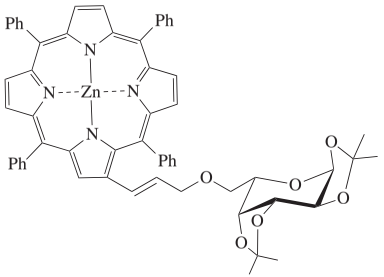
641

TABLE 9. CROSS-METATHESIS OF VINYL-SUBSTITUTED HETEROAROMATIC COMPOUNDS (*Continued*)

Heteroaromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{34} 	 2 eq	Gr II (0.25 eq), DCM, reflux, 8 h	 (93) (*E*) only	641
C_{46} 		Gr II (0.25 eq), DCM, reflux, 4 h	 (98) (*E*) only	641

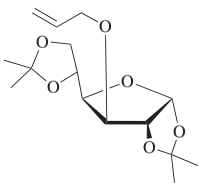


Gr II (0.25 eq),
DCM, reflux, 4 h

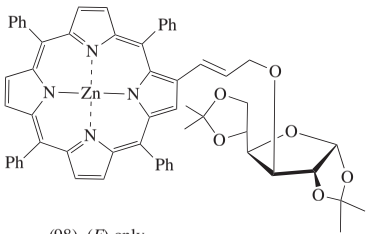


641

(95) (*E*) only



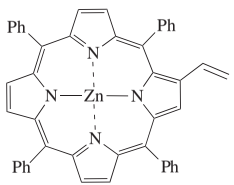
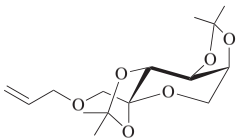
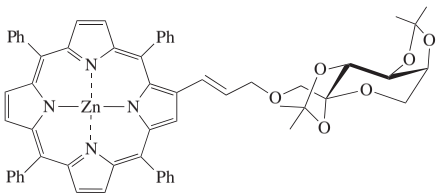
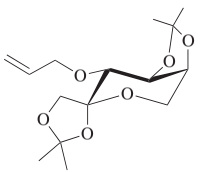
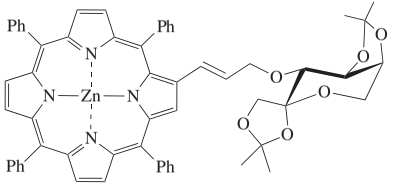
Gr II (0.25 eq),
DCM, reflux, 4 h



641

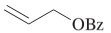
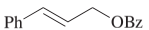
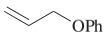
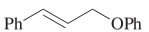
(98) (*E*) only

TABLE 9. CROSS-METATHESIS OF VINYL-SUBSTITUTED HETEROAROMATIC COMPOUNDS (*Continued*)

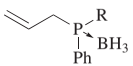
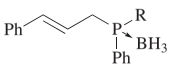
Heteroaromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{46} 		Gr II (0.25 eq), DCM, reflux, 4 h	 (97) (*E*) only	641
		Gr II (0.25 eq), DCM, reflux, 4 h	 (95) (*E*) only	641

[a] The conversion was determined by HPLC analysis.

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS

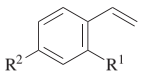
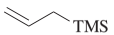
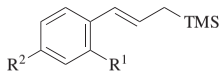
Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
 2 eq		Catalyst (0.05 eq), toluene, 100°, 12 h	 (*E*)/(*Z*) > 95:5	Catalyst Ru cat **77** (10) Ru cat **78** (8)	642
		Catalyst (*x* eq), DCM, 35°, 24 h		(*E*)/(*Z*) = 95:5	643

Catalyst	*x*	
Ru cat **118**	0.01	(94)
Ru cat **119**	0.01	(93)
Ru cat **120**	0.01	(94)
Ru cat **121**	0.0005	(94)
Ru cat **132**	0.01	(94)
Ru cat **133**	0.01	(93)
Ru cat **134**	0.01	(93)
Ru cat **135**	0.01	(92)

3 eq		Gr II (*x* eq), DCM, reflux		213

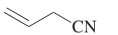
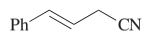
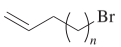
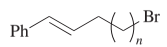
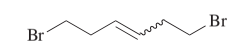
R	*x*	Time (h)		(*E*)/(*Z*)
MeO	0.02	12	(43)	91:9
Ph	0.06	36	(40)	(*E*) only

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

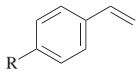
Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{8-9}				
	 2 eq	Mo cat **1** (0.02 eq), PPh_3 (*x* eq), solvent, rt, 4 h	 (*E*) only	208

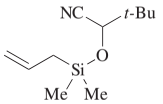
R^1	R^2	*x*	Solvent	
H	H	—	DME	(85)
H	H	0.04	Et_2O	(92)
H	Me	—	DME	(83)
H	MeO	—	DME	(61)
O_2N	H	—	DME	(40)

C_8

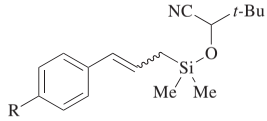
	 2 eq	Gr II (0.05 eq), DCM, reflux, 2 h	 (10)	(*E*) only	182
2 eq		Mo cat **1** (*x* eq), DCM, 40°, 12 h	 **I** (*E*) only +  **II**		

n	*x*	**I**	**II**	
1	0.01	(50)	(42)	645
2	0.01	(90)	(4)	645
2	0.05	(90)	(0)	36



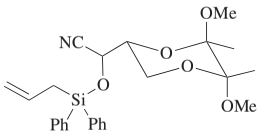


Gr II (0.1 eq),
DCM, reflux, 18 h

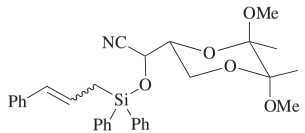


R		
H	(51)	644
O_2N	(40)	



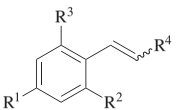


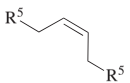
Gr II (0.075 eq),
DCM, reflux, 18 h



(51) 644

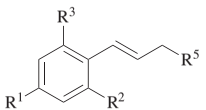
C_{8-9}





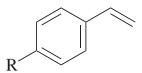
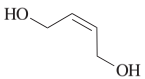
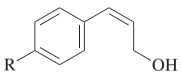
2 eq

Catalyst (*x* eq), DCM

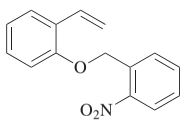
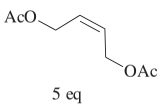
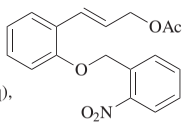
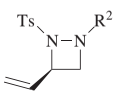
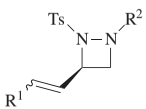


R^1	R^2	R^3	R^4	R^5	Catalyst	*x*	Temp (°)	Time (h)		(*E*)/(*Z*)	
H	H	H	H	AcO	Ru cat **158**	0.02	25	2	(84)	>99:1	590
H	H	H	H	AcO	Ru cat **157**	0.005	25	2	(92)	>99:1	590
H	H	H	H	AcO	Gr II	0.025	20	3	(81)	98:2	565
H	H	H	H	AcO	Hov II	0.025	20	3	(80)	98:2	565
H	H	H	H	AcO	Ru cat **155**	0.025	20	3	(76)	97:3	565
H	H	H	H	Cl	Gr II	0.05	reflux	12	(93)	>95:5	145
Br	H	H	H	AcO	Gr II	0.05	reflux	12	(93)	>95:5	145
MeO	H	H	H	AcO	Gr II	0.05	reflux	12	(83)	>95:5	145
H	TBSO	H	Me	AcO	Gr II	0.05	reflux	12	(94)	>95:5	145
H	F	H	H	AcO	Gr II	0.05	40	12	(98)	(*E*) only	36
H	F	F	H	AcO	Gr II	0.05	40	12	(50)	(*E*) only	36

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
	 2 eq	Catalyst (0.05 eq) THF, 22°, 4 h		183

R	Catalyst	Conv. (%)[a]		(*E*)/(*Z*)
H	Ru cat **153**	57	(53)	6:94
CF_3	Ru cat **152**	60	(55)	7:93
CF_3	Ru cat **153**	66	(60)	7:93
CF_3	Ru cat **215**	19	(—)	—

	 5 eq	Ru cat **353** (0.05 eq), 1-pyrene-carboxaldehyde (7 eq), DCM, 380 nm, 90 h	 (78) (*E*)/(*Z*) = 95:5	646
C_{8-14}				
 *x* eq		Hov II (*y* eq) DCM, reflux		647

R^1	x	R^2	y	Time (h)	
Ph	3	Boc	0.05	72	(83)
2-ClC_6H_4	3 + 3	Boc	0.05 + 0.05	48 + 24	(65)
Ph	3	Cbz	0.05	72	(85)
4-FC_6H_4	3 + 3	Cbz	0.05 + 0.05	48 + 24	(82)
2-ClC_6H_4	3 + 3	Cbz	0.05 + 0.05	48 + 24	(65)
3-MeC_6H_4	3	Cbz	0.05	72	(69)

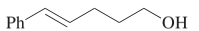
C_8



2 eq



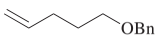
Gr II (0.05 eq), DCM, reflux, 2 h



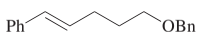
(20) (*E*) only

182

2 eq



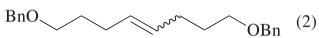
Mo cat **1** (0.01 eq)



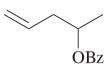
(85) (*E*) only

645

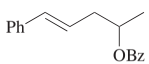
+



(2)



Gr II (0.05 eq), DCM, reflux, 12 h

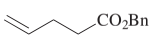


(81) (*E*)/(*Z*) > 95:5

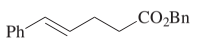
145

2 eq

2 eq



Mo cat **1** (0.01 eq)



(67) (*E*) only

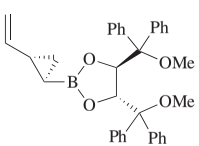
645

+

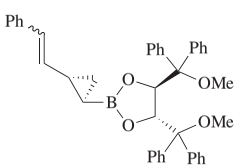


(20)

2 eq



Gr I (0.15 eq), DCM, reflux



(89)

648

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

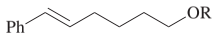
C_8



x eq

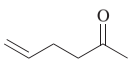


Catalyst (*y* eq), DCM

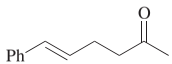


x	R	Catalyst	*y*	Temp (°)	Time (h)		(*E*)/(*Z*)	
2	TBS	Ru cat **158**	0.02	25	5	(83)	>99:1	590
2	TBS	Ru cat **157**	0.005	25	5	(85)	>99:1	590
1	THP	Gr II	0.05	40	12	(47)	(*E*) only	36
4	THP	Gr II	0.05	40	12	(71)	(*E*) only	36

2 eq



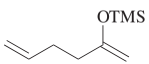
Mo cat **1** (*x* eq)



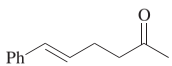
x		(*E*)/(*Z*)
0.01	(0)	—
0.05	(11)	(*E*) only

645

2 eq



Mo cat **1** (*x* eq)

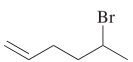


x	
0.01	(22)
0.05	(66)

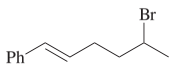
(*E*) only

645

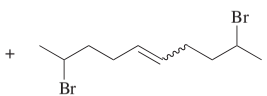
2 eq



Mo cat **1** (0.01 eq)



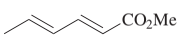
(84) (*E*) only



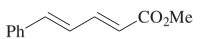
(8)

645

5 eq



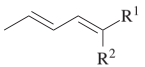
Hov II (0.05 eq), DCM, rt, 48 h



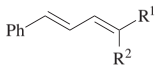
(35) (*E*) only

549

1.9 eq



Gr II (2 x 0.05 eq), DCM, 40°, 12 + 12 h

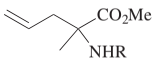


(*E*)/(*Z*) > 99:1

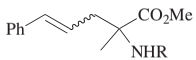
R^1	R^2	
Br	NC–	(39)
NC–	Br	(66)

649

4 eq



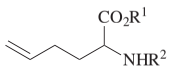
Gr II (0.05 eq), toluene, rt, 17 h



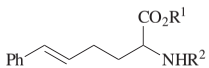
R	
Boc	(64)
Ts	(42)
Ac	(46)
OHC	(49)

457

2 eq

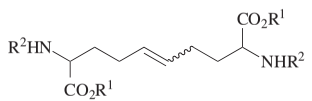


Gr I (0.05 eq), DCE, rt, 30 h



I (*E*)/(*Z*) > 91:9

\+

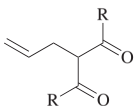
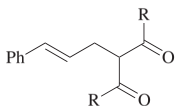
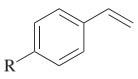
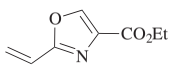
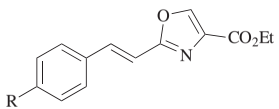
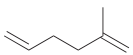
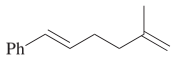
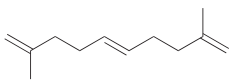
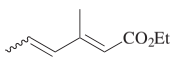
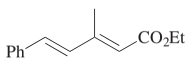


II

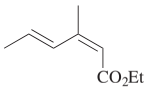
R^1	R^2	**I**	**II**
Me	Boc	(52)	(40)
Me	Phth	(55)	(35)
Me	Ac	(43)	(48)
Bn	Boc	(53)	(44)
t-Bu	Boc	(55)	(45)

434

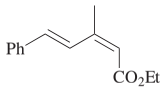
TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8 10 eq		Gr I (0.05 eq), DCM, 40°, 24 h	 (*E*)/(*Z*) = 91:9 R: Me (15); EtO (20)	492
C_{8-9}  1.5 eq		Hov II (0.1 eq), DCM, 40°	 R: Time (h) / Conv. (%)[a] / (*E*)/(*Z*): H: 36 / 37 / >95:5; F: 24 / 80 / 94:6; MeO: 36 / 26 / 92:8	650
C_8  2 eq		Mo cat **1** (0.01 eq), DCM, 23°, 1 h	 (86) (*E*) only +  (2)	645, 36
 3 eq		Gr II (0.1 eq), toluene, 50°, 16 h	 (56) (*E*) only	542

1 eq



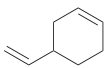
Gr II (0.05 eq),
DCM, 40°, 8 h



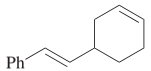
(73) (*E*) only

589

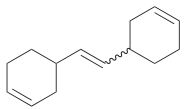
2 eq



Mo cat **1** (0.01 eq)



+

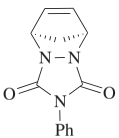


(60) (*E*) only

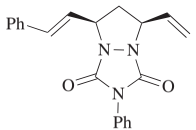
(15)

645

10 eq

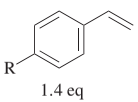


Catalyst (*x* eq),
NaI (*y* eq),
DCM, rt, 1 h

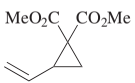


97

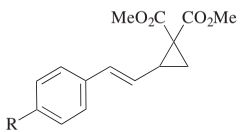
Catalyst	*x*	*y*		(*E*)/(*Z*)	er (*E*)	er (*Z*)
Ru cat **24**	0.01	—	(99)	55:45	84.0:16.0	57.5:42.5
Ru cat **25**	0.03	1	(99)	55:45	84.0:16.0	55.0:45.0



1.4 eq



Gr II (0.01 eq),
DCM, reflux

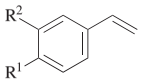
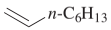
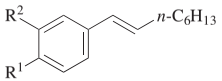
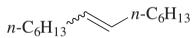


(*E*) only

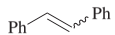
R	
H	(75)
MeO	(29)
O_2N	(60)

407

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
 2 eq		Mo cat **1** (0.01 eq), DCM, rt, 1 h	 **I** (*E*) only +  **II**	645

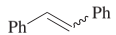
R^1	R^2	**I**	**II**
H	H	(89)	(2)
H	O_2N	(48)	(39)
MeO	H	(88)	(2)

  Catalyst (*x* eq), solvent 

Catalyst	*x*	Solvent	Temp (°)	Time (h)	Gas	Conv. (%)[b]		
Mo cat **1**	0.005	DME	—	3–24	—	—	(35)	651
Mo cat **1**	0.0002	DME	—	4	—	—	(4)	651
Mo cat **2**	0.00027	DME	—	2.5	—	—	(36)	651
Mo cat **2**	0.001	DME	—	10	—	—	(95)	651
Gr I	0.02	toluene	40	17	O_2	5	(—)	636
Gr I	0.02	toluene	40	17	N_2	19	(—)	636
Mo cat **1**	0.01	toluene	40	17	N_2	48	(—)	636



Catalyst (x eq),
milling, neat



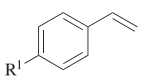
Catalyst	x	Mill	Time (h)	
Gr I	0.05	steel	1	(—)
Gr II	0.01	steel	0.5	(92)
Ru cat **67**	0.02	steel	0.5	(80)
Hov II	0.005	steel	0.5	(90)
Hov II	0.0075	steel	0.5	(95)
Hov II	0.0075	steel	0.5	(96)
Hov II	0.0075	steel	0.5	(95)
Hov II	0.0075	alumina	0.5	(96)

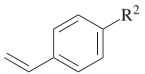
TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

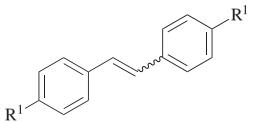
Please refer to the charts preceding the tables for the catalyst structures.

C_{8-9}



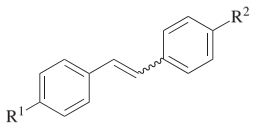


Catalyst (*x* eq), solvent



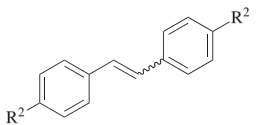
I

+



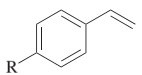
II

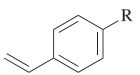
+



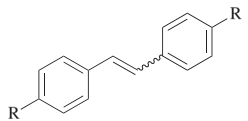
III

R^1	R^2	Catalyst	*x*	Solvent	Temp (°)	Time (h)		**I/II/III**	
H	H	Ru cat **35**	0.05	DCM	40	2	(98)	—	652
Cl	Cl	Ru cat **35**	0.05	DCM	40	2	(95)	—	652
CF_3	CF_3	Ru cat **35**	0.05	DCM	40	2	(91)	—	652
AcO	AcO	Ru cat **35**	0.05	DCM	40	2	(98)	—	652
MeO	MeO	Ru cat **35**	0.05	DCM	40	2	(94)	—	652
H	Cl	Ru cat **35**	0.05	DCM	40	2	(88)	31:33:36	652
H	MeO	Ru cat **35**	0.05	DCM	40	2	(95)	30:45:25	652
MeO	AcO	Ru cat **35**	0.05	DCM	40	2	(77)	26:36:38	652
Cl	AcO	Ru cat **35**	0.05	DCM	40	2	(91)	31:28:41	652
HO	MeO	Gr II	0.05	toluene	reflux	0.5	(100)	22:65:13	653
MeO	Me	Gr II	0.02	DCM	40	1.5	(75)	7:81:11	143
MeO	AcO	Gr II	0.02	DCM	40	1.5	(60)	20:62:18	143
AcO	Me	Gr II	0.02	DCM	40	1.5	(65)	5:77:17	143





Catalyst (0.05 eq),
DCM, rt, 5 h



654

R	Catalyst	Conv. (%)[a]
H	Gr I	12
Me	Gr I	15
Cl	Gr I	5
MeO	Gr I	16
H	Ru cat **4**	4
Me	Ru cat **4**	8
Cl	Ru cat **4**	6
MeO	Ru cat **4**	8
H	Ru cat **35**	30
Me	Ru cat **35**	25
Cl	Ru cat **35**	38
MeO	Ru cat **35**	14

R	Cat	Conv. (%)[a]
H	Ru cat **37**	57
Me	Ru cat **37**	73
Cl	Ru cat **37**	51
MeO	Ru cat **37**	24
H	Gr II	63
Me	Gr II	88
Cl	Gr II	51
MeO	Gr II	16
H	Ru cat **12**	73
Me	Ru cat **12**	90
Cl	Ru cat **12**	80
MeO	Ru cat **12**	44

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

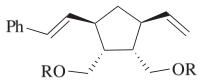
C_8



10 eq



Catalyst (*x* eq),
NaI (*y* eq),
DCM, rt, 1 h



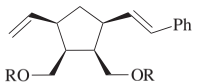
97

R	Catalyst	*x*	*y*		(*E*)/(*Z*)	er (*E*)	er (*Z*)
H	Ru cat **24**	0.01	—	(10)	—	66.5:33.5	64.5:35.5
Ac	Ru cat **24**	0.01	—	(99)	58:42	80.0:20.0	55.0:45.0
Ac	Ru cat **25**	0.03	1	(78)	58:42	86.0:14.0	70.0:30.0

5 eq



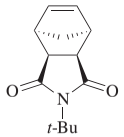
Ru cat **240** (0.01 eq),
DCM, –10°, 12 h



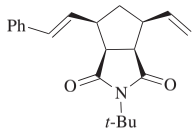
95

R	Conv. (%)[a]	(*E*)/(*Z*)	er
Ac	>98	95:5	80.0:20.0
TBS	>98	95:5	85.0:15.0

x eq

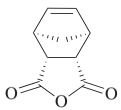


Catalyst (*y* eq),
NaI (*z* eq),
DCM, rt, 1 h

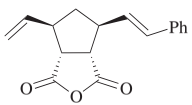


x	Catalyst	*y*	*z*	Temp (°)	Time (h)	Conv. (%)[a]		(*E*)/(*Z*)	er (*E*)	er (*Z*)	
10	Ru cat **24**	0.01	—	rt	1	—	(99)	58:42	78.5:21.5	66.5:33.5	97
10	Ru cat **25**	0.03	1	rt	1	—	(99)	55:45	87.5:12.5	75.0:25.0	97
5	Ru cat **240**	0.01	—	25	20	>98	(—)	96:4	91.0:9.0	—	95
5	Ru cat **240**	0.01	—	–10	72	>98	(—)	93:7	96.0:4.0	—	95
5	Ru cat **24**	0.01	—	25	1	>96	(—)	50:50	78.5:21.5	—	96
5	Ru cat **229**	0.025	—	25	72	98	(—)	92:8	95.5:4.5	—	96
5	Ru cat **32**	0.025	—	40	18	98	(—)	90:10	96.0:4.0	—	96

20 eq



Catalyst (0.025 eq),
THF, 50°, 2 h



655

Catalyst		(*E*)/(*Z*)	er
Ru cat **58**	(38)	57:43	52.5:47.5
Ru cat **59**	(78)	50:50	51.0:49.0
Ru cat **60**	(9)	77:23	54.5:45.5

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

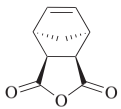
Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

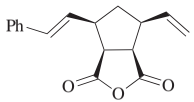
C_8



10 eq



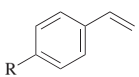
Catalyst (*x* eq),
NaI (*y* eq),
DCM, rt, 1 h



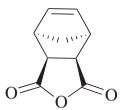
97

Catalyst	*x*	*y*	Conv. (%)[a]	(*E*)/(*Z*)	er (*E*)	er (*Z*)
Ru cat **18**	0.01	—	>95	50:50	73.5:26.5	—
Ru cat **16**	0.01	—	>95	50:50	64.5:35.5	—
Ru cat **20**	0.01	—	>95	50:50	81.0:19.0	—
Ru cat **24**	0.01	—	95	50:50	88.0:12.0	52.0:48.0
Ru cat **25**	0.03	1	96	50:50	90.0:10.0	—

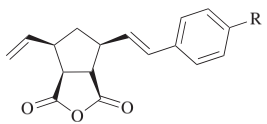
C_{8-9}



5 eq

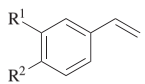


Catalyst (*x* eq),
DCM

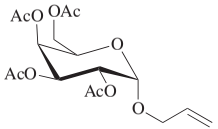


R	Catalyst	*x*	Temp (°)	Time (h)	Conv. (%)[a]	(*E*)/(*Z*)	er	
H	Ru cat **32**	0.07	40	16	78	94:6	93.0:7.0	96
H	Ru cat **229**	0.025	25	16	83	93:7	87.5:12.5	96
H	Ru cat **238**	0.01	25	1	>98	95:5	85.5:14.5	95
H	Ru cat **239**	0.01	25	1	>98	95:5	91.5:8.5	95
H	Ru cat **240**	0.01	25	1	>98	>97:3	94.0:6.0	95
H	Ru cat **240**	0.0005	25	15	>98	>97:3	94.0:6.0	95
H	Ru cat **240**	0.01	–10	12	>98	>97:3	96.5:3.5	95
H	Ru cat **24**	0.01	25	1	>98	50:50	88.0:12.0	95
MeO	Ru cat **240**	0.01	25	1	>98	93:7	90.5:9.5	95
CF_3	Ru cat **240**	0.01	25	1	>98	97:3	84.0:16.0	95
O_2N	Ru cat **240**	0.01	25	1	>98	—	86.0:14.0	95
MeO_2C	Ru cat **240**	0.01	25	1	>98	>97:3	89.5:10.5	95

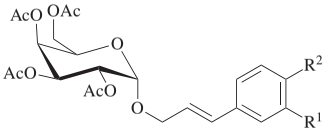
C_8



x eq

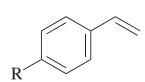


Gr I (*y* eq),
DCM, reflux

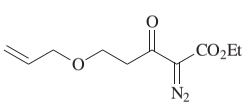


R^1	R^2	*x*	*y*	Time (h)		(*E*)/(*Z*)	
H	H	2	0.2	6	(60)	90:10	571
H	H	4	0.2	6	(80)	97:3	571
H	AcO	4	0.2	6	(75)	95:5	571
H	*t*-BuO	4	0.07	16	(72)	95:5	332
BnO	MeO	4	0.07	16	(44)	(*E*) only	332

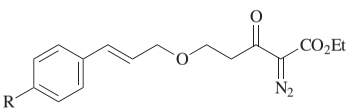
C_{8-9}



10 eq



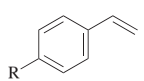
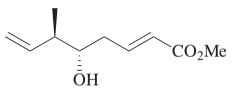
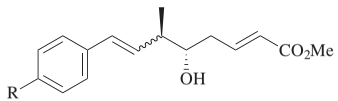
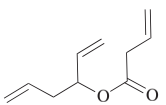
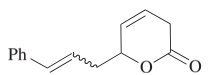
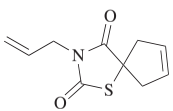
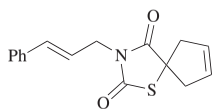
Gr II (0.05 eq),
DCM, reflux, 18 h

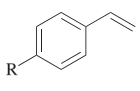


569

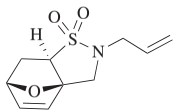
R		(*E*)/(*Z*)
H	(47)	94:6
Me	(65)	98:2
Cl	(54)	97:3

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{8-9}  4 eq		Hov II (0.05 eq), DCM, reflux, 2 h	 R: H (30); CF_3 (23); MeO (26); NC– (8)	656
C_8  3 eq		Gr II (0.025 eq), DCM, reflux, 16 h	 (62)	394
1.5 eq		Hov II (0.03 eq), DCM, 40°, 12 h	 (53) (*E*)/(*Z*) > 99:1	657

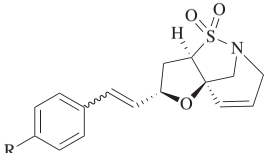


10 eq



(±)

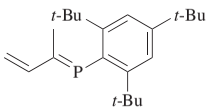
Gr II (0.1 eq),
DCM, 45°, 3 h



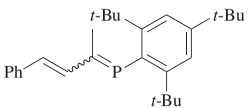
(±)

R		
H	(81)	359
Br	(80)	



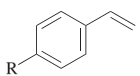


Gr II (1 eq),
DCM, 35°, 48 h

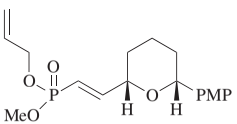


(23)

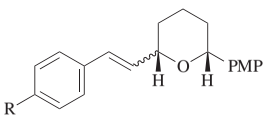
658



5 eq



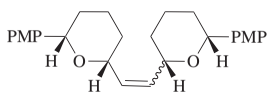
Gr II (0.1 eq),
CuI (0.1 eq),
DCM, reflux, 2 h



I

R	**I**	
H	(82)	220
F	(53)	
BnO	(50)	

\+



II (~20)

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

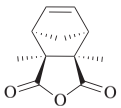
Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

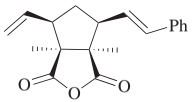
C_8



5 eq

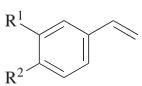


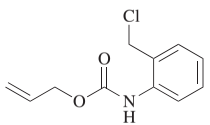
Catalyst (*x* eq), DCM



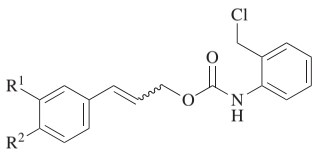
Catalyst	*x*	Temp (°)	Time (h)	Conv. (%)[a]	(*E*)/(*Z*)	er	
Ru cat **240**	0.01	25	3.5	>98	95:5	91.0:9.0	95
Ru cat **240**	0.01	–10	48	>98	96:4	95.0:5.0	95
Ru cat **32**	0.05	40	24	97	89:11	90.0:10.0	96
Ru cat **229**	0.05	40	24	96	92:8	85.5:14.5	96

C_{8-9}





Hov II
(0.05 + 0.02 eq),
DCM, 40°, 16 h



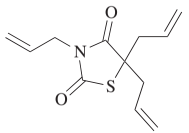
618

R^1	R^2	
H	H	(37)
H	CF_3	(32)
CF_3	H	(63)

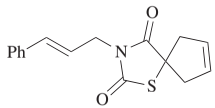
C_8



1.5 eq

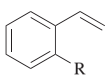


1. Hov II (0.02 eq), DCM, rt, 8 h
2. Hov II (0.03 eq), styrene, 40°, 12 h

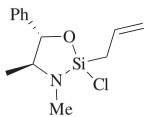


(47) (*E*)/(*Z*) > 99:1 657

C_{8-9}

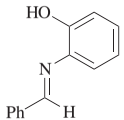


7.5 eq



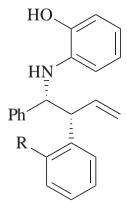
1.5 eq

+



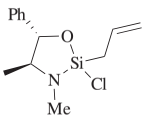
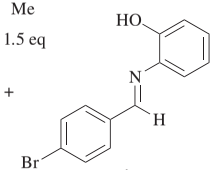
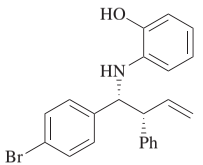
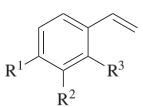
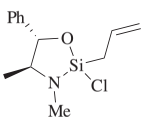
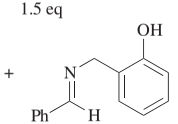
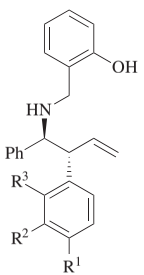
1 eq

1. Gr II (0.026 eq), DCE, reflux, 3.5 h
2. Imine, reflux, 14 h



R		dr	er	
H	(68)	87.5:12.5	98.0:2.0	211
Me	(55)	83:17	97.0:3.0	

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

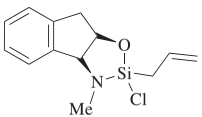
Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8 7.5 eq	 1.5 eq +  1 eq	1. Gr II (0.026 eq), DCE, reflux, 3.5 h 2. Imine, reflux, 14 h	 (54) dr 89:11, er 97.0:3.0	211
C_{8-9}  7.5 eq	 1.5 eq +  1 eq	1. Gr II (0.026 eq), solvent, reflux, time 2. Imine, reflux, 14 h		211

R^1	R^2	R^3	Solvent	Time (h)		dr	er
H	H	H	DCE	3.5	(64)	>95:5	98.0:2.0
H	H	Me	$CHCl_3$	5	(65)	>95:5	98.0:2.0
H	O_2N	H	$CHCl_3$	5	(57)	>95:5	99.0:1.0
F	H	H	$CHCl_3$	5	(65)	>95:5	98.0:2.0

C_8

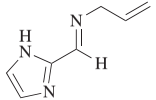


7.5 eq



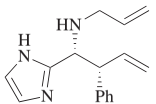
1.5 eq

+



1 eq

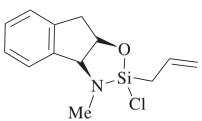
1. Hov II (0.036 eq), benzene, reflux, 2 h
2. Imine, rt, 14 h



(62) dr > 95:5, er 96.0:4.0

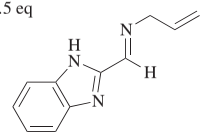
211

7.5 eq



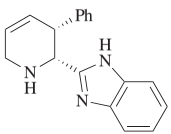
2.5 eq

+



1 eq

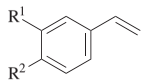
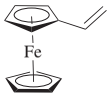
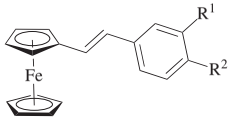
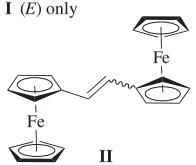
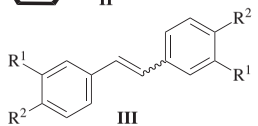
1. Hov II (0.06 eq), toluene, reflux, 2 h
2. Imine, 23°, 18 h
3. Hov II (0.1 eq), 45°, 24 h



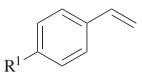
(48) dr > 95:5, er 94.5:5.5

211

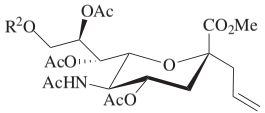
TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
$C_{8–14}$ 		Mo cat **1** (0.01 eq), solvent	 **I** (*E*) only +  **II** +  **III**	637, 659

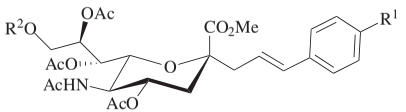
R^1	R^2	Solvent	Temp (°)	Time (h)	**I**	**I/II/III**
H	H	DCM	20	17	(55)	73:8:19
H	H	$CHCl_3$	20	17	(35)	89:3:8
H	H	*n*-hexane	20	17	(41)	64:16:20
H	H	toluene	20	17	(39)	78:3:19
H	H	toluene	–15	17	(42)	92:0:8
H	H	toluene	50	17	(59)	57:11:32
H	H	toluene	rt	15	(62)	87:4:9
H	Ph	toluene	20	17	(42)	88:9:3
H	Ph	toluene	rt	15	(79)	88:9:3
H	Me	toluene	20	17	(59)	81:13:6
H	Me	toluene	rt	15	(55)	81:13:6
H	H	benzene-d_6	20	1.66	(38)	89:2:9
H	Cl	benzene-d_6	20	1.66	(40)	71:0:29
H	*t*-Bu	benzene-d_6	20	1.66	(28)	87:2:11
Me	H	benzene-d_6	20	1.66	(39)	86:3:11



x eq



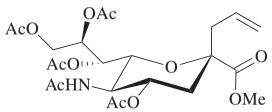
Catalyst (*y* eq),
DCM, 24 h



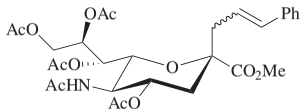
R^1	*x*	R^2	Catalyst	*y*	Temp (°)		(*E*)/(*Z*)	
H	10	Ac	Gr II	0.08	25	(34)	(*E*) only	660
H	10	Ac	Gr II	0.05	40	(92)	(*E*) only	660
H	10	Ac	Hov II	0.16	25	(17)	(*E*) only	660
H	10	Ac	Hov II	0.24	40	(94)	(*E*) only	660
H	10	Bn	Gr II	0.13	reflux	(78)	(*E*) only	661
H	10	Ac	Hov II	0.24	reflux	(94)	(*E*) only	661
O_2N	9	Ac	Hov II	0.12	reflux	(100)	83:17	661
MeO	8.6	Ac	Hov II	0.086	reflux	(47)	(*E*) only	661



10 eq

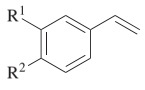
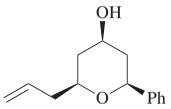
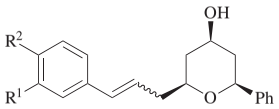
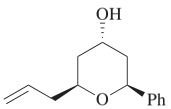
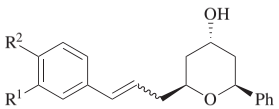


Gr II (0.12 eq),
DCM, 40°, 24 h



(100) 660

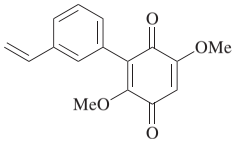
TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{8-9}				
 2 eq		Gr II (0.05 eq), DCM, 40°, 8 h	 R^1 R^2 H H (68) H F (53) H CF_3 (48) CF_3 H (58)	662
2 eq		Gr II (0.07 eq), DCM, 40°, 8 h	 R^1 R^2 H H (55) H F (45) H CF_3 (59) CF_3 H (75)	662

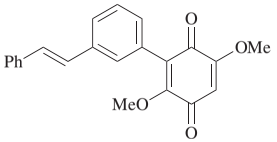
C_8



10 eq

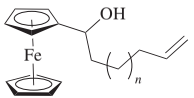


Gr II (0.1 eq),
DCM, reflux, 18 h

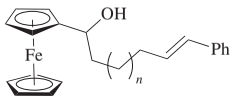


(60) (*E*) only 663

2 eq



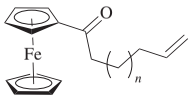
Gr I (0.19 eq),
DCM, reflux,
17–24 h



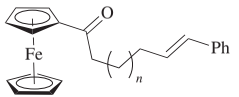
n		(*E*)/(*Z*)
1	(56)	94:6
2	(54)	94:6

587

2 eq



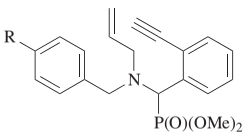
Gr I (0.19 eq),
DCM, reflux,
17–24 h



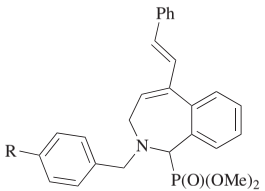
n		(*E*)/(*Z*)
1	(65)	94:6
2	(52)	96:4

587

5 + 5 eq



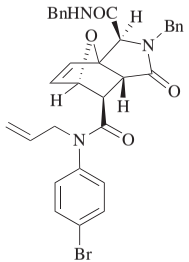
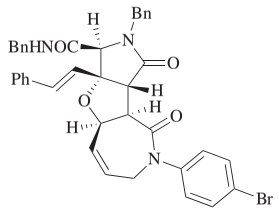
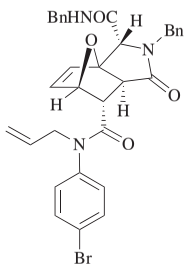
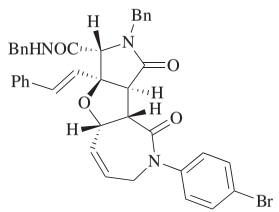
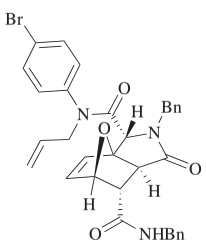
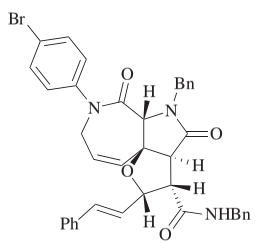
Gr II (0.1 eq),
DCM, reflux,
2 + 4 h



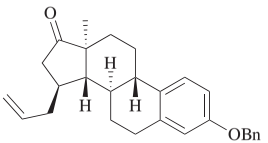
(*E*) only

R		
H	(78)	95
Br	(69)	

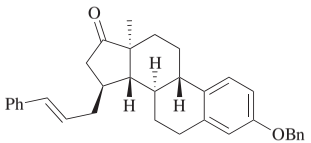
TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
 10 eq		Gr II (0.1 eq), DCM, rt, 12 h	 (81) (*E*)/(*Z*) > 95:5	664
10 eq		Gr II (0.1 eq), DCM, rt, 12 h	 (81) (*E*)/(*Z*) > 95:5	557
10 eq		Gr II (0.1 eq), DCM, rt, 3 h	 (65) (*E*)/(*Z*) > 95:5	557

2 eq



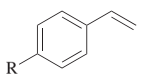
Catalyst (0.03 eq), solvent



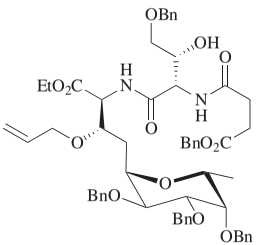
(*E*) only 163

Catalyst	Solvent	Temp (°)	Time (h)	
Gr II	DCM	40	2.5	(76)
Ru cat **68**	DCE	80	5.5	(55)
Ru cat **125**	DCM	40	5.5	(74)

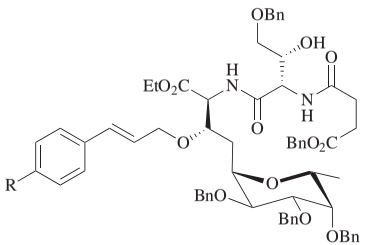
C_{8-14}



2 eq



Gr I (0.05 eq), DCM, reflux, 18–40 h



582

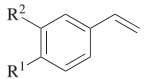
R		(*E*)/(*Z*)
H	(74)	>95:5
MeO	(79)	87:13
Ph	(73)	>95:5

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

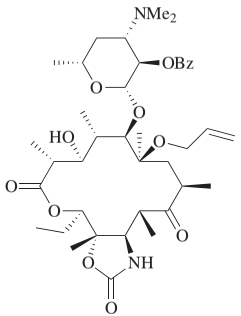
Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

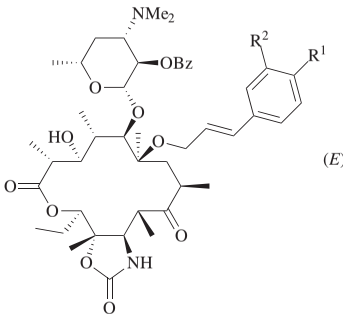
C_{8-9}



3 eq



Gr I (*x* eq),
DCM, reflux



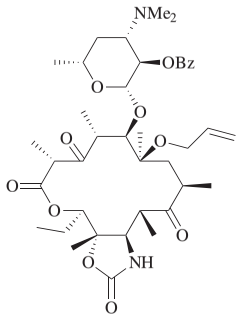
(*E*)/(*Z*) > 95:5 584

R^1	R^2	*x*	Time (h)	
H	H	0.1	26	(81)
H	Cl	0.1 + 0.1	65 + 20	(81)
Me	H	0.1 + 0.1	65 + 20	(91)

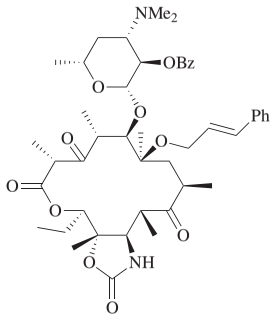
C_8



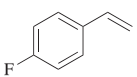
2 eq

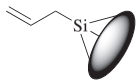


Gr I (3 x 0.1 eq), DCM, reflux, 24 + 24 + 6 h

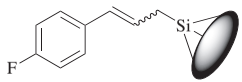


(52) (*E*)/(*Z*) > 95:5 584

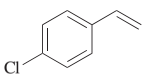


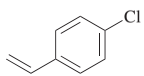


Gr I, THF, 70°, 72 h

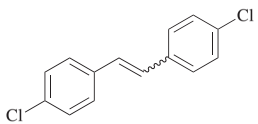


(53) 665



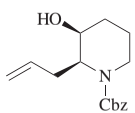


Hov I (0.05 eq), toluene, 60°, 24 h

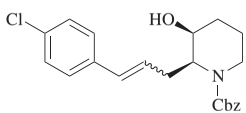


26% conv.[a] 654

2 eq

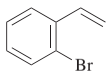
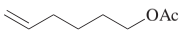
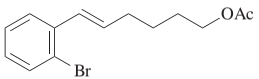
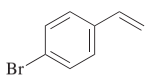
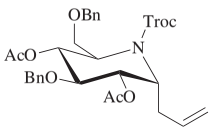
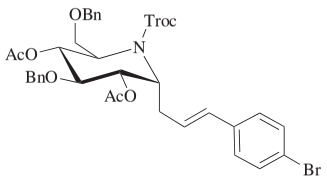
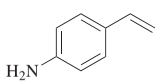
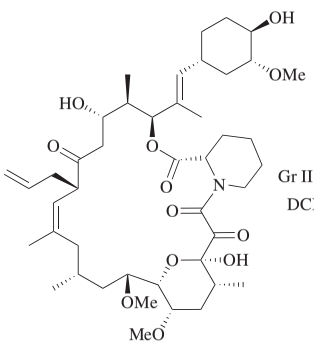
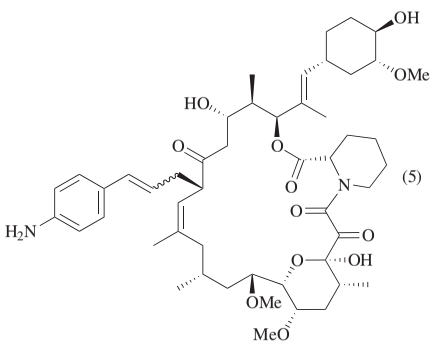


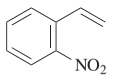
Gr II (0.1 eq), DCM, reflux, overnight



(55) 441

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

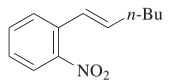
Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
 *x* eq		Gr II (0.05 eq), DCM, 40°, 12 h	 (*E*) only	*x* 1 (80) 3 (98) 36
 3 eq		Gr II (0.1 eq), DCM, reflux, 16–24 h	 (45) (*E*)/(*Z*) > 95:5	666
 20 eq		Gr II (0.1 eq), DCB, MW	 (5)	432



2 eq

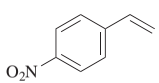


Mo cat **1** (0.05 eq),
DCM, 40°, 12 h

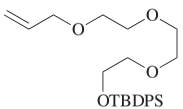


(48) (*E*) only

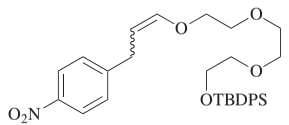
36



3 eq



Gr II (0.05 eq),
toluene, 70°, 5 h

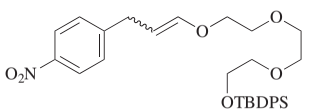


I

I + **II** + **III** (65)

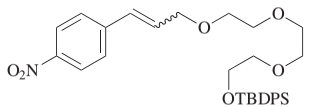
667

\+



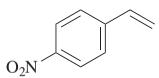
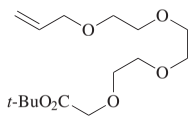
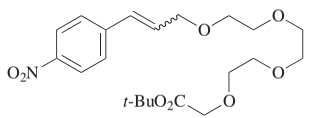
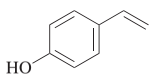
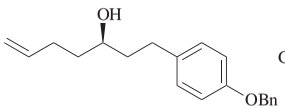
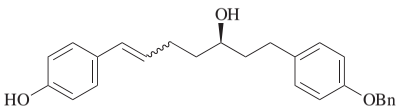
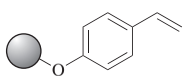
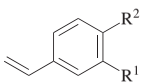
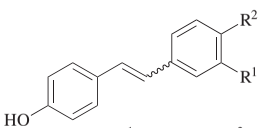
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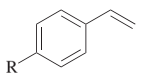


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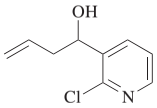
TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

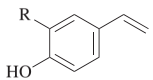
Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
 3 eq		Gr II (0.05 eq), DCM, reflux, 6 h	 (80)	667
 2.5 eq		Gr II (0.032 eq), DCM, 50°, 4 h	 (68)	668
	 *x* eq	1. Ru cat **35** (0.02 eq), benzene, 80°, 12 h 2. 20%TFA, DCM, rt, 0.5 h		652

R^1	R^2	*x*	
H	H	10	(71)
H	H	4	(63)
H	Cl	10	(81)
H	CF_3	10	(68)
H	AcO	10	(72)
H	Me	10	(61)
H	MeO	10	(68)
AcO	AcO	10	(61)
$MeOCH_2$	$MeOCH_2$	10	(54)

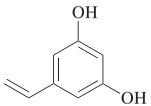


3 eq

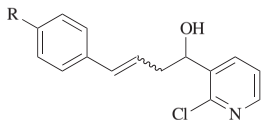




x eq

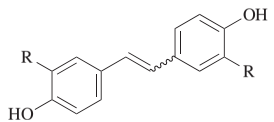


Hov II (0.1 eq),
DCM, 50°, 24 h

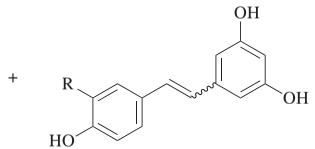


R		
MeO	(37)	603
F	(0)	

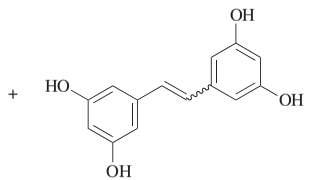
Gr II (0.03 eq),
THF, reflux, 1 h



I 653



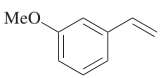
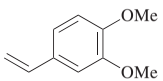
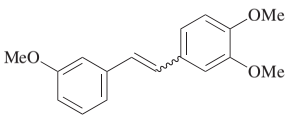
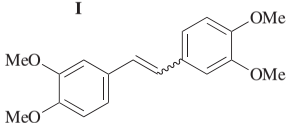
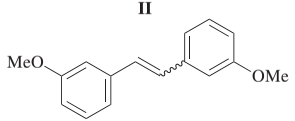
II

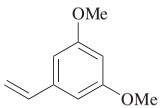


III

R	*x*	**I + II + III**	**I/II/III**
H	1	(87)	23:60:17
H	10	(94)	0:95:5
HO	1	(86)	26:52:22

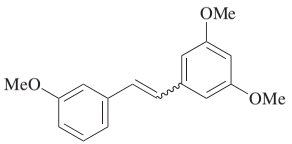
TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
	 1.5 eq	Gr II (0.02 eq), DCM, 40°, 1.5 h	 **I** +  **II** +  **III** **I** + **II** + **III** (67), **I/II/III** = 69:17:14	143



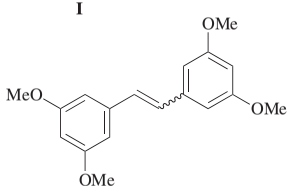
1.5 eq

Gr II (0.02 eq),
DCM, 40°, 1.5 h



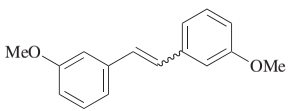
I

\+



II

\+



III

I + **II** + **III** (77), **I/II/III** = 79:13:7

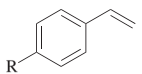
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TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

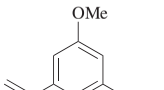
Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

C_{8-9}

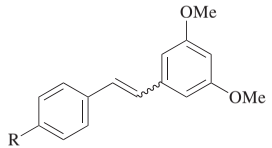


x eq



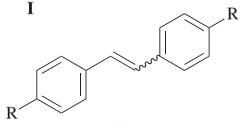
y eq

Catalyst (*z* eq),
solvent, reflux



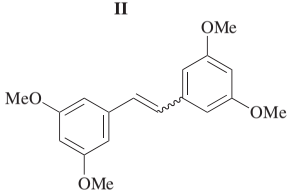
I

+



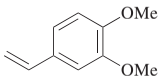
II

+



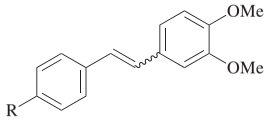
III

R	*x*	*y*	Catalyst	*z*	Solvent	Time (h)	**I + II + III**	**I/II/III**	
MeO	1	1	Gr II	0.05	toluene	1	(83)	63:19:18	653
MeO	1	1	Gr I	0.05	toluene	1	(78)	62:22:16	653
MeO	1	1	Hov II	0.05	toluene	1	(81)	52:20:28	653
MeO	2	1	Gr II	0.02	DCM	1.5	(86)	54:46:0	143
MeO	1.5	1	Gr II	0.02	DCM	1.5	(86)	47:53:0	143
MeO	1	1	Gr II	0.02	DCM	1.5	(86)	72:28:0	143
MeO	1	1.5	Gr II	0.02	DCM	1.5	(86)	88:5:7	143
MeO	1	2	Gr II	0.02	DCM	1.5	(76)	57:17:21	143
AcO	1	1.5	Gr II	0.02	DCM	1.5	(74)	60:1:39	143
Me	1	1.5	Gr II	0.02	DCM	1.5	(79)	80:9:11	143



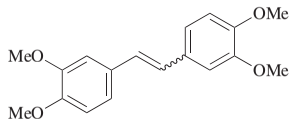
1.5 eq

Gr II (0.02 eq),
DCM, 40°, 1.5 h



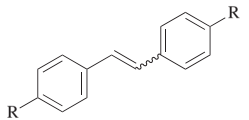
I

\+



II

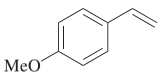
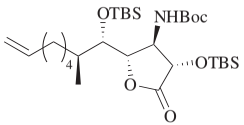
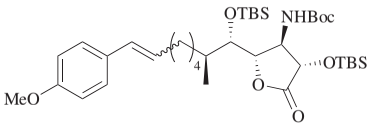
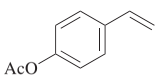
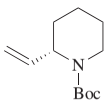
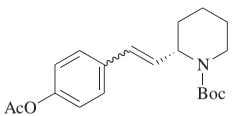
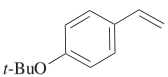
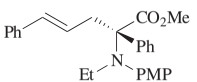
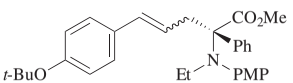
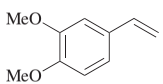
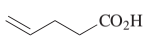
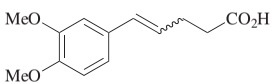
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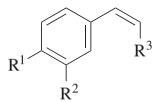
III

R	**I + II + III**	**I/II/II**
MeO	(65)	64:24:11
Me	(75)	67:20:13
AcO	(67)	64:31:5

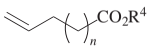
TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
 5 eq		Gr I (3 x 0.05 eq), DCM, rt, 144 h	 (88)	669
 2.5 eq		Gr II (0.1 eq), DCM, rt, 1.5 h	 (76)	670
 3.1 eq	 er 90.5:9.5	Hov II (0.2 eq), toluene, 90°, 20 h	 (74)	368
	 10 eq	Gr II (0.1 eq), DCM, 40°, 15 h	 (41)	671

C_{8-9}

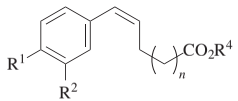


I



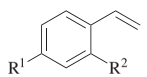
3 eq

1. Ru cat **152** (0.01 eq), (*Z*)-butene (*x* eq), THF, 22°, 1 h
2. Ru cat **152** (0.04 eq), **I** (1 eq), THF, 100 torr, 22°, time

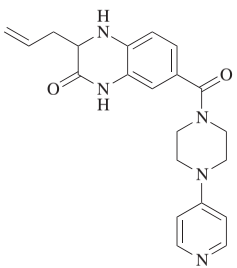


395

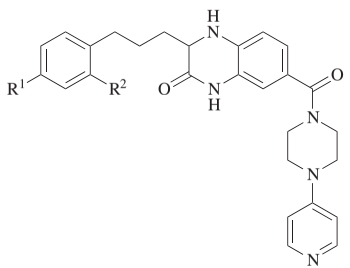
R^1	R^2	R^3	R^4	*n*	*x*	Time (h)		(*Z*)/(*E*)
H	H	Me	Bn	1	—	8	(48)	96:4
MeO	MeO	H	Bn	1	20	4	(50)	92:8
H	OHC	H	Me	2	20	4	(64)	96:4



4 eq



1. Gr II (0.1 eq), DCM/MeOH (3:1), 50°
2. H_2, 9 h



672

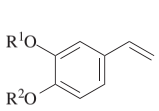
R^1	R^2	
H_2NO_2S	H	(49)
H	Me	(69)
H_2NCO	H	(52)

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

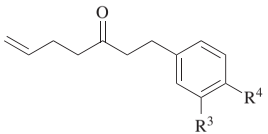
Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

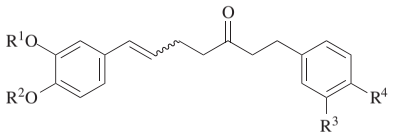
C_8



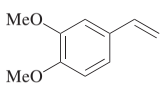
x eq

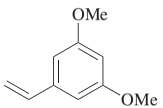


Gr II (*y* eq), solvent, reflux



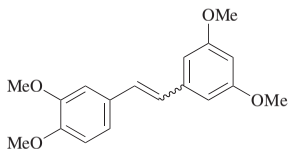
R^1	R^2	*x*	R^3	R^4	*y*	Solvent	Time (h)		
H	Me	2	H	Br	0.067	toluene	10	(48)	673
H	Me	—	Br	MeO	0.1	toluene	2	(53)	673
H	Me	—	Br	MOMO	0.1	toluene	2	(30)	674
Me	Bn	—	Br	MeO	0.1	DCM	4	(30)	674
Me	Bn	—	Br	MOMO	0.1	DCM	4	(26)	674





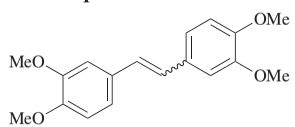
1.5 eq

Gr II (0.02 eq), DCM, 40°, 1.5 h



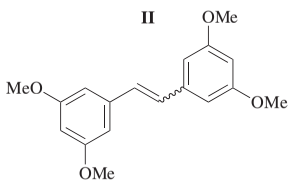
I

+



II

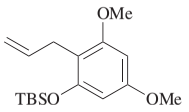
+



III

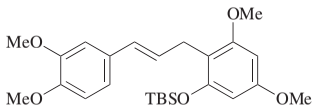
I + **II** + **III** (62), **I/II/III** = 73:17:10

143



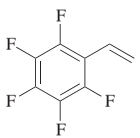
2 eq

Gr II (0.05 eq),
DCM, reflux, 12 h

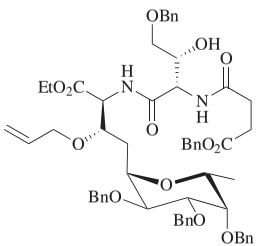


(82) (*E*)/(*Z*) > 95:5

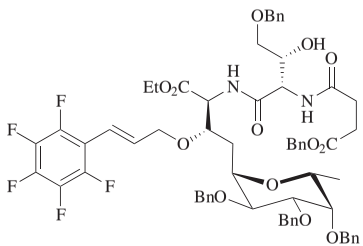
145



2 eq



Gr I (0.05 eq),
DCM, reflux,
18–40 h



(17) (*E*)/(*Z*) = 70:30

582

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

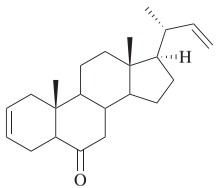
Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

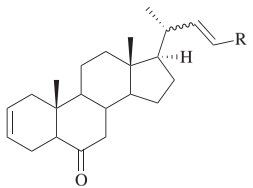
C_{8-14}



8 eq



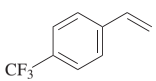
Hov II (0.1 + 0.1 eq)
DCE, 80°, 5 + 5 h



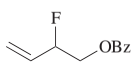
675

R		R	
Ph	(81)	2-MeC_6H_4	(65)
2-FC_6H_4	(65)	3-MeC_6H_4	(69)
3-FC_6H_4	(73)	4-MeC_6H_4	(71)
4-FC_6H_4	(75)	2-$CF_3C_6H_4$	(57)
2-ClC_6H_4	(64)	3-$CF_3C_6H_4$	(66)
3-ClC_6H_4	(70)	4-$CF_3C_6H_4$	(71)
4-ClC_6H_4	(75)	2,4-$Me_2C_6H_3$	(61)
2-BrC_6H_4	(59)	3,5-$Me_2C_6H_3$	(58)
3-BrC_6H_4	(66)	4-*t*-BuC_6H_4	(60)
4-BrC_6H_4	(73)	4-PhC_6H_4	(32)

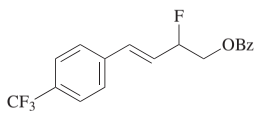
C_9



5 eq

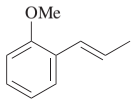


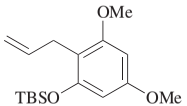
Hov II (0.03 eq),
DCM, 100°, 16 h,
sealed tube



(70) (*E*)/(*Z*) > 95:5

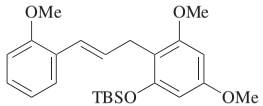
142



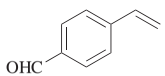


2 eq

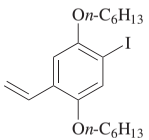
Gr II (0.05 eq),
DCM, reflux, 12 h



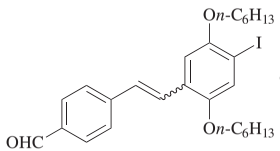
(97) (*E*)/(*Z*) > 95:5 145



2 eq

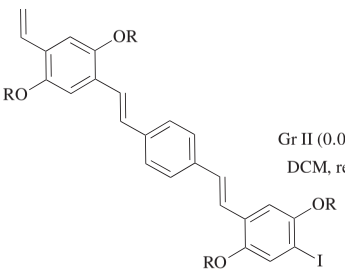


Gr II (0.024 eq),
DCM, reflux, 40 h



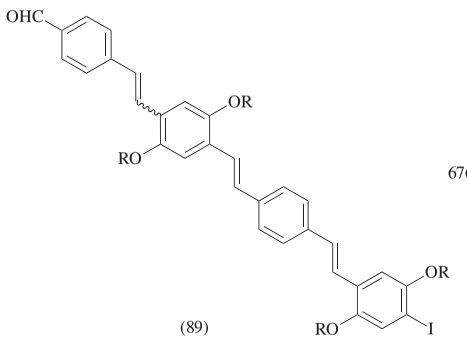
(75) 676

3 eq



R = *n*-C6H13

Gr II (0.028 eq),
DCM, reflux, 40 h



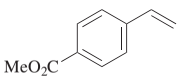
(89) 676

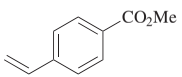
TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

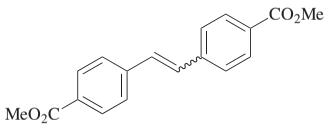
Please refer to the charts preceding the tables for the catalyst structures.

C_9



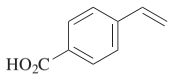


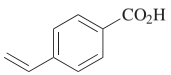
Catalyst (*x* eq),
milling,
additive (3.9 eq),
THF (*y* μL)



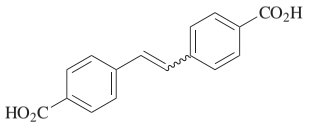
343

Catalyst	*x*	Mill	Additive	y	Time (h)	
Gr I	0.05	steel	—	—	1	(—)
Gr II	0.05	steel	—	—	1.5	(16)
Gr II	0.05	steel	—	—	1.5	(31)
Ru cat **67**	0.02	steel	—	—	1.5	(0)
Ru cat **67**	0.02	steel	—	—	1.5	(27)
Hov II	0.01	steel	—	—	1.5	(19)
Hov II	0.01	steel	—	—	1.5	(30)
Gr I	0.05	steel	—	50	1	(—)
Gr II	0.05	steel	—	50	1.5	(45)
Ru cat **67**	0.02	steel	—	50	1.5	(35)
Hov II	0.01	steel	—	50	1.5	(40)
Hov II	0.01	steel	—	—	1.5	(30)
Hov II	0.01	steel	NaCl	—	1.5	(93)
Hov II	0.01	steel	NaBr	—	1.5	(92)
Hov II	0.01	steel	NaI	—	1.5	(92)
Hov II	0.01	steel	KCl	—	1.5	(91)
Hov II	0.01	steel	K_2SO_4	—	1.5	(92)
Hov II	0.015	steel	—	—	1	(89)
Hov II	0.015	alumina	—	—	1.5	(91)





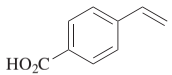
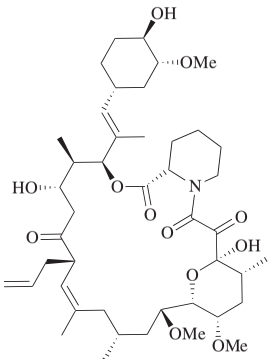
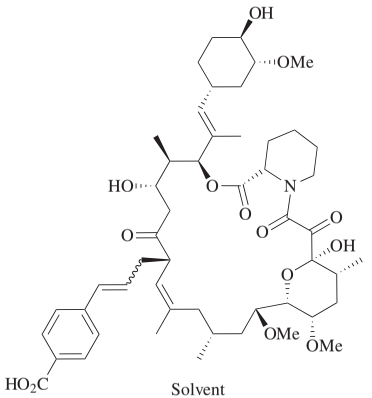
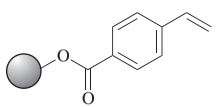
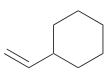
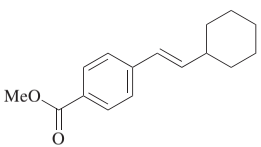
Catalyst (x eq),
milling,
additive (3.9 eq),
solvent (y μL)

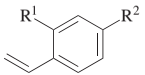


343

Catalyst	x	Mill	Additive	Solvent	y	
Gr I	0.05	steel	—	—	—	(—)
Gr II	0.05	steel	—	—	—	(—)
Ru cat **67**	0.05	steel	—	—	—	(—)
Hov II	0.02	steel	—	—	—	(—)
Gr I	0.05	steel	—	THF	50	(—)
Gr II	0.05	steel	—	THF	50	(15)
Gr II	0.05	steel	—	THF	100	(37)
Ru cat **67**	0.05	steel	—	THF	50	(45)
Hov II	0.02	steel	—	THF	50	(49)
Hov II	0.02	steel	NaCl	EtOAc	75	(73)
Hov II	0.02	steel	NaBr	EtOAc	75	(70)
Hov II	0.02	steel	NaI	EtOAc	75	(71)
Hov II	0.02	steel	KCl	EtOAc	75	(74)
Hov II	0.02	steel	K_2SO_4	EtOAc	75	(71)
Hov II	0.03	steel	—	EtOAc	500	(67)
Hov II	0.03	alumina	—	EtOAc	250	(70)

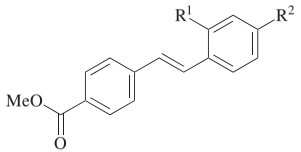
TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
 20 eq		Gr II (0.1 eq), solvent, MW	 Solvent / DCB (79) / *i*-PrOH (9)	432
	 5 eq	1. Gr II (0.05 eq), toluene, 75° (MW), 25 min 2. TFA (0.1 eq), DCM, 1 h 3. CH_2N_2, DCM, 0°, 0.5 h		(82) (*E*) only	418



5 eq

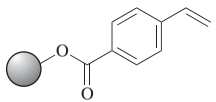
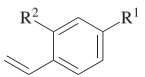
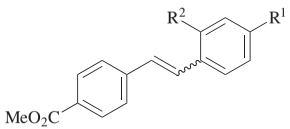
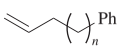
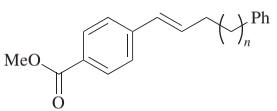
1. Catalyst (0.05 eq), solvent
2. TFA (0.1 eq), DCM, 1 h
3. CH_2N_2, DCM, 0°, 0.5 h



(*E*) only 418

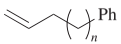
R^1	R^2	Catalyst	Solvent	Temp (°)	Time (h)	
H	Br	Gr II	DCM	40	20	(43)
H	Br	Hov II	DCM	40	20	(43)
H	Br	Gr II	toluene	75 (MW)	0.42	(80)
AcO	H	Gr II	toluene	75 (MW)	0.42	(85)
Me	H	Gr II	DCM	40	20	(31)
Me	H	Gr II	toluene	75 (MW)	0.42	(30)
Me	H	Hov II	DCM	40	20	(32)
$ClCH_2$	H	Gr II	DCM	40	20	(80)
$ClCH_2$	H	Gr II	toluene	75 (MW)	0.42	(90)
$ClCH_2$	H	Hov II	DCM	40	20	(28)

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
	 5 eq	1. Cat (0.05 eq), DCM, reflux, 20 h 2. TFA (0.1 eq), DCM, 1 h 3. CH_2N_2, DCM, 0°, 0.5 h		677
			 5 eq	1. Catalyst (0.05 eq), solvent 2. TFA (0.1 eq), DCM, 1 h 3. CH_2N_2, DCM, 0°, 0.5 h	 (*E*) only	418

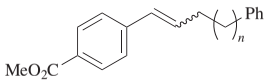
R^1	R^2	Catalyst	
H	Br	Gr II	(10)
H	Br	Hov II	(16)
Me	H	Gr II	(31)
Me	H	Hov II	(32)
$ClCH_2$	H	Gr II	(80)

n	Catalyst	Solvent	Temp (°)	Time (h)	
0	Gr I	DCM	40	20	(22)
0	Gr II	DCM	40	20	(86)
0	Gr II	toluene	75 (MW)	0.42	(79)
0	Hov II	DCM	40	20	(84)
1	Gr II	DCM	40	20	(57)
1	Gr II	toluene	75 (MW)	0.42	(86)

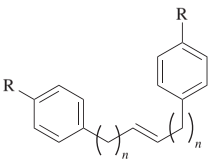


5 eq

1. Gr II (0.05 eq), DCM, reflux, 20 h
2. TFA (0.1 eq), DCM, 1 h
3. CH_2N_2, DCM, 0°, 0.5 h

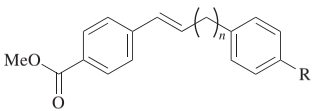


n		
0	(86)	677
1	(57)	



5 eq

1. Gr II (0.05 eq), solvent
2. TFA (0.1 eq), DCM, 1 h
3. CH_2N_2, DCM, 0°, 0.5 h



(*E*) only 418, 677

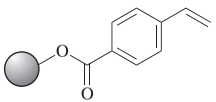
n	R	Solvent	Temp (°)	Time (h)	
0	Me	toluene	75 (MW)	0.5	(15)
0	Me	DCM	reflux	20	(0)
0	$ClCH_2$	DCM	reflux	20	(58)
1	H	DCM	reflux	20	(72)
2	H	DCM	reflux	20	(39)

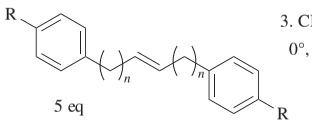
TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

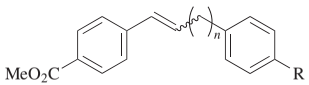
C_9





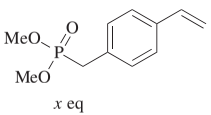
5 eq

1. Gr II (0.05 eq), DCM, reflux, 20 h
2. TFA (0.1 eq), DCM, 1 h
3. CH_2N_2, DCM, 0°, 0.5 h

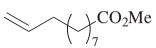


R	*n*	
Me	0	(0)
H	1	(72)
H	2	(39)
$ClCH_2$	0	(58)

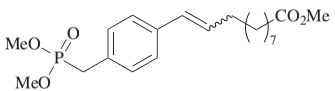
677



x eq

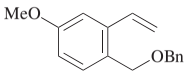


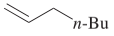
Catalyst (*y* eq), solvent, 40°



x	Catalyst	*y*	Solvent	Time (h)	
2	Gr I	0.02	DCM	12	(29)
2	Gr I	0.02	—	12	(38)
1.4	Gr I	0.02	DCM	24	(44)
1	Gr I	0.02	DCM	12	(38)
1	Gr II	0.01	—	12	(43)
1	Gr II	0.02	—	12	(60)
2	Gr II	0.02	DCM	12	(41)

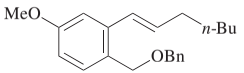
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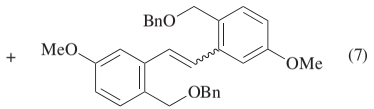
2 eq

Gr II (0.1 eq),
DCM, reflux, 12 h

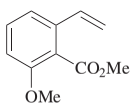


(80) (*E*) only

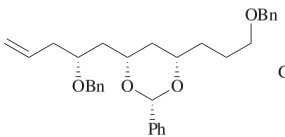
678a



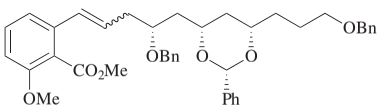
(7)



2 eq

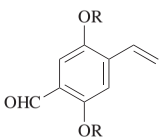


Gr II (0.05 eq),
DCM, reflux, 24 h



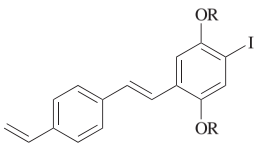
(86)

679

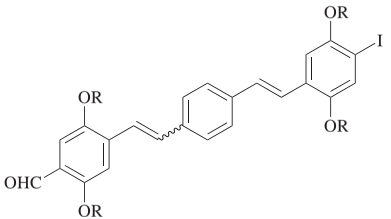


4 eq

R = *n*-C_6H_{13}

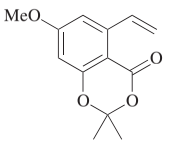


Gr II (0.06 eq),
DCM, reflux, 40 h

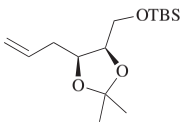


(72)

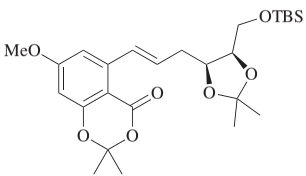
676



1.9 eq



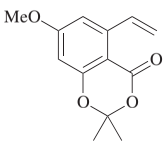
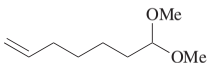
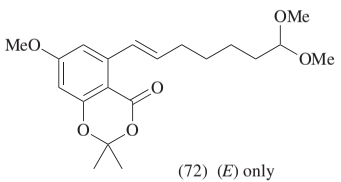
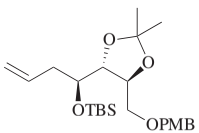
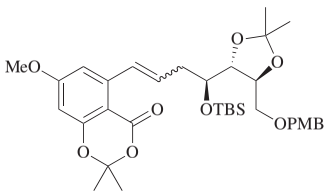
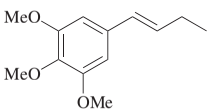
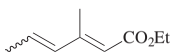
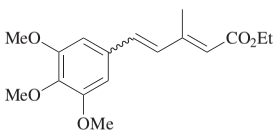
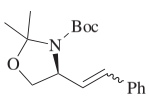
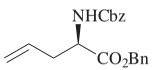
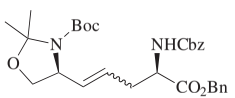
Hov II (0.08 eq),
DCM, 40°, 16 h



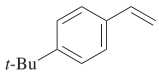
(86) (*E*) only

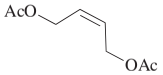
681

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

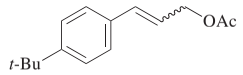
Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
	 3 x 1.25 eq	Gr II (98 x 0.025 eq), CuI (98 x 0.029 eq), Et_2O, reflux, 14 d	 (72) (*E*) only	680
2 eq		Hov II (0.06 eq), DCM, reflux, 2 d	 (72)	682
C_{10}				
	 3 eq	Gr II (0.1 eq), toluene, 50°	 (64)	542
 5 eq		Gr II (0.05 eq), toluene, reflux, 3 h	 (10)	563

C_{12}

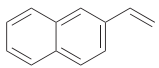


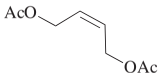


Ru cat **162** (0.02 eq), toluene, 80°, 1 h



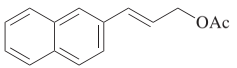
(53) 449





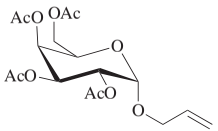
2 eq

Gr II (0.05 eq), DCM, reflux, 12 h

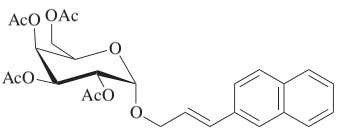


(81) (*E*)/(*Z*) > 95:5 145

4 eq

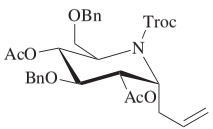


Gr I (0.07 eq), DCM, reflux, 16 h

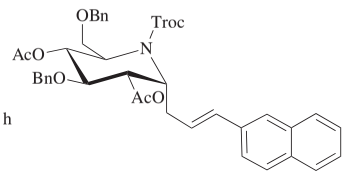


(53) (*E*)/(*Z*) = 81:19 332

5 eq

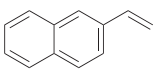
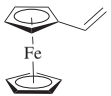
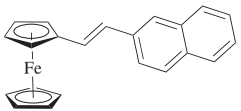
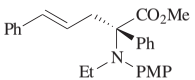
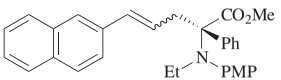
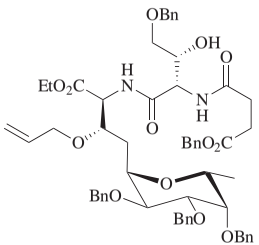
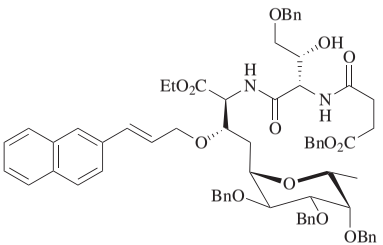


Gr II (0.2 eq), DCM, reflux, 16–24 h

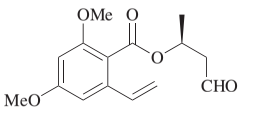


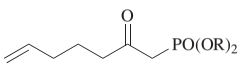
(90) (*E*)/(*Z*) > 95:5 666

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{12}				
		Mo cat **1** (*x* eq), solvent, rt	 (*E*) only	
		x = 0.01, benzene d_6, 100 min	(32)	659
		x = 0.017–0.01, toluene, 15 h	(45)	637
3.1 eq	 er 90.5:9.5	Hov II (0.2 eq), DCE, 70°, 20 h	 (68) er 90.5:9.5	368
2 eq		Gr I (0.05 eq), DCM, reflux, 18–40 h	 (71) (*E*)/(*Z*) > 95:5	582

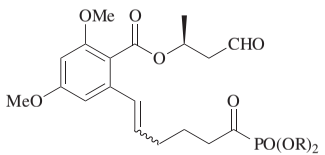
C_{13}





1.5 eq

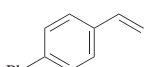
Hov II (0.1 eq),
DCM, 40°, 5 h



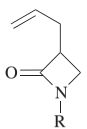
R	
CF_3CH_2	(65)
Ph	(69)

683

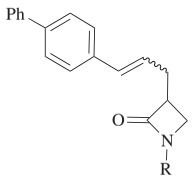
C_{14}



x eq

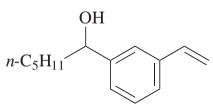


Gr II (0.05 eq),
DCM, reflux, 14 h

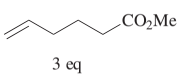


x	R	
2.5	H	(38)
2	MeS	(43)

422

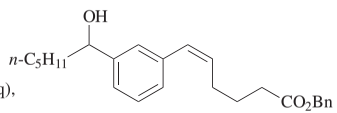


I



3 eq

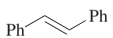
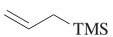
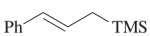
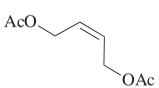
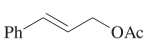
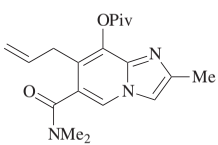
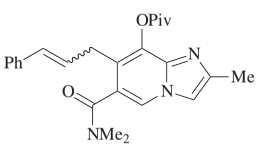
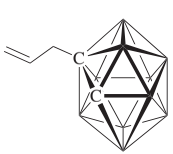
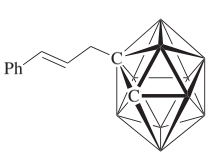
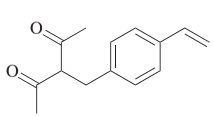
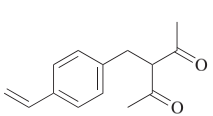
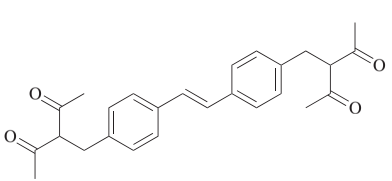
1. Ru cat **215** (20 eq),
(*Z*)-butene (0.01 eq),
THF, 22°, 1 h
2. Ru cat **215** (0.05 eq),
I (1 eq), THF,
100 torr, 35°, 4 h

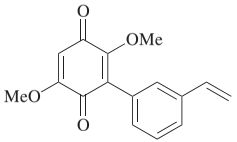


(35) (*Z*)/(*E*) = 71:29

395

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

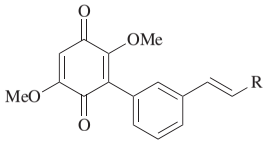
Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{14}				
	 2 eq	Mo cat **1** (0.02 eq), DME, 4 h	 (80) (*E*)/(*Z*) = 81:19	208
	 1.2 eq	Gr II (0.05 eq), DCM, 40°, 12 h	 (51) (*E*) only	36
4 eq		Gr II (0.04 eq), DCM, 40°, 18 h	 (53)	684
2 eq		Hov II (0.007 eq), DCM, reflux, 48 h	 (81) (*E*)/(*Z*) = 75:25	436
		Gr II (0.05 eq), DCM, 40°, 24 h	 (75) (*E*)/(*Z*) = 91:9	492





10 eq

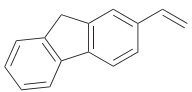
Gr II (0.1 eq),
DCM, reflux, 18 h



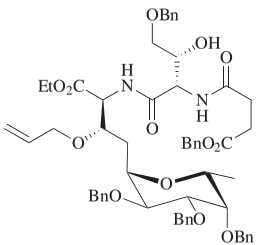
(*E*) only

R		
n-C_5H_{11}	(66)	663
n-C_6H_{13}	(53)	

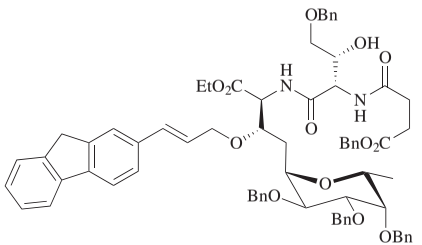
C_{15}



2 eq



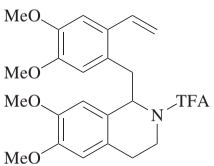
Gr I (0.05 eq),
DCM, reflux,
18–40 h

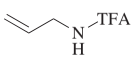


(70) (*E*)/(*Z*) > 95:5

582

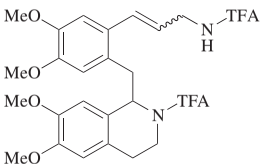
C_{18}



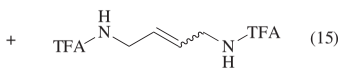


1.4 eq

Gr I (0.1 eq),
DCM, 24 h



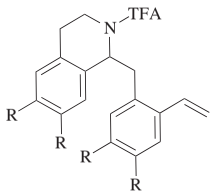
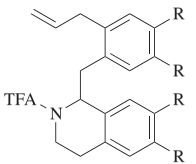
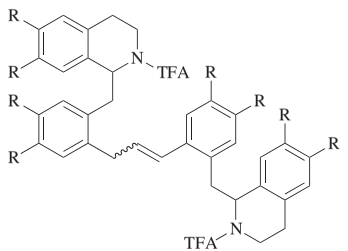
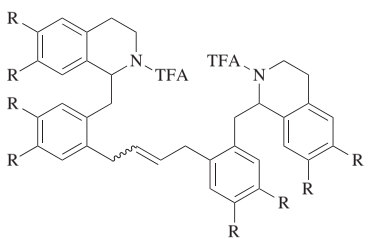
(30)



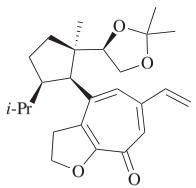
(15)

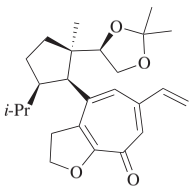
685

TABLE 10. CROSS-METATHESIS OF VINYL-SUBSTITUTED AROMATIC COMPOUNDS (*Continued*)

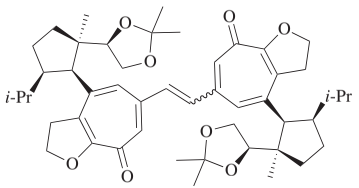
Aromatic Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{18}				
 R = OMe	 1.8 eq	Gr I (0.1 eq), DCM, reflux, 48 h	 (7.5)	685
			+  (7.5)	

C_{22}





Hov II (0.13 eq),
benzene, 80°, 4.5 h



(83) 686

[a] The conversion was determined by ^{1}H NMR analysis.

[b] The conversion was determined by GC analysis.

TABLE 11. CROSS-METATHESIS OF VINYL BORONIC COMPOUNDS
A. VINYL BORONIC ACIDS

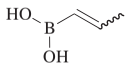
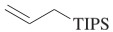
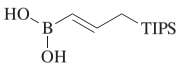
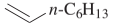
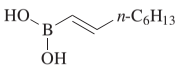
Vinyl Boronic Acid	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 1 eq		Gr II (0.05 eq), DCM, reflux	 (55) (*E*)/(*Z*) > 95:5	687
1 eq		Gr II (0.05 eq), DCM, reflux	 (31) (*E*)/(*Z*) > 95:5	687

TABLE 11. CROSS-METATHESIS OF VINYL BORONIC COMPOUNDS (*Continued*)

B. VINYL BORONIC ESTERS

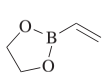
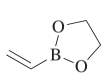
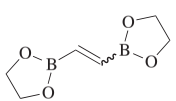
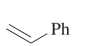
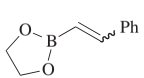
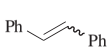
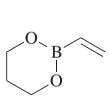
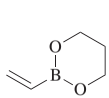
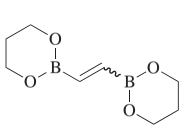
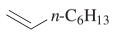
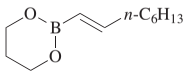
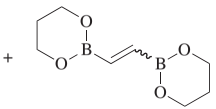
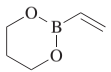
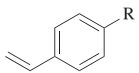
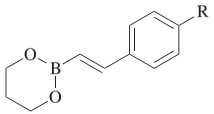
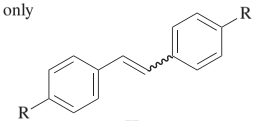
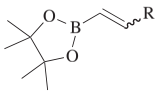
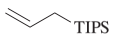
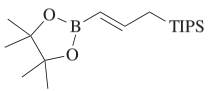
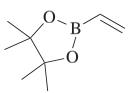
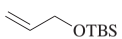
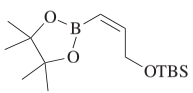
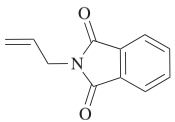
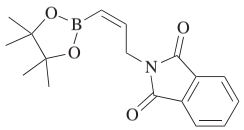
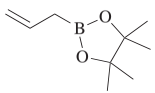
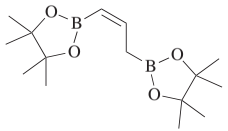
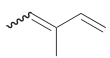
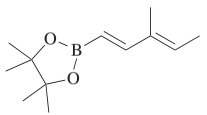
Vinyl Boronic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
		Gr I (0.05 eq), DCM, 40°, 3 h	 (80)	688
		Gr I (0.05 eq), DCM, 40°, 3 h	 (59) +  (11)	688
		Gr I (0.05 eq), DCM, 40°, 3 h	 (60)	688
1 eq		Gr I (0.05 eq), DCM, 40°, 3 h	 + 	688
			(75) (*E*)/(*Z*) > 96:4 (15)	
			+  (8)	

TABLE 11. CROSS-METATHESIS OF VINYL BORONIC COMPOUNDS (*Continued*)
B. VINYL BORONIC ESTERS (*Continued*)

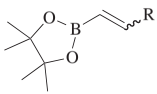
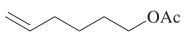
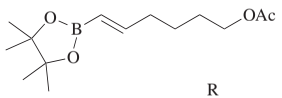
Vinyl Boronic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2  1 eq		Gr I (0.05 eq), DCM, 40°, 3 h	 **I** (*E*) only +  **II**	688
C_{2-3}  1 eq		Gr II (0.05 eq), DCM, reflux		687
C_2  5 eq		Mo cat **5** (0.05 eq), benzene, 22°, 24 h	 (70) (*Z*)/(*E*) = 96:4	547

R	**I**	**II**
H	(85)	(5)
Cl	(90)	(—)
Me	(85)	(—)

R		(*E*)/(*Z*)
H	(86)	88:12
Me	(99)	91:9

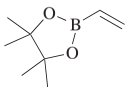
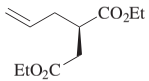
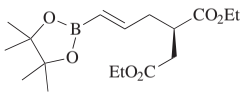
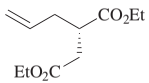
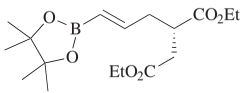
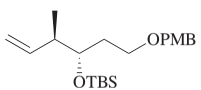
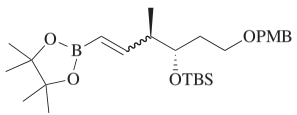
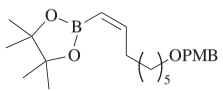
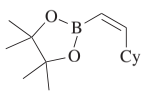
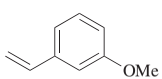
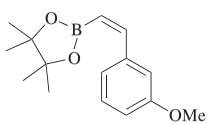
5 eq		Mo cat **5** (0.05 eq), benzene, 22°, 24 h		(71) (*Z*)/(*E*) = 93:7	547
5 eq		Mo cat **5** (0.05 eq), benzene, 22°, 24 h		(60) (*Z*)/(*E*) = 97:3	547
1–4 eq		Gr II (0.05 eq), DCM, reflux, 12 h		(80) (*E*) only	132

C_{2-3}

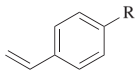
 1 eq		Gr II (0.05 eq), DCM, reflux			687

R		(*E*)/(*Z*)
H	(60)	91:9
Me	(65)	93:7

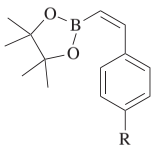
TABLE 11. CROSS-METATHESIS OF VINYL BORONIC COMPOUNDS (*Continued*)
B. VINYL BORONIC ESTERS (*Continued*)

Vinyl Boronic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2  3 eq		Gr I (0.1 eq), DCM, reflux, overnight	 (92) (*E*)/(*Z*) = 86:14	333
3 eq		Gr I (0.1 eq), DCM, reflux, overnight	 (90) (*E*)/(*Z*) = 83:17	333
3 eq		Hov II (0.05 eq), DCM, reflux, 18 h	 (74)	689
5 eq		Mo cat **5** (0.05 eq), benzene, 22°, 24 h	 (92) (*Z*)/(*E*) = 97:3	547
5 eq		Mo cat **5** (0.05 eq), benzene, 22°, 24 h	 (51) (*Z*)/(*E*) = 93:7	547
5 eq		Mo cat **5** (0.05 eq), benzene, 22°, 24 h	 (69) (*Z*)/(*E*) = 95:5	547

5 eq



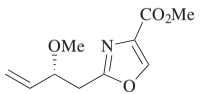
Mo cat **5** (0.05 eq), benzene, 22°, 24 h



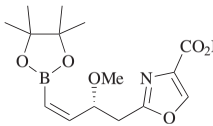
R		(*Z*)/(*E*)
MeO	(69)	93:7
CF_3	(93)	95:5

547

5 eq



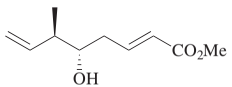
Mo cat **7** (0.1 eq), benzene, 22°, 18 h, 100 torr



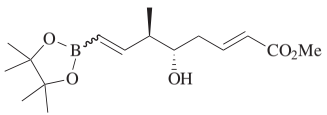
(76) (*Z*)/(*E*) = 92:8

690

2 eq



Hov II (0.05 eq), DCM, reflux, 4 h



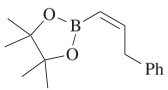
(50)

656



5 eq

Catalyst (*x* eq), benzene, 22°



547

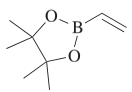
Catalyst	*x*	Conv. (%)[a]		(*Z*)/(*E*)
Mo cat **1**	0.05	33	(15)	68:32
Hov II	0.05	98	(78)	9:91
Gr II	0.05	86	(65)	11:89
Mo cat **18**	0.03	56	(—)	96:4
Mo cat **19**	0.03	50	(—)	93:7
Mo cat **5**	0.05	95	(68)	93:7
Mo cat **7**	0.05	98	(69)	93:7
W cat **3**	0.05	66	(—)	86:14

TABLE 11. CROSS-METATHESIS OF VINYL BORONIC COMPOUNDS (*Continued*)
B. VINYL BORONIC ESTERS (*Continued*)

Vinyl Boronic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

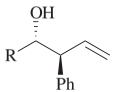
C_2



2 eq



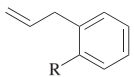
1. Gr I (0.03 eq)
DCM, reflux, 18 h
2. RCHO (1 eq),
[Ir(cod)(PPh_3Me_2)]PF_6
(0.03 eq),
THF, rt, 20 h



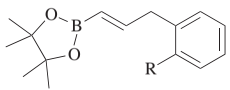
anti/syn > 98:2

R		
n-C_5H_{11}	(70)	691
Ph	(60)	
4-BrC_6H_4	(66)	
4-$O_2NC_6H_4$	(63)	
3-F-4-$O_2NC_6H_3$	(65)	

2 eq

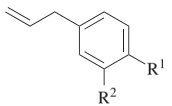
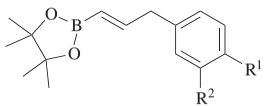


Catalyst (0.03 eq),
BQ (*x* eq),
solvent, 18 h

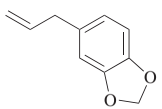
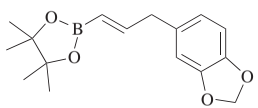


692

R	Catalyst	*x*	Solvent	Temp		(*E*)/(*Z*)
BnO	Gr I	0	DCM	reflux	(73)	90:10
MeO	Gr I	0	DCM	reflux	(89)	87:13
NsHN	Gr I	0	DCM	reflux	(62)	70:30
AcO	Ru cat **170**	0.5	toluene	60°	(55)	85:15

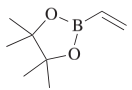
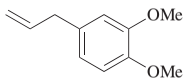
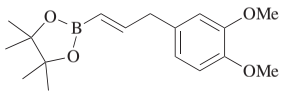
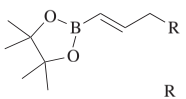
2 eq  Catalyst (0.03 eq), BQ (*x* eq), solvent, 18 h  692

R^1	R^2	Catalyst	*x*	Solvent	Temp		(*E*)/(*Z*)
MeO	MeO	Ru cat **170**	0.5	toluene	60°	(60)	80:20
HO	MeO	Gr I	0	DCM	reflux	(65)	83:17
BnO	MeO	Gr I	0	DCM	reflux	(56)	75:25
H	BnO	Gr I	0	DCM	reflux	(71)	86:14
MeO	H	Gr I	0	DCM	reflux	(67)	85:15
Me	H	Gr I	0	DCM	reflux	(70)	84:16
MeS	H	Ru cat **170**	0.5	toluene	60°	(42)	70:30
H	H	Gr I	0	DCM	reflux	(70)	85:15
F	H	Gr I	0	DCM	reflux	(76)	93:7
CF_3	H	Gr I	0	DCM	reflux	(70)	92:8

2 eq  Catalyst (0.03 eq), solvent, reflux 

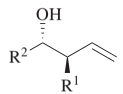
Catalyst	Solvent	Time (h)		(*E*)/(*Z*)	
Gr I	DCM	18	(79)	88:12	692
Ru cat **170**	toluene	1	(65)	(*E*) only	693

TABLE 11. CROSS-METATHESIS OF VINYL BORONIC COMPOUNDS (*Continued*)
B. VINYL BORONIC ESTERS (*Continued*)

Vinyl Boronic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 2 eq		Catalyst (0.03 eq), toluene, 1 h		693
			Catalyst / Temp / (%): Ru cat **170** / 50° / (60); Ru cat **170** / 70° / (72); Ru cat **170** / reflux / (84); Gr II / reflux / (—); Hov II / reflux / (—); Ru cat **187** / reflux / (78); Ru cat **93** / reflux / (—)	
2 eq		Ru cat **170** (0.03 eq), toluene, reflux, 1 h	 (*E*) only	693
			R / (%): Ph (65); 4-$MeOC_6H_4$ (65); 3-$BnOC_6H_4$ (58); 4-MeC_6H_4 (65); 4-FC_6H_4 (47); 4-$CF_3C_6H_4$ (66); 3,4-$(MeO)_2C_6H_3$ (62); 3-MeO-4-$BnOC_6H_3$ (80); 3-MeO-4-HOC_6H_3 (49)	

2 eq 

1. Gr I (0.03 eq)
DCM, reflux, 18 h
2. R^2CHO (1 eq),
$[Ir(cod)(PPh_3Me_2)]PF_6$
(0.03 eq),
THF, rt, 20 h



anti/syn > 98:2

691

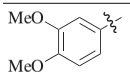
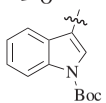
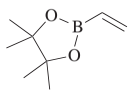
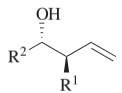
R^1	R^2	
	$4\text{-}BrC_6H_4$	(40)
	$4\text{-}O_2NC_6H_4$	(57)
	Ph	(31)

TABLE 11. CROSS-METATHESIS OF VINYL BORONIC COMPOUNDS (*Continued*)
B. VINYL BORONIC ESTERS (*Continued*)

Vinyl Boronic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 2 eq		1. Gr I (0.03 eq) DCM, reflux, 18 h 2. R^2CHO (1 eq), $[Ir(cod)(PPh_3Me_2)]PF_6$ (0.03 eq), THF, rt, 20 h	 *anti/syn* > 98:2	691

R^1	R^2	
4-MeC_6H_4	$4\text{-O}_2NC_6H_4$	(76)
4-MeC_6H_4	Ph	(68)
4-MeOC_6H_4	$4\text{-O}_2NC_6H_4$	(85)
4-MeOC_6H_4	4-BrC_6H_4	(55)
4-MeOC_6H_4	$3\text{-MeO-4-PivOC}_6H_3$	(42)
4-MeOC_6H_4	PhCH=CH	(49)
4-MeOC_6H_4	$n\text{-C}_5H_{11}$	(49)
2-MeOC_6H_4	$4\text{-O}_2NC_6H_4$	(33)
2-BnOC_6H_4	$4\text{-O}_2NC_6H_4$	(30)
2-AcOC_6H_4	$4\text{-O}_2NC_6H_4$	(57)
2-AcOC_6H_4	4-MeOC_6H_4	(42)
4-FC_6H_4	$4\text{-O}_2NC_6H_4$	(72)
$4\text{-CF}_3C_6H_4$	4-ClC_6H_4	(58)
$4\text{-CF}_3C_6H_4$	$4\text{-O}_2NC_6H_4$	(61)
3-BnOC_6H_4	2-Br-4-FC_6H_3	(62)
3-MeO-4-HOC_6H_3	$2\text{-Cl-5-O}_2NC_6H_3$	(40)

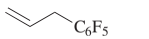
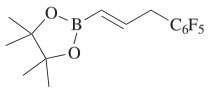
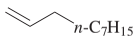
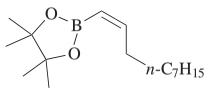
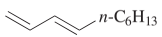
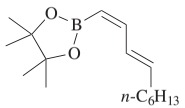
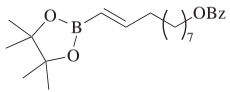
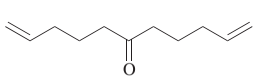
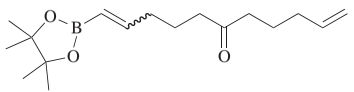
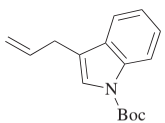
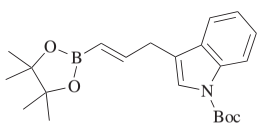
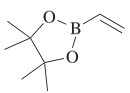
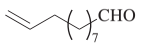
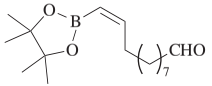
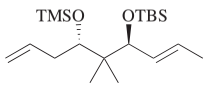
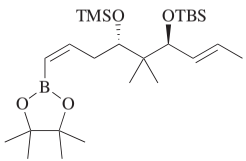
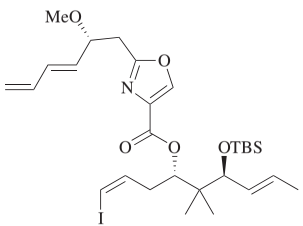
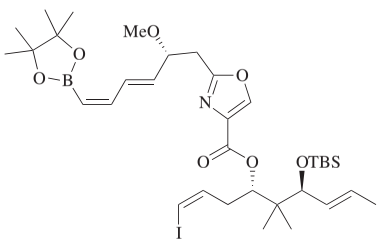
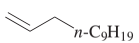
2 eq		Gr I (0.03 eq), DCM, reflux, 18 h		(65) (*E*)/(*Z*) = 84:16	692
5 eq		Mo cat **5** (0.05 eq), benzene, 22°, 24 h		(68) (*Z*)/(*E*) = 90:10	547
5 eq		Mo cat **5** (0.05 eq), benzene, 22°, 24 h		(72) (*Z*)/(*E*) = 93:7	547
2 eq		Gr I (0.025 eq), DCM, 45°, 12 h		(67) (*E*)/(*Z*) > 95:5	124
6 eq		Ru cat **190** (2 x 0.025 eq), DCM, rt, 11 d		(47)	231
2 eq		Gr I (0.03 eq), DCM, reflux, 18 h		(81) (*E*)/(*Z*) = 86:14	692

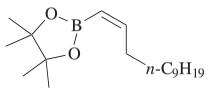
TABLE 11. CROSS-METATHESIS OF VINYL BORONIC COMPOUNDS (*Continued*)
B. VINYL BORONIC ESTERS (*Continued*)

Vinyl Boronic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 **I**		1. Ru cat **152** (0.01 eq), (*Z*)-butene (20 eq), THF, 22°, 1 h 2. Ru cat **152** (0.04 eq), **I** (3 eq), THF, 22°, 1 h, 100 torr		(54) (*Z*)/(*E*) = 95:5	395
5 eq		Mo cat **7** (0.03 eq), benzene, 22°, 20 h, 100 torr		(72) (*Z*)/(*E*) = 98:2	690
7 eq		Mo cat **5** (0.1eq), benzene, 22°, 4 h, 100 torr		(91) (*Z*)/(*E*) = 98:2	690



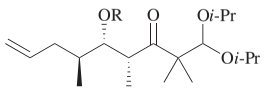
4 eq

Ru cat **216** (0.02 eq),
THF, 35°, 5 h

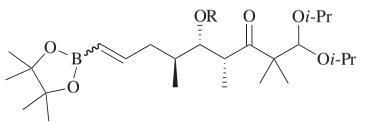


(81) (*Z*)/(*E*) = 92:8 461

3 eq



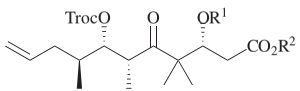
Gr I (0.1 eq),
DCM, reflux, 8 h



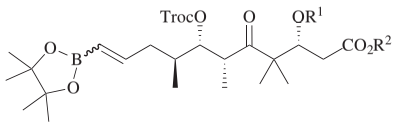
694

R	
H	(88)
Troc	(94)

3 eq



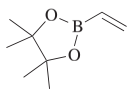
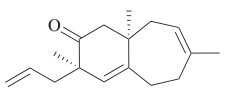
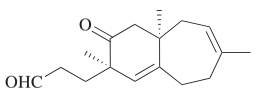
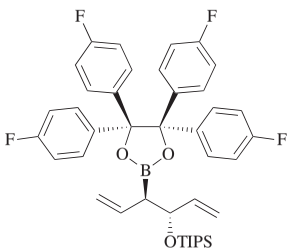
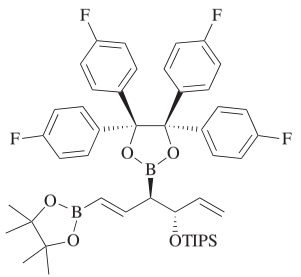
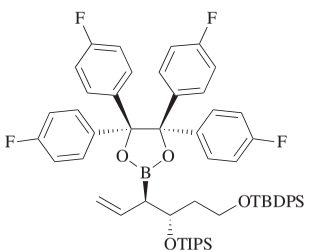
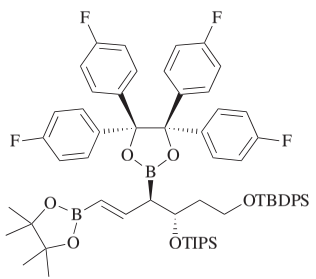
Gr I (0.1 eq),
DCM, reflux, 8 h



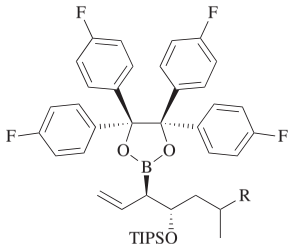
694

R^1	R^2	
H	*t*-Bu	(84)
TES	H	(94)
TES	*t*-Bu	(86)

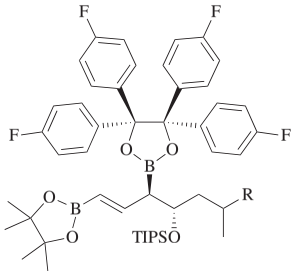
TABLE 11. CROSS-METATHESIS OF VINYL BORONIC COMPOUNDS (*Continued*)
B. VINYL BORONIC ESTERS (*Continued*)

Vinyl Boronic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 1.5 eq		1. Ru cat **271** (0.1 eq) toluene, 60° 2. $NaBO_3$, THF, H_2O	 (56)	695
1.5 eq		Hov II (0.1 eq), F_4BQ (0.1 eq), toluene, 80°, 24 h	 (67) (*E*)/(*Z*) > 95:5	696
1.5 eq		Hov II (0.1 eq), F_4BQ (0.1 eq), toluene, 80°, 24 h	 (69) (*E*)/(*Z*) > 95:5	696

1.5 eq



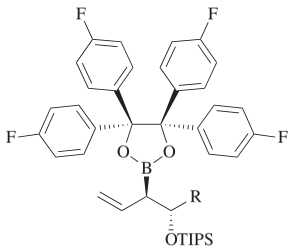
Hov II (0.1 eq),
F_4BQ (*x* eq),
toluene, 80°, 24 h



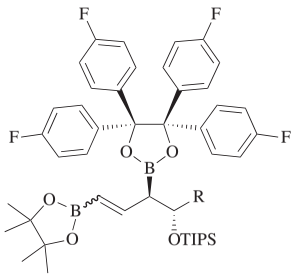
$(E)/(Z) > 95:5$ 696

R	*x*	
H	0.08	(55)
H	—	(67)
Me	0.1	(45)
Me	—	(43)

1.5 eq



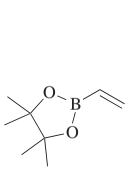
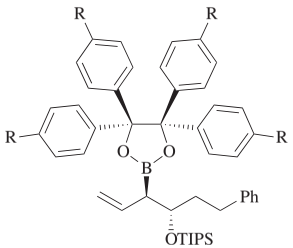
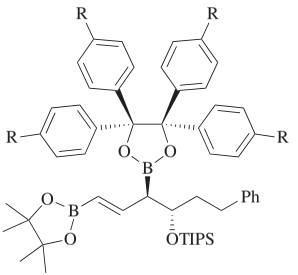
Hov II (0.1 eq),
F_4BQ (*x* eq),
toluene, 80°, 24 h



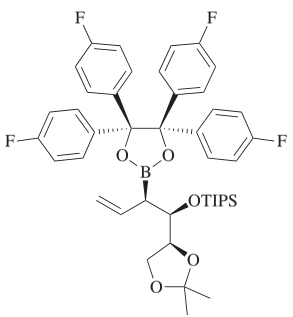
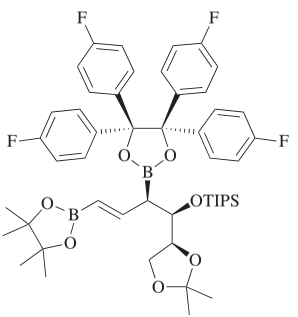
$(E)/(Z) > 95:5$ 696

R	*x*	
Cy	0.1	(46)
Cy	—	(88)
Ph	—	(52)

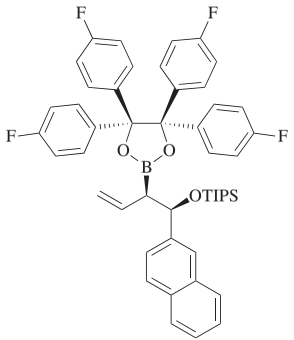
TABLE 11. CROSS-METATHESIS OF VINYL BORONIC COMPOUNDS (*Continued*)
B. VINYL BORONIC ESTERS (*Continued*)

Vinyl Boronic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 1.5 eq		Hov II (*x* eq), F_4BQ (*y* eq), toluene, 80°, 24 h	 (*E*)/(*Z*) > 95:5	696

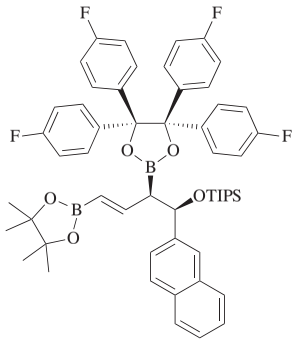
R	*x*	*y*	
H	0.1	0.1	(56)
H	0.1	—	(51)
F	0.1	0.1	(61)
F	0.12	—	(74)

1.5 eq		Hov II (0.1 eq), F_4BQ (0.1 eq), toluene, 80°, 24 h	 (50) (*E*)/(*Z*) > 95:5	696

1.5 eq



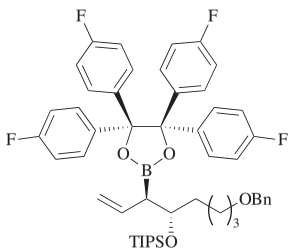
Hov II (0.1 eq),
toluene, 80°, 24 h



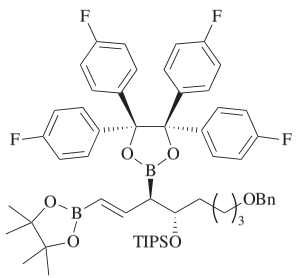
696

(67) $(E)/(Z) > 95:5$

1.5 eq



Hov II (x eq),
F_4BQ (y eq),
toluene, 80°, 24 h

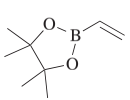
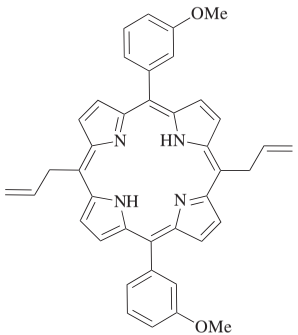
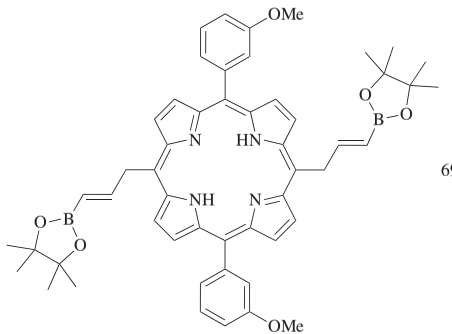
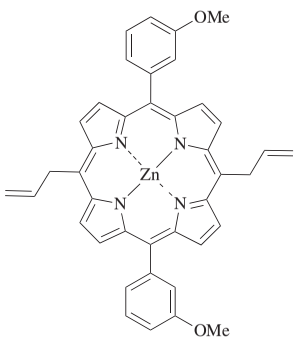
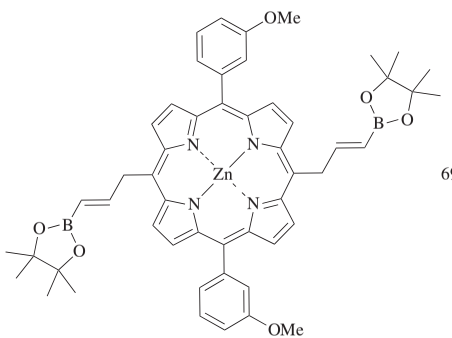


$(E)/(Z) > 95:5$ 696

x	y	
0.1	0.1	(74)
0.15	—	(75)

TABLE 11. CROSS-METATHESIS OF VINYL BORONIC COMPOUNDS (*Continued*)

B. VINYL BORONIC ESTERS (*Continued*)

Vinyl Boronic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 10–20 eq		Gr I or Gr II (0.2 eq), DCM, reflux, 12–24 h	 (50) (*E*) only	697
10–20 eq		Gr I or Gr II (0.2 eq), DCM, reflux, 12–24 h	 (65) (*E*) only	697

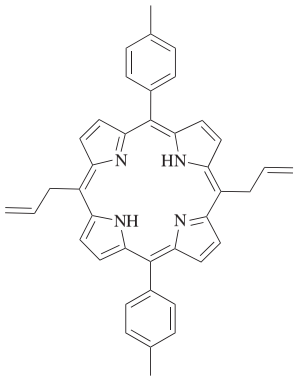
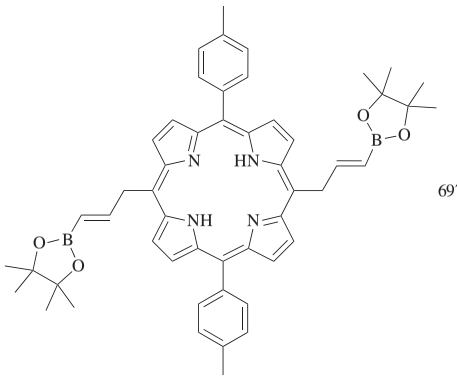
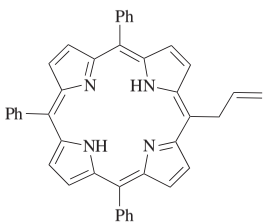
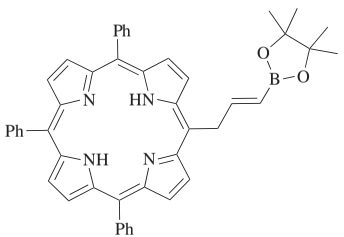
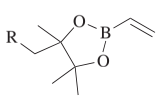
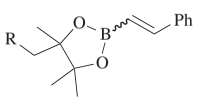
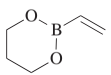
10–20 eq		Gr I or Gr II (0.2 eq), DCM, reflux, 12–24 h	 (52) (*E*) only		697
10–20 eq		Gr I or Gr II (0.2 eq), DCM, reflux, 12–24 h	 (66) (*E*) only		697
 R = $Si(CH_2CH_2C_6F_{13})_3$	 2.13 eq	Ru cat **35** (0.02 eq), $C_6H_5CF_3$, reflux, overnight		(78)	698

TABLE 11. CROSS-METATHESIS OF VINYL BORONIC COMPOUNDS (*Continued*)
B. VINYL BORONIC ESTERS (*Continued*)

Vinyl Boronic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

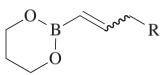
C_2





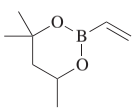
5 eq

Gr I (0.05 eq), DCM, 24 h

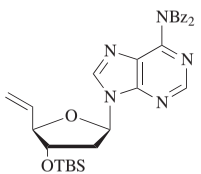


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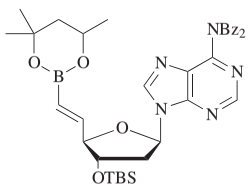
R	Temp (°)		(*E*)/(*Z*)
$(EtO)_3Si$	40	(90)	83:17
$(MeO)_3Si$	40	(60)	88:12
$(MeO)_3Si$	rt	(55)	(*E*) only
TMS	40	(88)	(*E*) only



3 eq

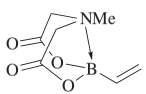


Hov II (0.1 eq), DCM, rt, 41 h



(44) (*E*) only

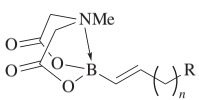
700



x eq



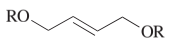
Gr II (0.1 eq), DCM, 40°, 12 h



(*E*)/(*Z*) > 95:5

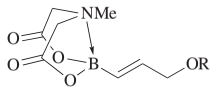
701

R	*n*	*x*	
Cy	0	1.5	(96)
TIPS	1	2.5	(85)
Me	5	2.5	(80)



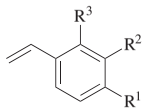
I (*x* eq)

Gr II (0.1 eq),
DCM, 40°, 12 h



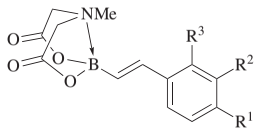
(*E*)/(*Z*) > 95:5 701

R	*x*	(*E*)/(*Z*) **I**	
Ac	2.5	(*E*) only	(84)
Bz	1.5	50:50	(98)



x eq

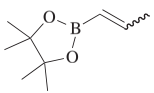
Gr II (0.1 eq),
DCM, 40°, 12 h



(*E*)/(*Z*) > 95:5 701

R^1	R^2	R^3	*x*	
H	H	H	2.5	(93)
H	H	Br	1.5	(81)
H	Br	H	1.5	(91)
Br	H	H	1.5	(89)

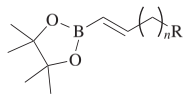
C_3





2 eq

Gr II (0.05 eq),
DCM, reflux



687

R	*n*		(*E*)/(*Z*)
BzO	2	(66)	89:11
Me	5	(83)	90:10
c-C_5H_9	0	(80)	>95:5
Cy	0	(80)	>95:5

TABLE 11. CROSS-METATHESIS OF VINYL BORONIC COMPOUNDS (*Continued*)

B. VINYL BORONIC ESTERS (*Continued*)

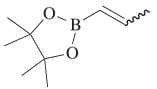
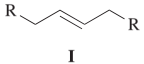
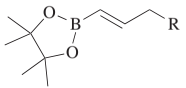
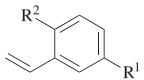
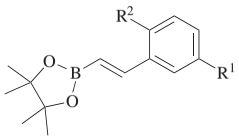
Vinyl Boronic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)		Refs.
Please refer to the charts preceding the tables for the catalyst structures.					
C_3					
 2.5 eq	 **I**	Gr II (0.05 eq), DCM, reflux			687
			R / (*E*)/(*Z*) **I** / (*E*)/(*Z*): BzO — (*E*) only (58) 91:9; PhthN — 6:94 (65) 94:6		
1 eq		Gr II (0.05 eq), DCM, reflux		(*E*)/(*Z*) > 95:5	687
			R^1 / R^2: H H (92); H Br (80); O_2N H (68)		

TABLE 12. CROSS-METATHESIS OF ALLYLIC AMINES (AMINES SUBSTITUTED ON THE α-CARBON)

A. PRIMARY AMINES

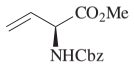
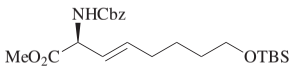
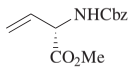
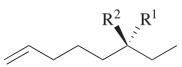
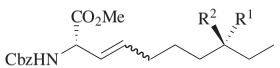
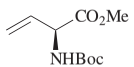
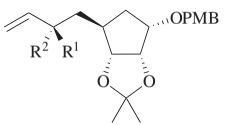
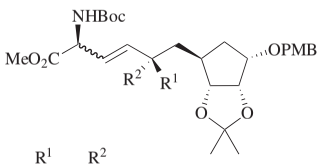
Primary Amine	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 2 eq		Catalyst (*x* eq), DCM, 25°, 5 h	 Catalyst / *x* / (*E*)/(*Z*) Ru cat **158** / 0.02 / (62) / >99:1 Ru cat **157** / 0.005 / (65) / >99:1	590
 2 eq		Gr II (0.086 eq), DCM, 35°, 5 h	 R^1 / R^2 H / HO / (83) HO / H / (77)	702
 5 eq		Gr II (0.06 eq), DCM, rt, 24 h	 R^1 / R^2 H / HO / (75) HO / H / (78)	703

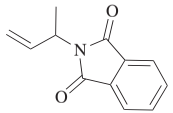
TABLE 12. CROSS-METATHESIS OF ALLYLIC AMINES (AMINES SUBSTITUTED ON THE α-CARBON) (*Continued*)

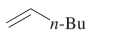
A. PRIMARY AMINES (*Continued*)

Primary Amine	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

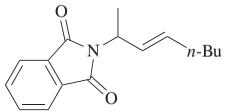
C_4





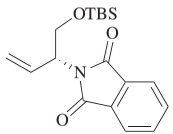
5 eq

Hov II (0.05 eq), DCM, 40°



(78) (*E*)/(*Z*) = 91:9

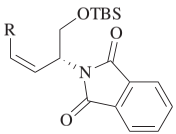
551





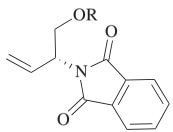
3 eq

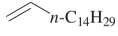
Mo cat **18** (0.03 eq), benzene, 22°, 5 h, 7.0 torr



5

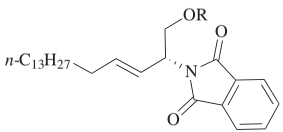
R		(*Z*)/(*E*)
$PhO_2C(CH_2)_2$	(63)	96:4
Cy	(65)	97:3
$PMBO(CH_2)_6$	(97)	93:7
$Br(CH_2)_6$	(93)	94:6





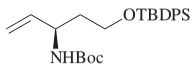
x eq

Catalyst (*y* eq), solvent

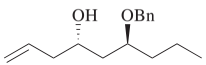


R	*x*	Catalyst	*y*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
H	4	Gr II	0.05	DCM	40	12	(99)	(*E*) only	704
TBS	3	Mo cat **5**	0.03	benzene	22	5	(35)	4:96	5
TBS	3	Mo cat **6**	0.03	benzene	22	5	(21)	3:97	5
TBS	3	Mo cat **18**	0.03	benzene	22	5	(88)	3:97	5
TBS	3	Mo cat **8**	0.03	benzene	22	5	(6)	79:21	5
TBS	3	Mo cat **1**	0.03	benzene	22	5	(68)	88:12	5
TBS	3	Hov II	0.03	benzene	22	5	(64)	89:11	5

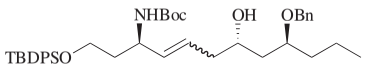
C_5



2 eq



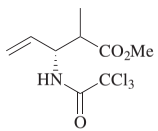
Gr II (0.1 eq),
toluene, 110°, 18 h

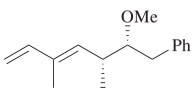


(60)

705

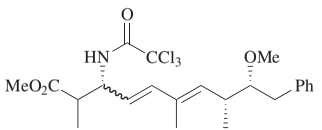
C_6





1.5 eq

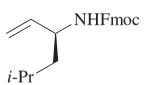
Hov II (0.07 eq),
THF, 110°, 24 h



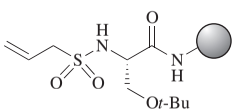
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706

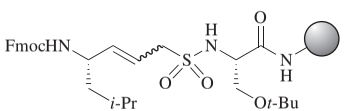
C_7



1.25 eq

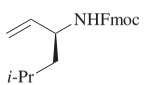


Hov II (0.5 eq),
toluene, 80°, 16 h,
Cy_2BCl

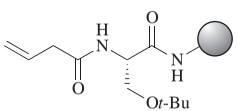


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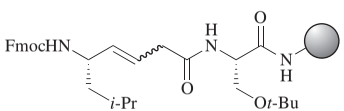
154



1.25 eq



Hov II (0.5 eq),
toluene, 80°, 16 h,
Cy_2BCl



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154

TABLE 12. CROSS-METATHESIS OF ALLYLIC AMINES (AMINES SUBSTITUTED ON THE α-CARBON) (*Continued*)

A. PRIMARY AMINES (*Continued*)

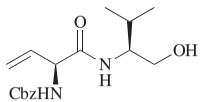
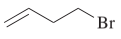
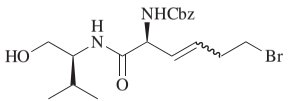
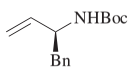
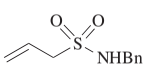
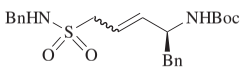
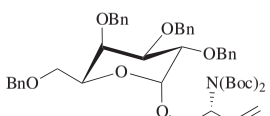
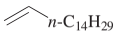
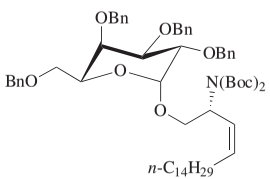
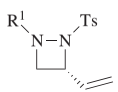
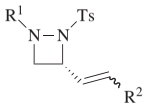
Primary Amine	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9 	 2 x 5 eq	Gr II (0.08 eq), DCM, reflux		(69)	707
C_{10}  2 eq		Gr II, DCM, reflux		(39)	154
  5 eq		Mo cat **18** (0.08 eq), benzene, 22°, 5 h, 1.0 torr	 (85) (*Z*)/(*E*) = 96:4		5

TABLE 12. CROSS-METATHESIS OF ALLYLIC AMINES (AMINES SUBSTITUTED ON THE α-CARBON) (*Continued*)

B. SECONDARY AMINES

Secondary Amine	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
	 *x* eq	Hov II (*y* eq) DCM, reflux		647

R^1	R^2	*x*	*y*	Time (h)	
Cbz	$Br(CH_2)_3$	3	0.05	72	(84)
Cbz	*n*-C_6H_{13}	3 + 3	0.05 + 0.05	48 + 24	(87)
Boc	*n*-C_6H_{13}	3	0.05	72	(95)

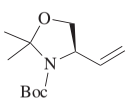
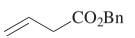
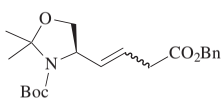
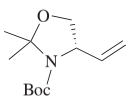
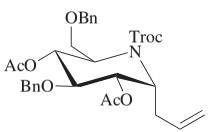
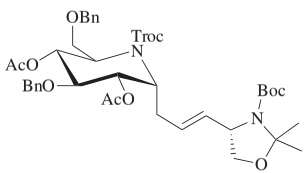
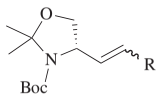
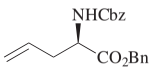
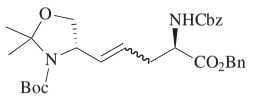
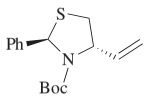
	 1.2 eq	Gr II (0.004 eq), DCM, reflux, 12 h		(58)	708
 5 eq		Gr II (0.2 eq), DCM, reflux, 16–24 h	 (87) (*E*)/(*Z*) > 95:5		666

TABLE 12. CROSS-METATHESIS OF ALLYLIC AMINES (AMINES SUBSTITUTED ON THE α-CARBON) (*Continued*)
B. SECONDARY AMINES (*Continued*)

Secondary Amine	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{4-10}  5 eq		Catalyst (0.05 eq), solvent, reflux		563

R	Catalyst	Solvent	Time (h)	
H	Gr II	DCM	7	(56)
H	Ru cat **13**	DCM	4.5	(28)
H	Ru cat **271**	DCM	36	(33)
H	Gr II	toluene	3	(64)
Me	Gr II	toluene	4	(76)
Me	Hov II	toluene	3	(56)
Me	Ru cat **112**	toluene	4	(9)
MeO_2C	Gr II	toluene	4	(tr)
$HOCH_2$	Gr II	toluene	3	(9)
Ph	Gr II	toluene	3	(10)

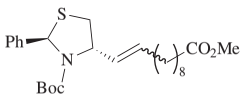
C_4





x eq

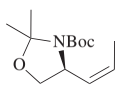
Catalyst (*y* eq),
DCM, reflux



709

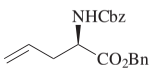
x	Catalyst	*y*	Concn (M)	
10	Gr I	0.2	0.04	(0)
10	Gr II	0.2	0.04	(26)
3	Gr II	0.04	0.04	(23)
3	Hov II	0.05	0.03	(81)
1.5	Hov II	0.05	0.03	(53)
3	Hov II	0.025	0.03	(44)
3	Hov II	0.05	0.04	(73)
2.2	Hov II	0.05	0.2	(82)

C_5

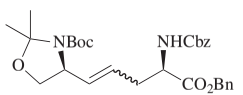


5 eq

(*Z*)/(*E*) = 91:9



Gr II (0.05 eq),
reflux, toluene, 4 h

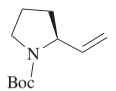
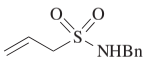
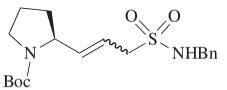
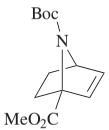
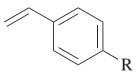
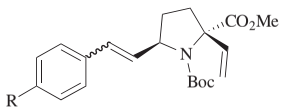


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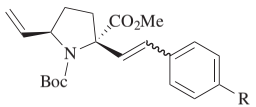
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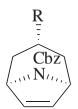
TABLE 12. CROSS-METATHESIS OF ALLYLIC AMINES (AMINES SUBSTITUTED ON THE α-CARBON) (*Continued*)

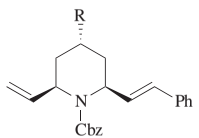
B. SECONDARY AMINES (*Continued*)

Secondary Amine	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6  2 eq		Gr II, DCM, reflux	 (64)	154
C_7 	 4 eq	Gr II (0.08 eq), $CHCl_3$, 55°	 **I**	710

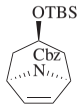
R	I + II	I/II
H	(82)	36:64
F	(81)	67:33
MeO	(79)	22:78
MeO_2C	(71)	48:52

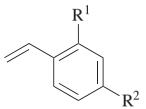
+  **II**

  *x* eq

Catalyst (0.1 eq), benzene, 22°, 24 h  (*E*)/(*Z*) > 98:2 102

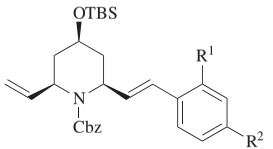
R	*x*	Catalyst		er
H	10	Mo cat **12**	(80)	91.0:9.0
H	20	Ru cat **210**	(70)	5.0:95.0
TBSO	10	Mo cat **12**	(80)	92.5:7.5





10 eq

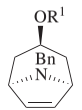
Mo cat **12** (0.1 eq), benzene, 22°, 12 h

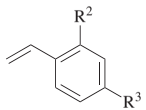


(*E*)/(*Z*) > 98:2

R^1	R^2		er
H	H	(93)	95.0:5.0
H	MeO	(65)	90.0:10.0
Me	H	(92)	93.0:7.0

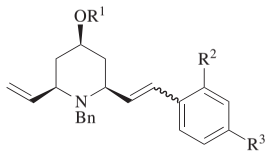
102





x eq

Catalyst (0.05 eq), solvent, 22°

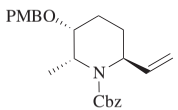
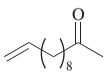
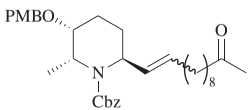
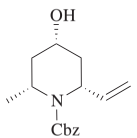
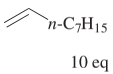
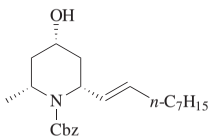
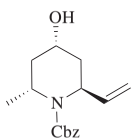
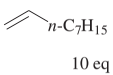
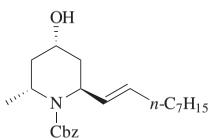
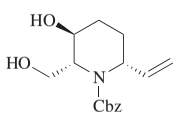
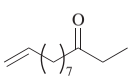
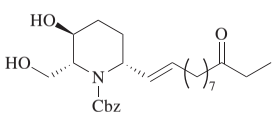


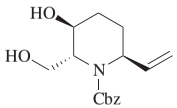
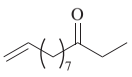
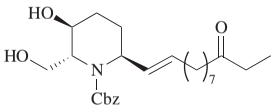
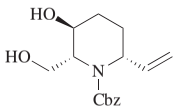
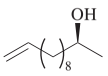
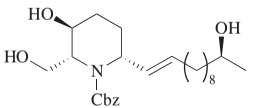
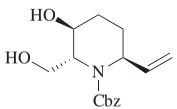
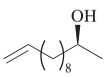
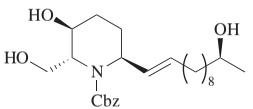
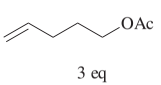
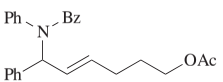
R^1	R^2	R^3	*x*	Catalyst	Solvent	Time (h)	Conv. (%)[a]		er
H	H	H	20	Ru cat **210**	—	24	>98	(82)	>99.0:1.0
H	H	H	20	Ru cat **212**	—	24	80	(65)	97.0:3.0
H	Br	H	20	Ru cat **210**	—	24	63	(55)	98.5:1.5
H	Br	H	20	Ru cat **212**	—	24	27	(—)	—
H	Me	H	20	Ru cat **210**	—	24	>98	(81)	99.0:1.0
H	Me	H	20	Ru cat **212**	—	24	95	(60)	99.0:1.0
H	F	H	20	Ru cat **210**	—	24	87	(70)	>99.0:1.0
H	H	MeO	20	Ru cat **210**	—	24	87	(67)	>99.0:1.0
H	H	MeO	20	Ru cat **212**	—	24	50	(38)	98.0:2.0
H	H	CF_3	5	Ru cat **210**	—	24	>98	(78)	98.5:1.5
TBS	H	H	20	Ru cat **210**	—	24	>98	(80)	>99.0:1.0
TBS	H	H	20	Ru cat **212**	—	24	70	(—)	98.0:2.0
TBS	H	H	20	Ru cat **213**	—	24	<5	(—)	—
TBS	H	H	10	Mo cat **12**	benzene	1	>98	(85)	60.5:39.5

91

TABLE 12. CROSS-METATHESIS OF ALLYLIC AMINES (AMINES SUBSTITUTED ON THE α-CARBON) (*Continued*)

B. SECONDARY AMINES (*Continued*)

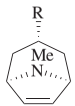
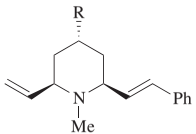
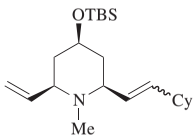
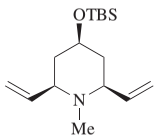
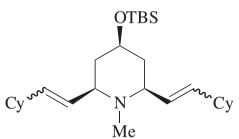
Secondary Amine	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
		Gr II, DCM, reflux		(62)	711
	 10 eq	Gr II (0.1 eq), DCM, reflux, 7 h		(71) (*E*) only	712
	 10 eq	Gr II (0.1 eq), DCM, reflux, 8 h		(46) (*E*) only	712
	 5 eq	Hov II (0.12 eq), DCM, 40°, 25 h		(58) (*E*) only	712

	 5 eq	Hov II (0.09 eq), DCM, 40°, 24 h		(62) (*E*) only	712
	 3 eq	Hov II (0.05 eq), DCM, 40°, 1 h		(30) (*E*) only	712
	 5 eq	Hov II (0.07 eq), DCM, 40°, 1 h		(57) (*E*) only	712
C_9					
	 3 eq	Catalyst (0.05 eq), DCM, reflux, 6 h	 (*E*)/(*Z*) > 95:5	Catalyst Hov II (19) Ru cat **271** (30)	177

[a] The conversion was determined by ^{1}H NMR analysis.

TABLE 12. CROSS-METATHESIS OF ALLYLIC AMINES (AMINES SUBSTITUTED ON THE α-CARBON) (*Continued*)

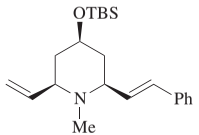
C. TERTIARY AMINES

Tertiary Amine	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_7				
	 *x* eq	Mo cat **12** (0.05 eq), benzene, 22°, 1 h	 (*E*)/(*Z*) > 98:2	102
			R *x* er H 2 (64) 90.0:10.0 TBSO 10 (90) 92.5:7.5	
	 10 eq	Mo cat **12** (0.05 eq), benzene, 22°, 12 h	 (43) er 84.0:16.0 +  (25)	102
			+  (25)	



x eq

Catalyst (0.05 eq),
solvent, 22°

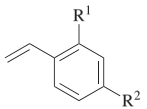
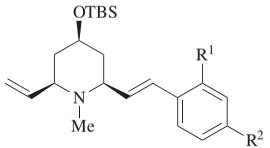


(*E*)/(*Z*) > 98:2

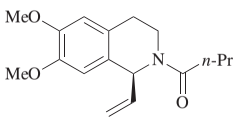
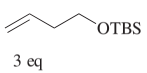
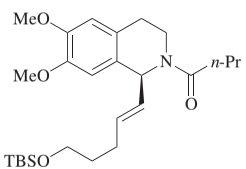
x	Catalyst	Solvent	Time (h)	Conv (%)[a]		er	
20	Ru cat **210**	—	36	30	(—)	66.5:33.5	91
20	Ru cat **212**	—	36	<5	(—)	—	91
20	Ru cat **213**	—	36	<4	(—)	—	91
10	Mo cat **12**	benzene	1	>98	(95)	97.0:3.0	91
2	Ru cat **210**	benzene	12	<2	(—)	—	102
2	Ru cat **212**	benzene	12	<2	(—)	—	102
2	Ru cat **213**	benzene	12	<2	(—)	—	102
2	Mo cat **8**	benzene	12	<2	(—)	—	102
2	Mo cat **9**	benzene	12	>98	(—)	<51.0:49.0	102
2	Mo cat **10**	benzene	12	<2	(—)	—	102
2	Mo cat **12**	benzene	12	>98	(—)	97.0:3.0	102

TABLE 12. CROSS-METATHESIS OF ALLYLIC AMINES (AMINES SUBSTITUTED ON THE α-CARBON) (*Continued*)

C. TERTIARY AMINES (*Continued*)

Tertiary Amine	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_7 	 10 eq	Mo cat **12** (0.05 eq), benzene, 22°, 12 h	 $(E)/(Z) > 98:2$	102

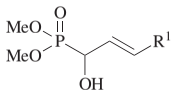
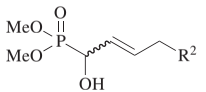
R^1	R^2		er
H	H	(95)	97.0:3.0
H	MeO	(92)	94.5:5.5
H	CF_3	(88)	82.0:18.0
Br	H	(86)	94.0:6.0
Me	H	(91)	99.0:1.0

C_{11} 	 3 eq	Hov II (0.2 eq), BQ, toluene, reflux, 24 h		(52)	$(E)/(Z) = 91:9$	713

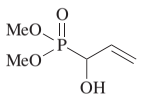
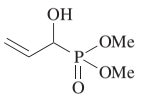
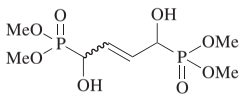
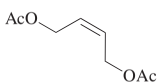
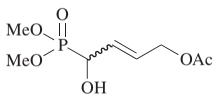
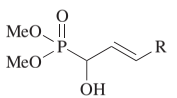
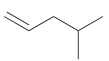
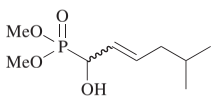
[a] The conversion was determined by ^{1}H NMR analysis.

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES

A. ALLYLIC ALCOHOLS

Allylic Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{3-9} 	 5 eq	Gr II (0.05 eq), solvent, 40°		221

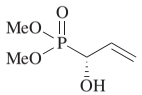
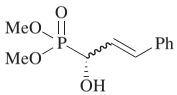
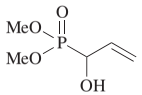
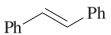
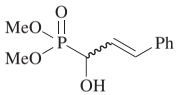
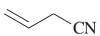
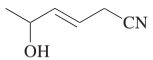
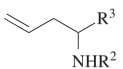
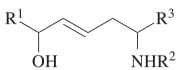
R^1	R^2	Solvent	Time (h)	
H	AcO	$CHCl_3$	—	(<30)
H	TMS	$CHCl_3$	—	(82)
Me	AcO	DCM	12	(46)
Ph	AcO	DCM	96	(0)

C_3 		Gr II (0.05 eq), DCM, 40°	 (76)	221
	 5 eq	Gr II (0.05 eq), $CHCl_3$, 40°	 (61)	221
C_{3-4} 	 *x* eq	Gr II (*y* eq), solvent, 40°		221

R	*x*	*y*	Solvent	Time (h)	
H	5	0.05	$CHCl_3$	—	(57)
Me	3.75	0.0375	DCM	12	(48)

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

A. ALLYLIC ALCOHOLS (*Continued*)

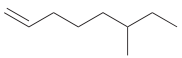
Allylic Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 er 85.0:15.0	 5 eq	Gr II (0.05 eq), $CHCl_3$, 40°	 (51) er 85.0:15.0	221
	 5 eq	Gr II (0.05 eq), $CHCl_3$, 40°	 (31)	221
C_4				
	 2 eq	Gr II (0.05 eq), DCM, reflux, 2 h	 (21) (*E*)/(*Z*) = 83:17	182
C_{4-9}				
 2 eq		Gr II (*x* eq), DCM, 45°		714

R^1	R^2	R^3	*x*		(*E*)/(*Z*)
Me	Troc	MeO_2C	0.03	(80)	83:17
Me	Cbz	MeO_2C	0.03	(74)	83:17
Me	Fmoc	MeO_2C	0.03	(72)	83:17
Me	Tos	MeO_2C	0.03	(75)	50:50
Me	*p*-Nos	MeO_2C	0.03	(78)	29:71
Me	Boc	MeO_2C	0.015	(85)	55:45
Me	Troc	$AcOCH_2$	0.04	(90)	(*E*) only
Ph	Troc	MeO_2C	0.04	(88)	(*E*) only

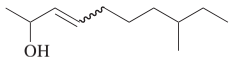
C_4



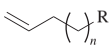
3.2 eq



Gr II (0.0063 eq), DCM, 0.5 h, 45°

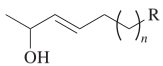


(67) 443



x eq

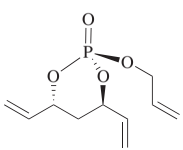
Gr II (*y* eq), solvent



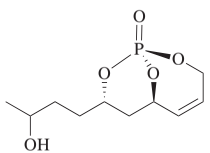
R	*n*	*x*	*y*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
AcO	3	2	0.03	DCM	40	12	(92)	93:7	36
AcO	3	1	0.03	DCM	40	12	(50)	93:7	36
AcO	3	1	0.03	DCM	23	12	(62)	93:7	36
MeO_2C	22	3	0.08	DCE	60	5	(65)	>95:5	715



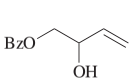
I



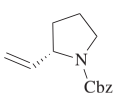
1. Hov II (0.06 eq), BQ, DCM, reflux, 0.75 h
2. Hov II (0.04 eq), **I** (2–4 eq), CuI, DCE, reflux, 4–6 h
3. *o*-NBSH (15 eq), Et_3N, rt, overnight



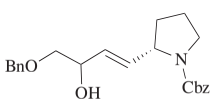
(48) 716



2 eq



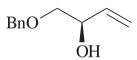
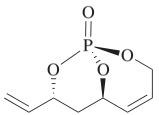
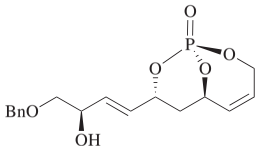
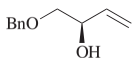
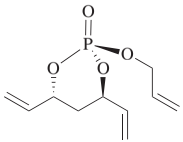
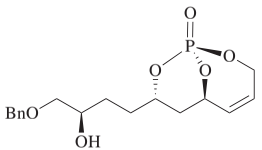
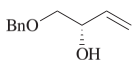
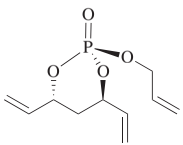
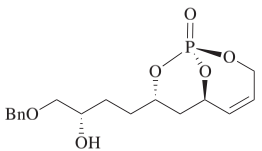
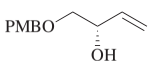
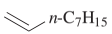
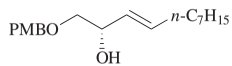
Hov II (0.05 eq), DCM, reflux, 60 h

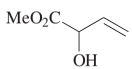


(60) (*E*)/(*Z*) = 50:50 717

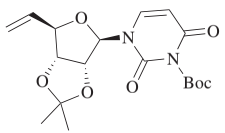
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

A. ALLYLIC ALCOHOLS (*Continued*)

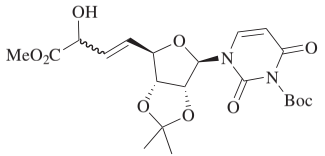
Allylic Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 4–5 eq		Hov II (0.09 eq), DCM, 40°, 3 h	 (72) (*E*)/(*Z*) > 99:1	719
 **I**		1. Hov II (0.06 eq), BQ, DCM, reflux, 0.75 h, 2. Hov II (0.04 eq), **I** (2–4 eq), CuI, DCE, reflux, 4–6 h 3. *o*-NBSH (15 eq), Et_3N, rt, overnight	 (41)	716
 **I**		1. Hov II (0.06 eq), BQ, DCM, reflux, 0.75 h, 2. Hov II (0.04 eq), **I** (2–4 eq), CuI, DCE, reflux, 4–6 h 3. *o*-NBSH (15 eq), Et_3N, rt, overnight	 (35)	716
	 5 eq	Gr II (0.1 eq), DCM, reflux, 24 h	 (81) (*E*)/(*Z*) = 95:5	718



3 eq

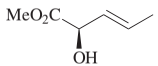


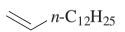
Gr II (0.14 eq),
DCM, reflux, 24 h



(85) 721

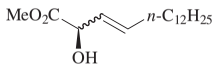
C_5



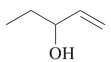


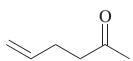
2 eq

Gr II (0.05 eq),
AcOH (0.5 eq),
DCM, reflux, 60 h



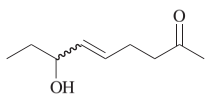
(73) 722



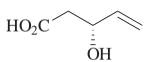


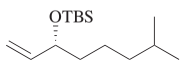
1 eq

Hov II (0.006 eq),
DCM, reflux



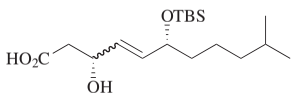
(48) 723



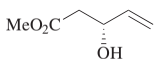


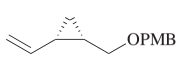
1.2 eq

Gr II (0.05 eq),
DCM, reflux, 1 h



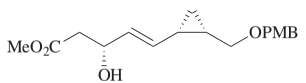
(72) 724





2 eq

Gr II (0.05 eq),
DCM, 40°, 17.5 h

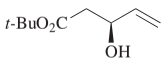
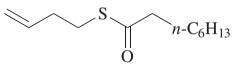
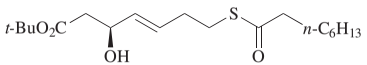
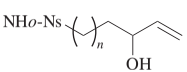
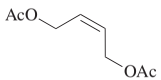
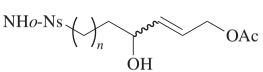
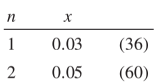
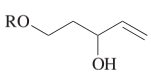
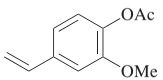
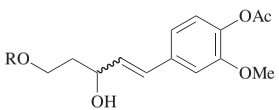
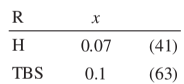
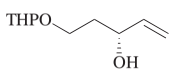
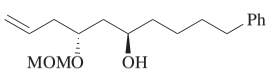
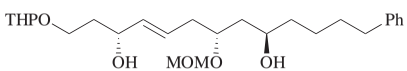


(70) (*E*)/(*Z*) = 91:9

725

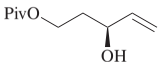
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

A. ALLYLIC ALCOHOLS (*Continued*)

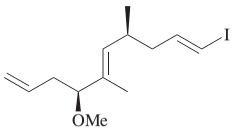
Allylic Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5 	 2 eq	Gr II (0.03 eq), DCM, 40°, 12 h	 (67) (*E*) only	726
C_{5-6} 		Gr II (*x* eq), DCM, reflux	 	727
C_5  9.8 eq		Hov II (*x* eq), DCM, rt, 16 h	 	728
  2 eq		Gr II (0.10 eq), DCM, 0°, 1 h	 (68) (*E*)/(*Z*) = 95:5	720

n	*x*	
1	0.03	(36)
2	0.05	(60)

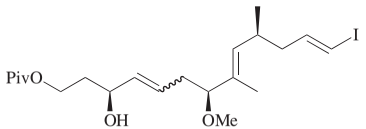
R	*x*	
H	0.07	(41)
TBS	0.1	(63)



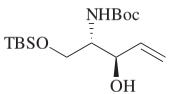
2 eq

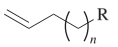


Gr II (0.1 eq), toluene, 80°, 24 h



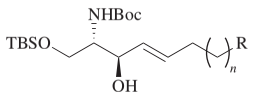
(44) 729





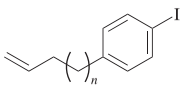
4 eq

Gr II (0.03 eq), DCM, reflux, 2 h



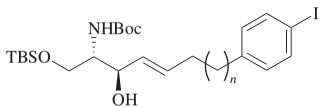
730

R	*n*	
HO	8	(76)
Me	5	(55)



2 eq

Gr II (0.03 eq), DCM, reflux, 2 h

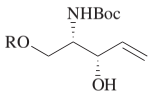
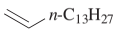
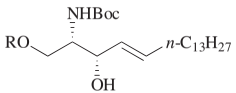
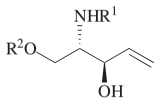
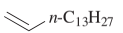
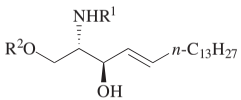


(*E*) only 731

n	
5	(51)
7	(47)
8	(54)
9	(52)
10	(51)
12	(57)

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

A. ALLYLIC ALCOHOLS (*Continued*)

Allylic Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
	 *x* eq	Hov II (0.1 eq), DCM, 21°, 16 h		732
	 4 eq	Gr II (*x* eq), DCM, reflux, 2 h		730

R	*x*		(*E*)/(*Z*)
TIPS	3	(80)	(*E*) only
Bn	2	(84)	—

R^1	R^2	*x*		(*E*)/(*Z*)
Boc	TBS	0.03	(72)	—
Boc	TBS	0.01	(75)	94:6
Boc	H	0.03	(58)	—
n-$C_{15}H_{31}CO$	H	0.03	(56)	—
Boc	$(MeO)_2PO$	0.03	(76)	—
Boc	$(Br(CH_2)_2O)(MeO)PO$	0.03	(70)	—
n-$C_{15}H_{31}CO$	$(Br(CH_2)_2O)(MeO)PO$	0.03	(55)	—

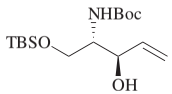
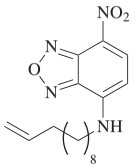
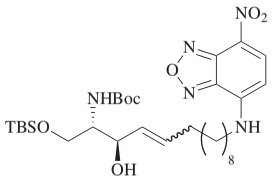
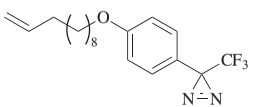
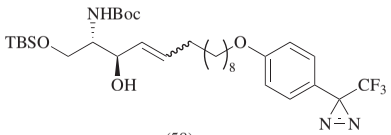
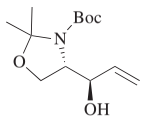
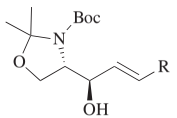
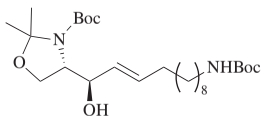
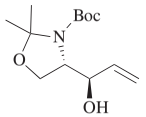
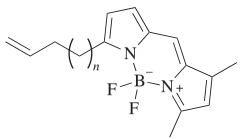
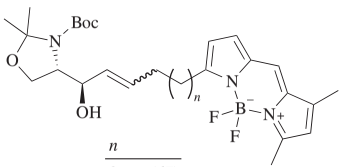
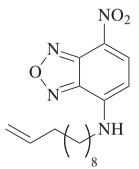
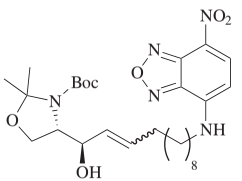
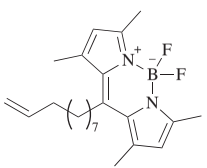
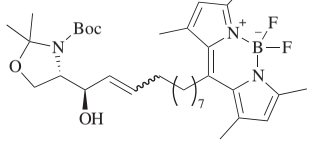
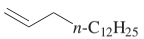
	 4 eq	Gr II (0.03 eq), DCM, reflux, 2 h		(57)	730
	 4 eq	Gr II (0.03 eq), DCM, rt, 0.5 h	 (58)		730
	 4 eq	Gr II (0.03 eq), DCM, reflux, 5 h	 (*E*) only	R Ph (65) *n*-C_9H_{19} (69)	733
	 4 eq	Gr II (0.10 eq), DCM, reflux, 4 h		(86) (*E*) only	734

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

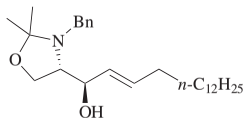
A. ALLYLIC ALCOHOLS (*Continued*)

Allylic Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
	 2 eq	Gr II (0.1 eq), DCM, reflux, 5 h	 *n* 3 (67) 8 (57)	735
	 2 eq	Gr II (0.1 eq), DCM, reflux, 5 h	 (66)	735
	 2 eq	Gr II (0.1 eq), DCM, reflux, 5 h	 (79)	735



2 eq

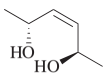
Catalyst (*x* eq),
additive, solvent



736

Catalyst	*x*	Additive	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)
Gr I	0.05	—	DCM	40	43	(0)	—
Gr II	0.05	—	DCM	rt	72	(35)	93:7
Gr II	0.05	—	DCM	40	24	(49)	83:17
Gr II	0.1	—	toluene	50	1.5	(7)	92:8
Gr I	0.05	Ti(O*i*-Pr)$_4$	DCM	40	40	(7)	—
Gr II	0.1	Ti(O*i*-Pr)$_4$	DCM	40	22	(30)	—
Gr II	0.1	Ti(O*i*-Pr)$_4$	DCM	40	0.75	(52)	94:6
Ru cat **67**	0.1	—	DCM	rt	48	(53)	93:7
Ru cat **67**	0.1	—	DCM	40	1.5	(59)	94:6

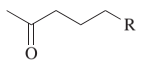
C_6



3 eq



Hov II (0.005 eq),
DCM, 200°, 7 h

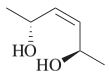
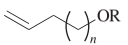
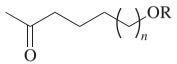
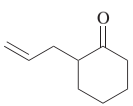
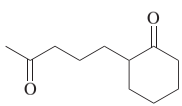
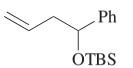
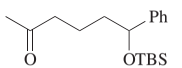
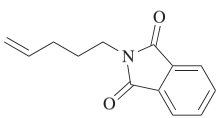
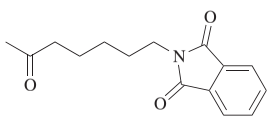
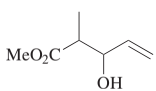
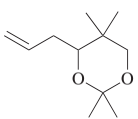
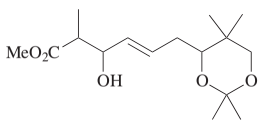


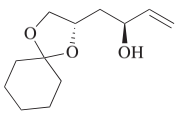
R		
BnO	(52)	
Ph	(63)	

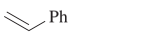
737

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

A. ALLYLIC ALCOHOLS (*Continued*)

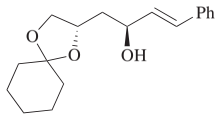
Allylic Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6				
 3 eq		Hov II (0.005 eq), DCM	 R = Ac, n = 3, Temp (°) = 200, Time (h) = 7, (71); R = Bn, n = 4, Temp (°) = rt, 200, Time (h) = 1 + 7, (57)	737
3 eq		1. Hov II (0.005 eq), DCM, rt, 2 h 2. 200°, 7 h	 (51)	737
3 eq		1. Hov II (0.005 eq), DCM, rt, 2 h 2. 200°, 7 h	 (69)	737
3 eq		1. Hov II (0.005 eq), DCM, rt, 1 h 2. 200°, 7 h	 (69)	737
 2 eq		Gr II (0.025 eq), DCM, reflux, 14 h	 (80)	738



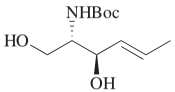


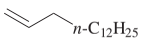
1.5 eq

Gr II (0.05 eq), benzene, reflux, 6 h



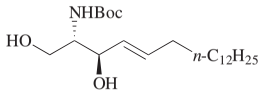
(84) (*E*)/(*Z*) = 95:5 739





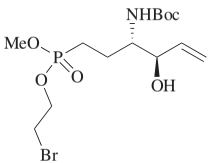
x eq

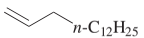
Gr II (0.08 eq), benzene, 55°



x		
1	(62)	740
2	(30)	

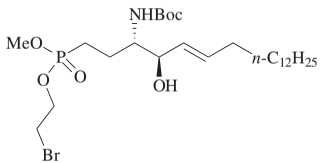
(*E*) only





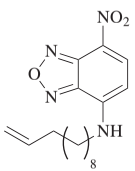
4 eq

Gr II (0.03 eq), DCM, reflux, 2 h



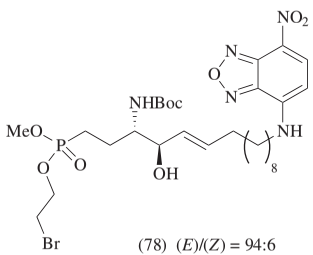
741

(60) (*E*)/(*Z*) = 95:5



4 eq

Gr II (0.03 eq), DCM, reflux, 2 h

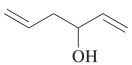
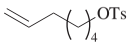
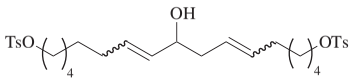
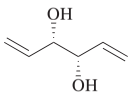
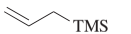
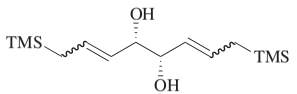
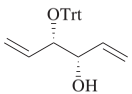
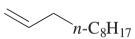
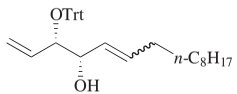
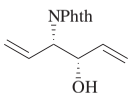
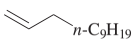
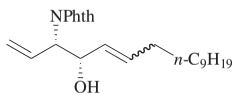


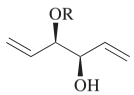
741

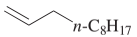
(78) (*E*)/(*Z*) = 94:6

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

A. ALLYLIC ALCOHOLS (*Continued*)

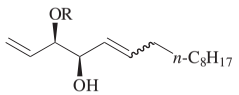
Allylic Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6				
	 10 eq	Gr II (0.075 eq), DCM, 20°, 5 h	 (99)	403
	 3 eq	Gr II (0.05 eq), DCM, 40°, 12 h	 (82)	209
	 8 eq	Ru cat **139** (0.01 eq), DCM, 20°, 6 h	 (92)	742
	 2.5 eq	Gr II (0.05 eq), DCM, reflux, 1 h	 (76)	743





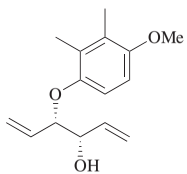
x eq

Catalyst (*y* eq), solvent



742

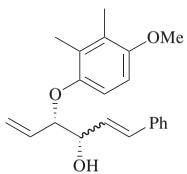
R	*x*	Catalyst	*y*	Solvent	Temp (°)	
TBS	5	Gr II	0.02	toluene	80	(51)
TBS	5	Gr II	0.02	DCM	40	(53)
TBS	5	Gr II	0.02	DCM	40	(58)
TBS	5	Gr II	0.02	DCM	20	(66)
TBS	2 + 3	Gr II	0.02	DCM	20	(73)
Tr	5	Gr II	0.02	toluene	80	(53)
Tr	5	Gr II	0.02	DCM	40	(58)
Tr	5 + 5	Ind II	0.02	DCM	40	(83)
Tr	5	Ru cat **139**	0.01	DCM	20	(74)
Tr	8	Ru cat **139**	0.01	DCM	20	(92)





10 eq

Gr II (0.1 eq),
DCM, reflux, 2.5 h

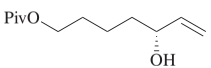
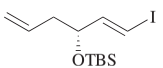
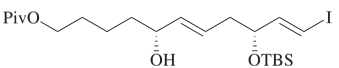
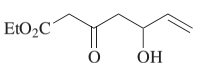
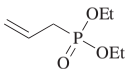
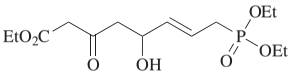
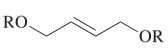
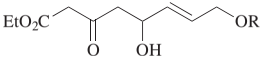
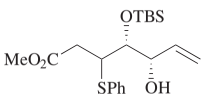
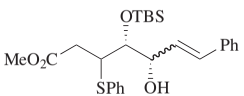
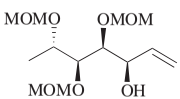
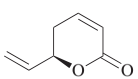
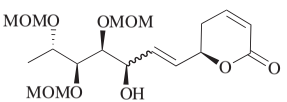


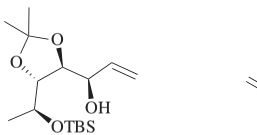
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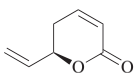
743

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

A. ALLYLIC ALCOHOLS (*Continued*)

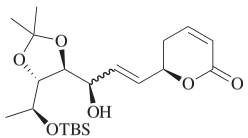
Allylic Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_7				
 3 eq		Gr II (0.03 eq), DCM, reflux, 3 h	 (70) (*E*)/(*Z*) = 91:9	744
	 5 eq	Gr II (0.05 eq), DCM, 40°, 16 h	 (88) (*E*) only	745
	 2 eq	Gr II (0.05 eq), DCM, 40°	 (*E*) only	745
			R / Time (h) / Ac 20 (70) / Bn 18 (90)	
	 5 eq	Gr II (0.05 eq), DCM, reflux, 16 h	 (90)	743
		Gr II, DCM, reflux, 0.5 h	 (86)	746





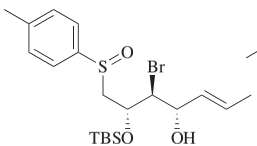
2 eq

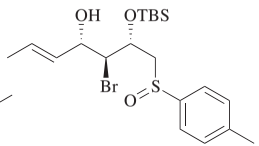
Gr II (0.1 eq),
DCM, reflux, 5 h



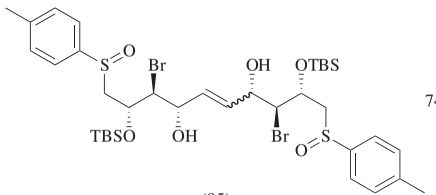
(86)

747



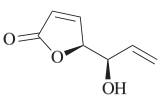


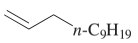
Gr II (0.03 eq),
DCM, reflux, 4 d



(95)

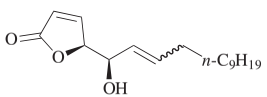
748





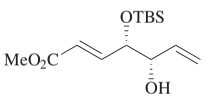
10 eq

Gr II (0.025 eq),
DCM, reflux, 12 h



(95)

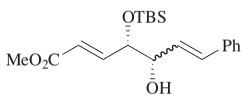
749





5 eq

Gr II (0.1 eq),
DCM, reflux, 16 h

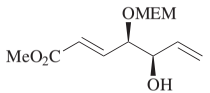
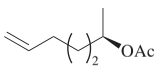
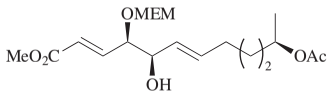
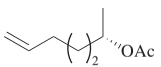
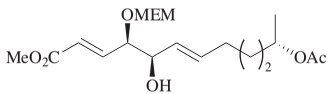
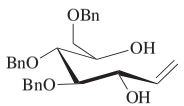
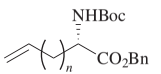
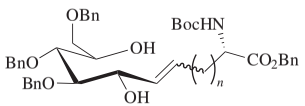
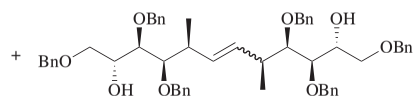


(59)

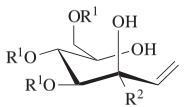
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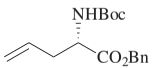
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

A. ALLYLIC ALCOHOLS (*Continued*)

Allylic Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_7				
	 1.5 eq	Gr II (0.05 eq), DCM, reflux, 16 h, *p*-cresol (0.5 eq)	 (60) (*E*) only	750
	 1.5 eq	Gr II (0.05 eq), DCM, reflux, 16 h, *p*-cresol (0.5 eq)	 (60) (*E*) only	750
 *x* eq		Gr II (*y* eq), DCM, reflux	 **I** +  **II**	426

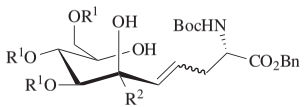
x	*n*	*y*	Time (h)	**I**	**II**
0.5	0	0.075	20	(68)	(—)
0.5	1	0.15	15	(48)	(—)
2	1	0.15	15	(54)	(39)
4	1	0.15	15	(70)	(64)
2	1	0.1	15	(54)	(39)





2 eq

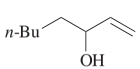
Gr II (*x* eq),
DCM, reflux, 16 h

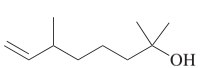


426

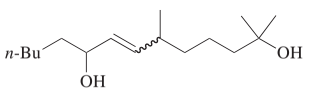
R^1	R^2	*x*	
TBS	H	0.1	(51)
Bn	AcHN	0.2	(16)

C_8

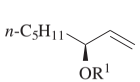




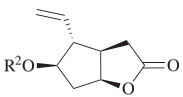
Ru cat **170** (0.01 eq),
DCM, 50°, 24 h



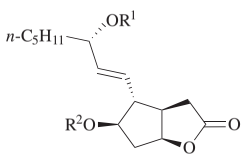
(43) 751



2 eq



Catalyst (0.06 eq),
DCM, 40°, 12 h

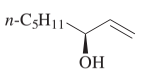
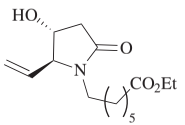
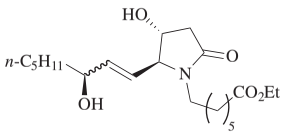
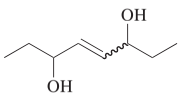
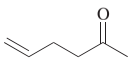
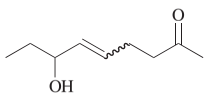
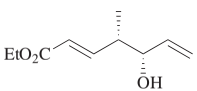
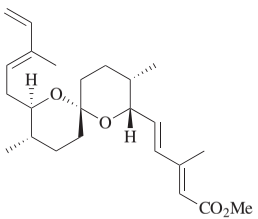
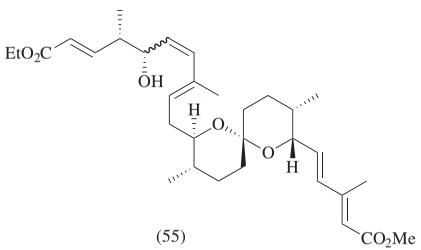


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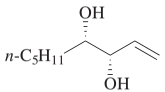
R^1	R^2	Catalyst		(*E*)/(*Z*)
H	TBS	Gr II	(60)	92:8
TBS	H	Gr II	(70)	93:7
TBS	Bz	Gr II	(40)	88:12
TBS	Bz	Hov II	(25)	88:12
TBS	TBS	Gr II	(76)	86:14
TBS	TBS	Gr II	(84)	94:6

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

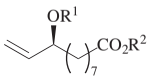
A. ALLYLIC ALCOHOLS (*Continued*)

Allylic Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
 5 eq		Gr II (0.2 eq), DCM, 40°, 24 h	 (53)	255
	 0.5 eq	Hov II (0.001 eq), DCM, reflux	 (72)	723
 1.5 eq		Gr II (2 x 0.2 eq), DCM, 18 h	 (55)	753

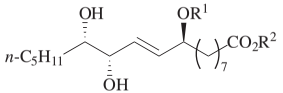
C_9



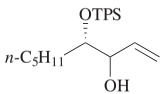
x eq



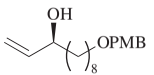
Gr II (*y* eq), DCM



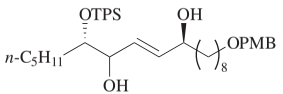
x	R^1	R^2	*y*	Temp (°)	Time (h)		(*E*)/(*Z*)	
1.7	H	H	—	25	18	(78)	(*E*) only	754
3	H	Me	0.05	40	5	(35)	—	755
3	TBS	Me	0.05	40	5	(24)	—	755



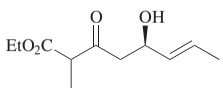
1.7 eq



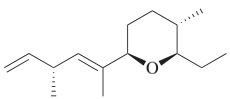
Gr II, DCM, 25°, 18 h



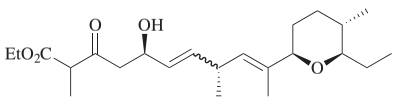
(78) (*E*) only 754



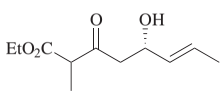
2.5 eq



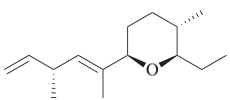
Ru cat **88**
(0.08 + 0.05 eq),
$C_6F_5CF_3$, 62°, 4 h



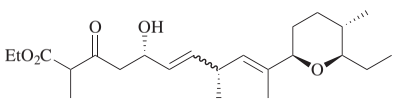
(86) 529



4.67 eq



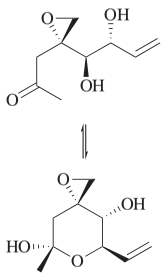
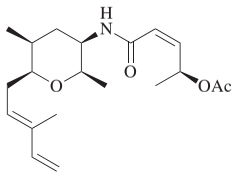
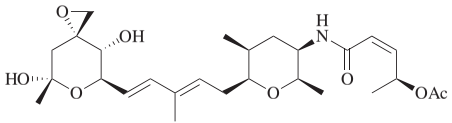
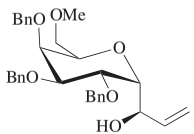
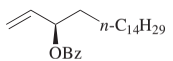
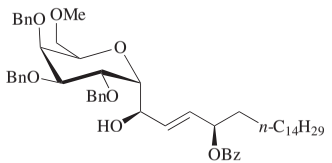
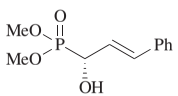
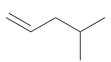
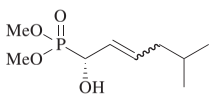
Ru cat **88**
(0.06 + 0.09 eq),
$C_6F_5CF_3$, 70°, 4 h



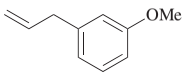
(75) 529

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

A. ALLYLIC ALCOHOLS (*Continued*)

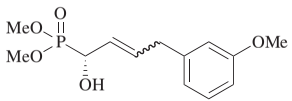
Allylic Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
	 1.8 eq	Ru cat **88** (0.1 eq), DCE, 23°, 10 h	 (40) (*E*) only	756
	 3.2 eq	Gr II (0.15 eq), DCM, reflux, 2 h	 (70) (*E*)/(*Z*) = 95:5	757
 er 97.5:2.5	 5 eq	Gr II (0.05 eq), DCM, 40°, 36 h	 (74) er 97.5:2.5	221

er 97.5:2.5



1.7 eq

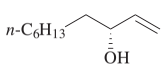
Gr II (0.025 eq), DCM, 40°, 12 h



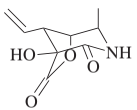
50% conv., er 96.5:3.5

221

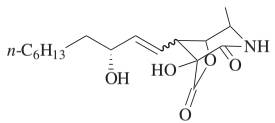
C_{10}



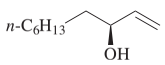
x eq



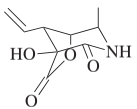
Gr II (*y* eq), DCM, 6 h



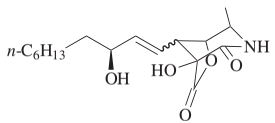
x	*y*	Temp (°)		
2	0.1	rt	(64)	758
5	0.2	35	(58)	759



5 eq



Gr II (0.2 eq), DCM, 35°, 6 h



(59) 759

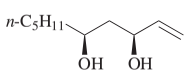
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

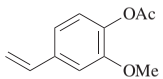
A. ALLYLIC ALCOHOLS (*Continued*)

Allylic Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

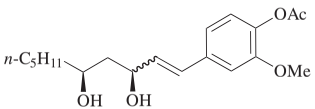
C_{10}



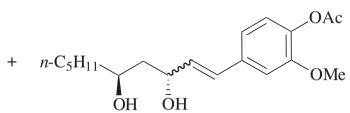


x eq

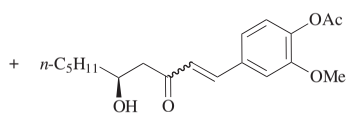
Hov II (*y* eq),
PhOH (*z* eq),
solvent, rt, 16 h



I



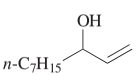
II

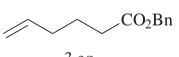


III

728

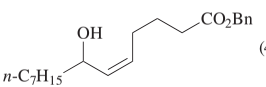
x	*y*	*z*	Solvent	**I** + **II**	**I**/**II**	**III**
4.1	0.11	—	toluene	(24)	**I** only	(tr)
5.2	0.11	0.15	DCM	(55)	80:20	(9)
5.6	0.12	0.7	toluene	(63)	**I** only	(9)
9.8	0.1	—	DCM	(21)	80:20	(7)



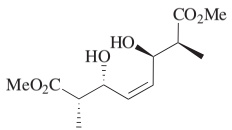


3 eq

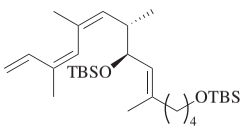
1. Ru cat **152** (0.01 eq),
(*Z*)-butene (20 eq),
THF, 22°, 1 h
2. Ru cat **152** (0.04 eq),
THF, 100 torr, 22°, 8 h



(47) (*Z*)/(*E*) = 90:10 395

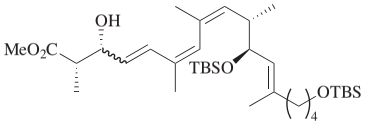


x eq



y eq

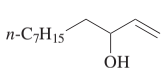
Catalyst (*z* eq), solvent



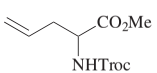
760

x	*y*	Catalyst	*z*	Solvent	Temp (°)	Time (h)	
1	1	Hov II	0.05	toluene	50	24	(10)
1	3	Hov II	0.05	toluene	50	24	(18)
1	3	Gr II	0.05	toluene	50	24	(tr)
1	3	Hov II	0.1	toluene	50	24	(19)
1	3	Ru cat **67**	0.05	toluene	50	24	(—)
1	3	Ru cat **271**	0.05	toluene	21	24	(—)
1	3	Ru cat **271**	0.05	toluene	50	24	(—)
1	3	Hov II	0.15	toluene	50	72	(26)
3 x 0.2	1	Hov II	3 x 0.025	C_6D_6	50	36	(78)

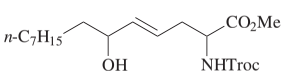
C_{11}



2 eq



Gr II (0.04 eq),
DCM, 45°

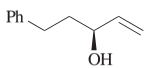
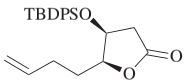
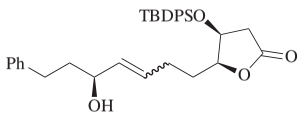
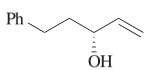
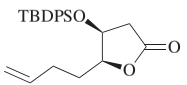
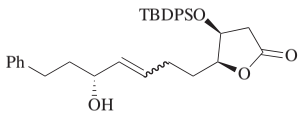
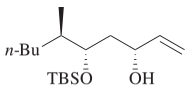
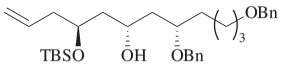
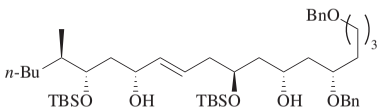
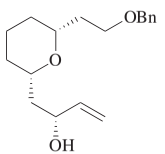
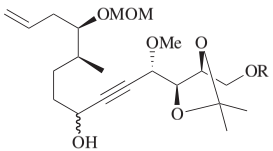
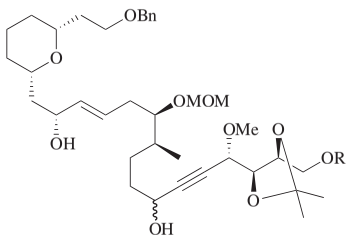


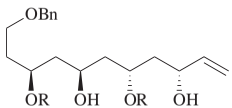
714

(78) (*E*)/(*Z*) = 83:17

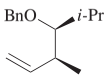
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

A. ALLYLIC ALCOHOLS (*Continued*)

Allylic Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{11}				
		Gr II (0.1 eq), $CHCl_3$, 40°, 2 h	 (63)	761
		Gr II (0.1 eq), $CHCl_3$, 40°, 2 h	 (66)	761
		Gr II, DCM, reflux, 6 h	 (72) $(E)/(Z)$ = 80:20	762
	 R = TBDPS	Gr II (0.1 eq), DCM, rt	 (65) (*E*) only	763

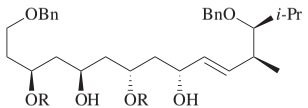


R = TBDPS



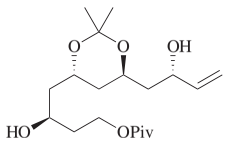
2 eq

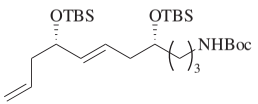
Hov II (0.05 eq), DCM, reflux, 6 h



(52) (*E*)/(*Z*) = 90:10

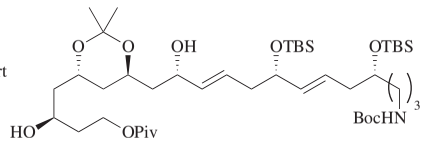
764





2 eq

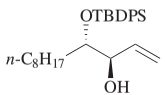
Hov II (0.05 eq), DCM, rt



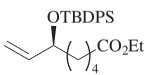
(68) (*E*) only

765

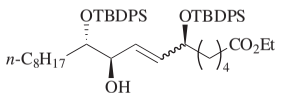
C_{12}



1.5 eq

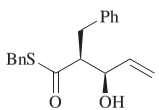


Gr II (0.05 eq), DCM, rt, 22 h

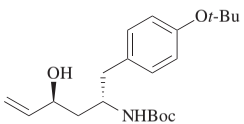


(63)

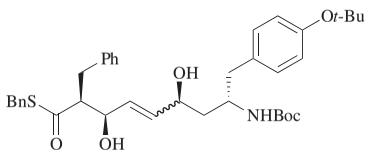
766



5 eq



Gr II, DCM, 40°

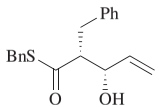
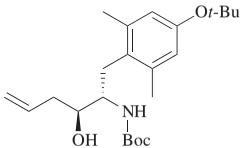
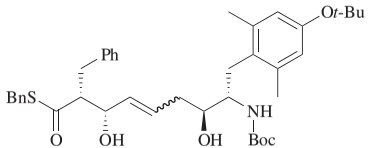
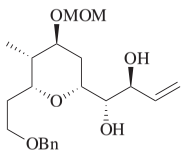
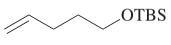
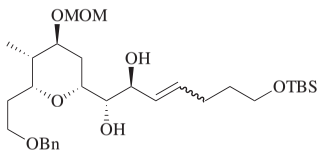
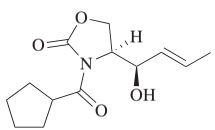
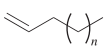
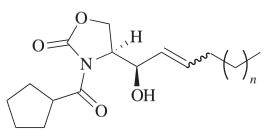
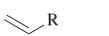
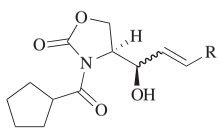


(53)

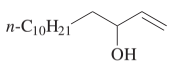
767

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

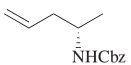
A. ALLYLIC ALCOHOLS (*Continued*)

Allylic Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{12}				
 5 eq		Gr II, DCM, 40°	 (54)	768
	 6 eq	Gr II (0.05 eq), DCM, rt, 12 h	 (65)	769
C_{13}				
	 1.2 eq	Gr II (0.05 eq), DCM, rt, 24 h		770
			n (%): 2 (88); 4 (86); 6 (88); 8 (89)	
	 1.2 eq	Gr II (0.05 eq), DCM, rt, 24 h		770
			R (%): *c*-C_5H_9 (78); *c*-C_6H_{11} (75); $PhCH_2$ (82)	

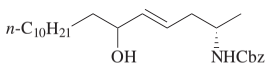
C_{14}



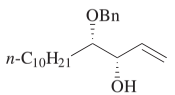
2.5 eq



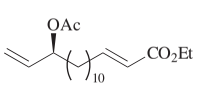
Gr II (0.05 eq), DCM, 45°



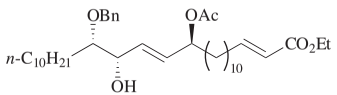
(75) (*E*) only 714



1.5 eq

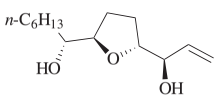


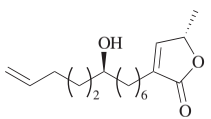
Gr II (0.04 eq), DCM, 25°, 22 h



772

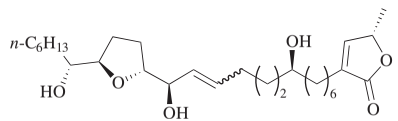
(61) (*E*) only





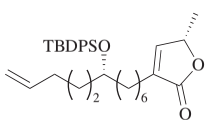
2 eq

Gr II (0.1 eq), DCM, rt, 20 h



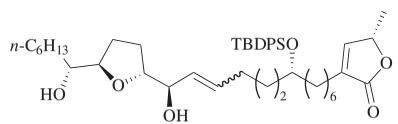
771

(73)



2 eq

Gr II (0.1 eq), DCM, rt, 20 h

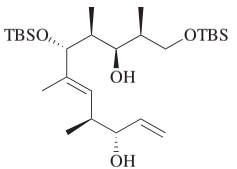
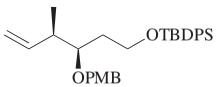
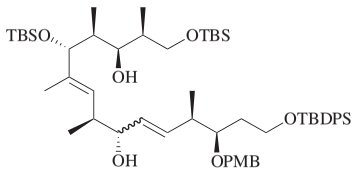
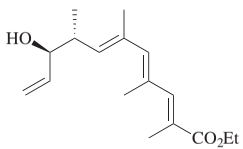
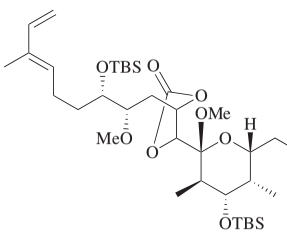
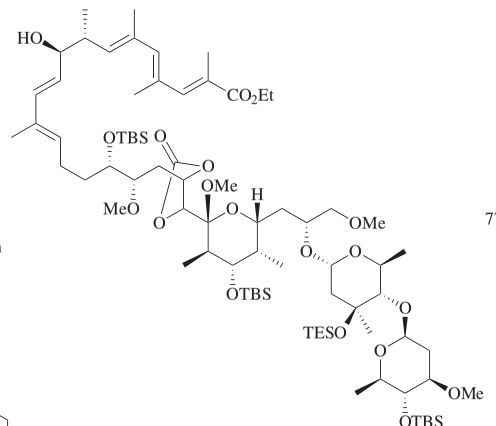


771

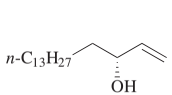
(73)

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

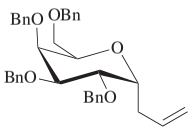
A. ALLYLIC ALCOHOLS (*Continued*)

Allylic Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{15}				
	 3 eq	Gr II (0.1 eq), DCM, reflux	 (60)	773
 2.2 eq		Gr II (0.09 eq), DCM, 25°, 4.5 h	 (60) (*E*)/(*Z*) = 95:5	774

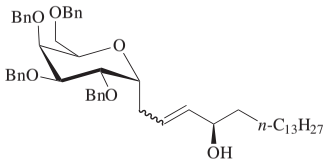
C_{17}



x eq



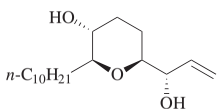
Catalyst (*y* eq),
DCM, 45°

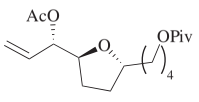


775

x	Catalyst	*y*	Time (h)	
4	Gr II	0.17	21	(38)
3	Hov II	0.10	3	(52)
0.33	Hov II	0.10	3	(63)

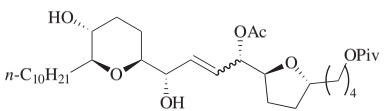
C_{18}





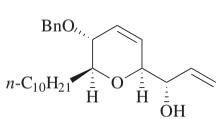
3 eq

Gr II (2 x 0.1 eq),
DCM, rt, 2 x 18 h

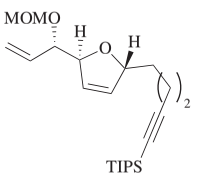


257

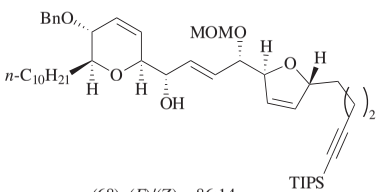
(51)



1 eq



Hov II (2 x 0.01 eq),
DCM, reflux

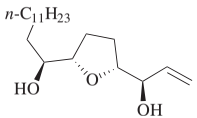
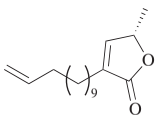
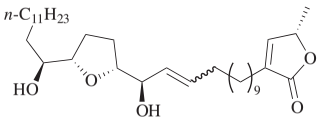
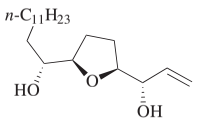
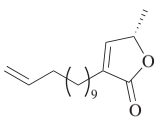
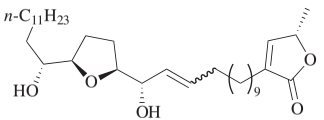
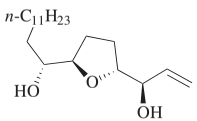
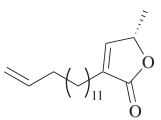
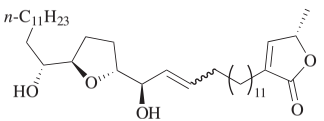


776

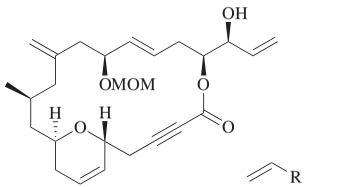
(68) (*E*)/(*Z*) = 86:14

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

A. ALLYLIC ALCOHOLS (*Continued*)

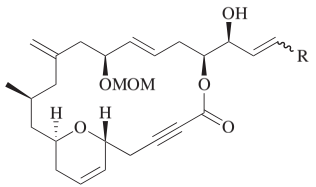
Allylic Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{20}				
	 2 eq	Gr II (0.3 eq), DCM, 40°, 12 h	 (52)	777, 778
	 2 eq	Gr II (0.3 eq), DCM, 40°, 12 h	 (64)	778
	 2 eq	Gr II (0.3 eq), DCM, 40°, 12 h	 (32)	778

C_{24}



x eq

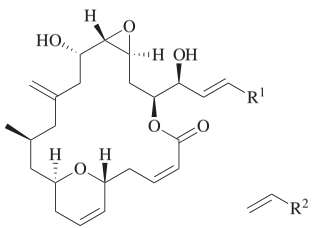
Gr II (0.1 eq),
DCM, rt, 24 h



779

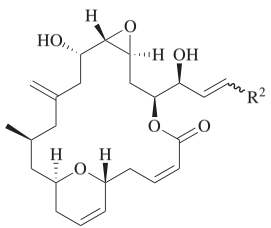
R	*x*	
$MeOCH_2$	20	(36)
c-C_6H_{11}	20	(68)
3-MeC_6H_4	50	(40)

C_{25}



50 eq

Gr II (*x* eq),
DCM, rt, 18 h



780

R^1	R^2	*x*	
$MeOCH_2$	Cy	0.1	(50)
Cy	3-MeC_6H_4	0.2	(50)
Cy		0.3	(55)

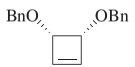
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

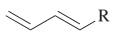
B. ALLYLIC ETHERS

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

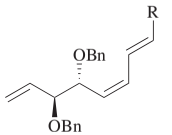
C_4





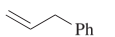
10 eq

Ru cat **151** (0.05 eq), DCM, 40°, 12 h



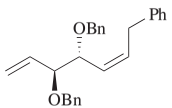
R		(*Z*)/(*E*)
MeO	(88)	98:2
n-C_6H_{13}	(60)	98:2

83



10 eq

Ru cat **151** (0.05 eq), DCM, 40°, 12 h

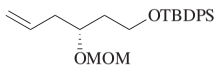


(58) (*Z*)/(*E*) = 98:2

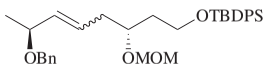
83



2 eq



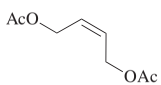
Gr II (0.05 eq), DCM, reflux, 6 h



(80)

781





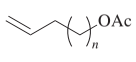
2 eq

Gr I (0.05 eq), DCM, 45°



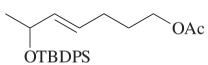
(23) (*E*)/(*Z*) = 88:12

124



x eq

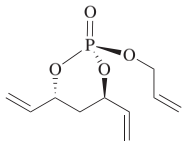
Catalyst (*y* eq), DCM, 40°



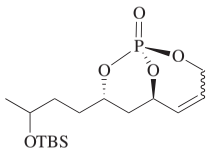
n	*x*	Catalyst	*y*	Time (h)		(*E*)/(*Z*)	
2	3	Hov II	0.05	6	(68)	>95:5	177
2	3	Ru cat **271**	0.05	6	(91)	>95:5	177
3	0.5	Gr II	0.03	12	(53)	87:13	36



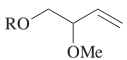
I

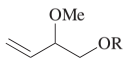


1. Hov II (0.06 eq), BQ, DCM, reflux, 0.75 h
2. Hov II (0.04 eq), **I** (2–4 eq), CuI, DCE, reflux, 4–6 h
3. *o*-NBSH (15 eq), Et_3N, rt, overnight

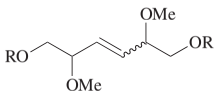


(69) 716

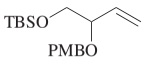




Gr I (0.05 eq), DCM, reflux



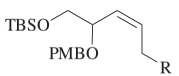
R		
Me	(7)	782
Ac	(18)	





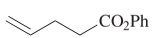
x eq

Mo cat **18** (0.03 eq), benzene, 7 torr, 22°, 8 h



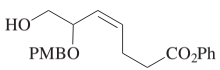
184

R	*x*	Conv. (%)[a]		(*Z*)/(*E*)
TESO	3	91	(72)	92:8
$Br(CH_2)_5$	2	82	(70)	90:10



3 eq

1. Mo cat **18** (0.03 eq), benzene, 7 torr, 22°, 8 h
2. DDQ (2 eq), DCM, H_2O, 0°, 1 h

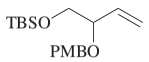
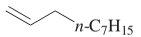
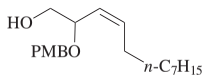
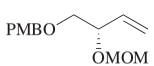
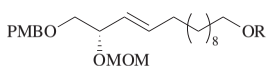


184

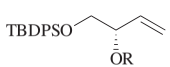
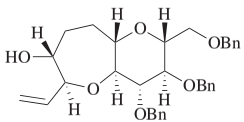
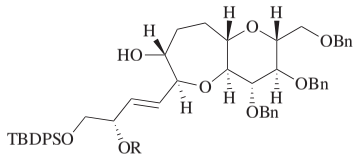
89% conv.[a], (87) (*Z*)/(*E*) = 90:10

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

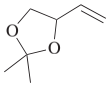
B. ALLYLIC ETHERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
		1. Mo cat **18** (0.03 eq), benzene, 7 torr, 22°, 8 h 2. $(n\text{-Bu})_4NF$ (2 eq), THF, 22°, 1 h		93% conv.[a], (87) (*Z*)/(*E*) > 98:2	184
	3 eq				
		Gr II (*z* eq), DCM, rt, 10 h			783
x eq	*y* eq				

x	R	*y*	*z*		(*E*)/(*Z*)
1	H	1.5	0.1	(60)	90:10
1	H	1	0.1	(65)	90:10
1.5	H	1	0.1	(76)	90:10
1.5	H	1	0.05 + 0.03	(76)	90:10
1	TBS	1.5	0.1	(0)	—

		Gr II (0.2 eq), benzene, reflux, 6.5 h		(*E*) only	784
8 eq					

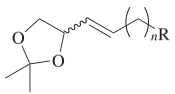
R	
TBS	(23)
PMB	(34)



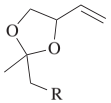
x eq

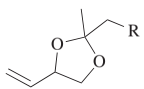


Gr I (0.05 eq),
DCM, reflux, 1 h

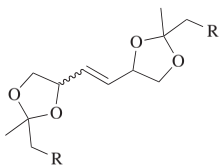


x	R	*n*		
3	TMS	1	(63)	782
2	Me	5	(68)	
0.5	Me	5	(36)	
2	Me	7	(72)	
3	Ph	0	(75)	

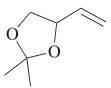


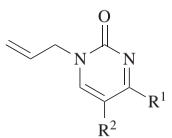


Gr I (0.05 eq),
DCM, reflux

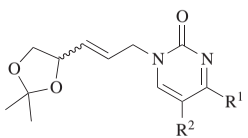


R		
H	(83)	782
Me	(81)	



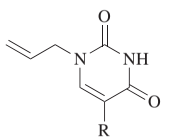


Ru cat **35**,
DCM, 40°

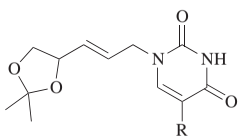


R^1	R^2		
HO	H	(78)	785
HO	Me	(50)	
HO	I	(56)	
BzHN	H	(57)	

5 eq



Ru cat **35** (0.1 eq),
DCM, 40°, 5 h

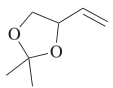
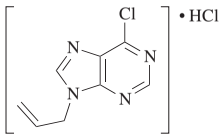
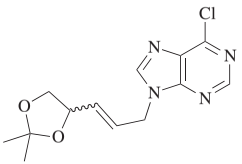
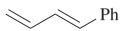
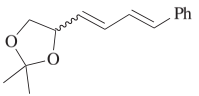
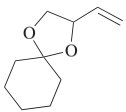
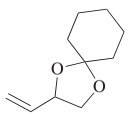
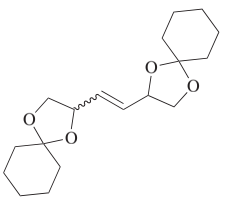


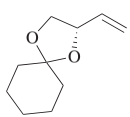
(*E*) only

R		
H	(78)	628
F	(62)	
I	(56)	
Me	(50)	

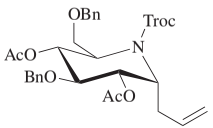
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

B. ALLYLIC ETHERS (*Continued*)

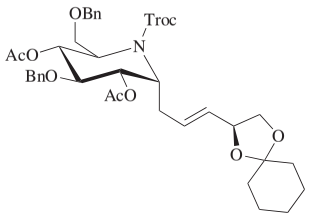
Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 5.12 eq		Ru cat **35**, DCM, 40°	 (14)	785
3 eq		Gr I (0.05 eq), DCM, reflux, 2 h	 (64)	782
		Gr I (0.05 eq), DCM, reflux	 (80)	782



5 eq

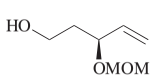


Gr II (0.2 eq),
DCM, reflux,
16–24 h

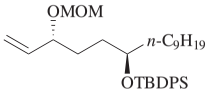


(88) $(E)/(Z) > 95:5$

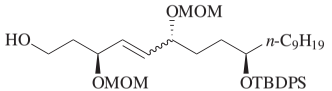
666



4 eq

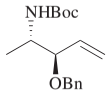


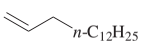
Hov II (0.05 eq),
DCM, reflux, 24 h



(75)

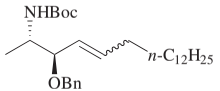
786





3 eq

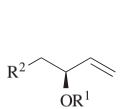
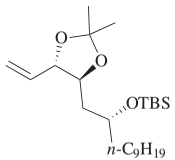
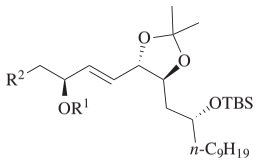
Gr II (0.05 eq),
DCM, reflux, 18 h



(87)

787

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)
B. ALLYLIC ETHERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5  4 eq		Catalyst (*x* eq), DCM, 40°		786

R^1	R^2	Catalyst	*x*	Time (h)		(*E*)/(*Z*)
H	$PMBOCH_2$	Gr II	0.05	24	(30)	50:50
H	$PMBOCH_2$	Hov I	0.05	24	(—)	—
H	$PMBOCH_2$	Hov II	0.05	24	(70)	92:8
H	$PMBOCH_2$	Ru cat **271**	0.05	24	(10)	—
H	$PMBOCH_2$	Ru cat **271**	0.2	80	(40)	89:11
H	$PMBOCH_2$	Ru cat **1**	0.05	24	(25)	50:50
MOM	$PMBOCH_2$	Gr II	0.05	24	(—)	—
MOM	$PMBOCH_2$	Hov I	0.05	24	(—)	—
MOM	$PMBOCH_2$	Hov II	0.05	24	(—)	—
MOM	$PMBOCH_2$	Ru cat **271**	0.05	24	(—)	—
MOM	$PMBOCH_2$	Ru cat **1**	0.05	24	(—)	—
MOM	$HOCH_2$	Hov II	0.05	24	(40)	90:10
MOM	HO_2C	Gr II	0.05	24	(—)	—
MOM	HO_2C	Hov I	0.05	24	(—)	—
MOM	HO_2C	Hov II	0.05	24	(—)	—
MOM	HO_2C	Ru cat **271**	0.05	24	(—)	—
MOM	HO_2C	Ru cat **1**	0.05	24	(—)	—

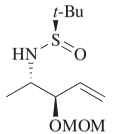
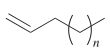
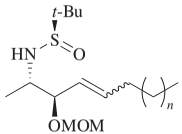
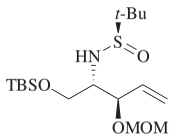
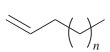
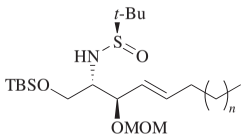
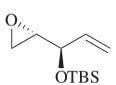
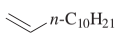
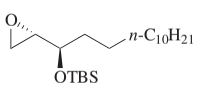
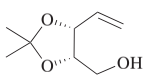
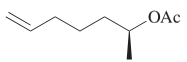
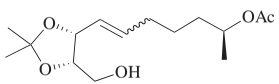
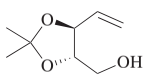
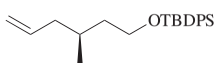
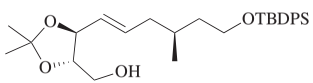
	 4 eq	Gr II (3 x 0.04 eq), DCM, reflux, 20 h		*n* 10 (67) 11 (72)	788
	 4 eq + 3 x 2 eq	Hov II (4 x 0.04 eq), DCM, reflux, 26 h		*n* (*E*)/(*Z*) 5 (78) 86:14 11 (78) 90:10	788
	 6 eq	1. Gr II (0.05 eq), benzene, 50°, 10 h 2. H_2, Pd/C, EtOAc		(73)	521
	 2.5 eq	Gr II (0.05 eq), DCM, 40°, 4 h		(76)	250
	 1.5 eq	Gr II (0.03 eq), DCM, reflux, 12 h		(72) (*E*) only	789

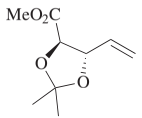
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

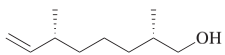
B. ALLYLIC ETHERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

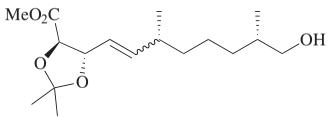
C_5



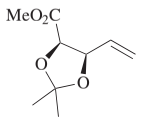


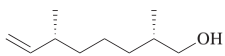
1.2 eq

Gr II (0.1 eq), DCM, rt, 10 h



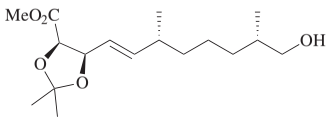
(75) 790



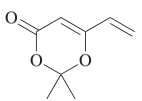


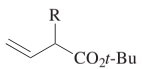
1.5 eq

Gr II (0.1 eq), DCM, 40°, 7 h



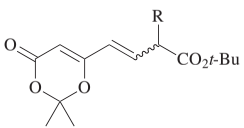
(73) (*E*) only 791





x eq

Hov II (*y* eq), solvent



792

x	R	*y*	Solvent	Temp (°)	Time (h)	
1.5	H	0.05	DCM	40	2.5	(82)
1.5	Me	0.05	DCM	40	2.5	(0)
1.5	Me	0.01	$C_6F_5CF_3$	70	16	(43)
3	Me	0.01	$C_6F_5CF_3$	70	2	(68)
3	Bn	0.01	$C_6F_5CF_3$	70	2	(61)

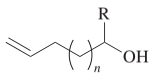
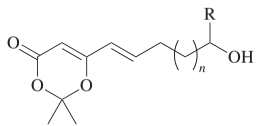
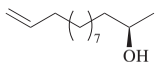
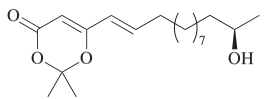
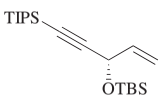
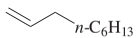
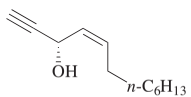
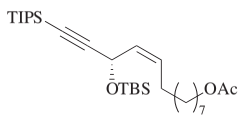
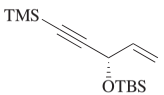
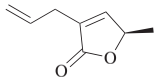
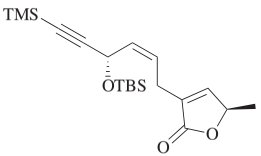
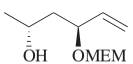
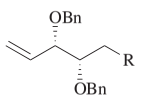
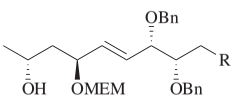
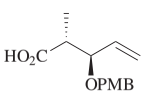
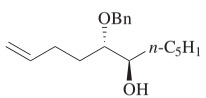
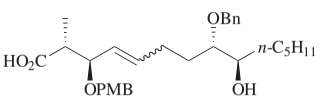
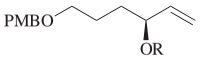
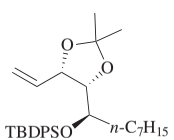
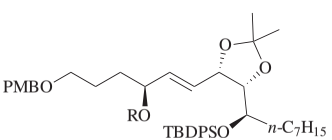
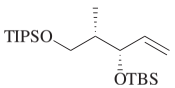
1 eq		Hov II (0.05 eq), DCM, 40°, 24 h		R H H Me H / n 6 8 9 10 / (71) (75) (78) (77)	793
			$(E)/(Z) > 95:5$		
1.5 eq		Hov II (0.05 eq), DCM, 40°, 24 h		(88)	$(E)/(Z) > 95:5$ 793
	 10 eq	1. Mo cat **18** (0.045 eq), benzene, 7 torr, 22°, 4 h 2. $(n\text{-Bu})_4NF$ (3 eq), THF, 22°, 1 h		(94)	$(Z)/(E) = 92:8$ 184
	 3 eq	Mo cat **18** (0.03 eq), benzene, 7 torr, 22°, 8 h		(92)	$(Z)/(E) = 92:8$ 184

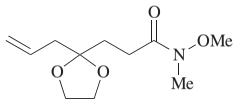
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

B. ALLYLIC ETHERS (*Continued*)

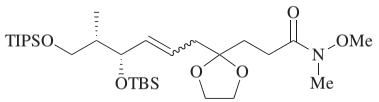
Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
 3 eq		Mo cat **18** (0.06 eq), PhCl, 100 torr, 22°, 5.5 h	 (56) (*Z*)/(*E*) = 91:9	184
 2 eq		Gr II (0.2 eq), DCM, rt, 2 d	 (*E*)/(*Z*) = 83:17 R: HOCH$_2$ (38); HO_2C (54)	794
C_6				
 1.25 eq		Gr II (0.1 eq), DCM, reflux, 12 h	 (70)	795
 2 eq		Hov II (0.05 eq), DCM, 40°, 24 h	 R: H (65) 94:6; MOM (32) 94:6	796



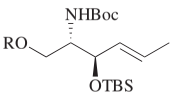
2 eq

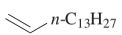


Hov II (0.09 eq), DCM, reflux, 7 d



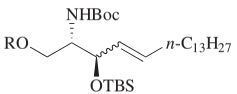
(85) 797



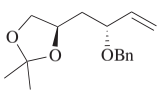


1 eq

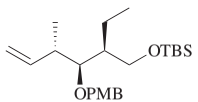
Gr II (6 × 0.05 eq), benzene, 55°



R		
H	(18)	740
TBS	(—)	

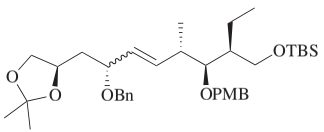


x eq



y eq

Catalyst (0.1 eq), solvent, reflux

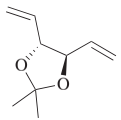
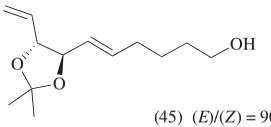
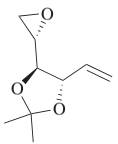
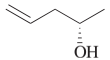
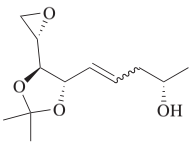
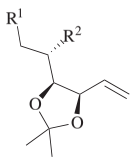
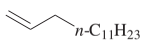
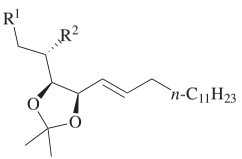


798

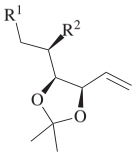
x	*y*	Catalyst	Solvent	Time (h)	
1	1	Gr I	DCM	24	(10)
1	1	Gr II	DCM	24	(29)
1.5	1	Gr II	DCM	24	(35)
1.5	1	Gr II	DCM	48	(47)
1	1.5	Gr II	DCM	24	(40)
1.5	1	Gr II	toluene	24	(32)
1.5	1	Hov I	DCM	24	(0)

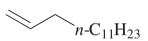
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

B. ALLYLIC ETHERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6 	 2.5 eq	Gr II (0.05 eq), DCM, reflux	 (45) (*E*)/(*Z*) = 90:10	799
	 1.5 eq	Gr II (0.02 eq), DCM, reflux, 24 h	 (85)	334
	 *x* eq	Gr II (*y* eq), DCM, reflux		

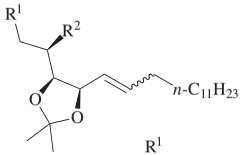
R^1	R^2	*x*	*y*	Time (h)		(*E*)/(*Z*)	
HO	AcHN	5	0.2	18	(82)	94:6	800
HO	BocHN	5	0.2	18	(77)	92:8	800
HO	TFAHN	5	0.2	18	(83)	100:0	800
TBSO	HO	4	0.04	24	(60)	—	801
PhthN	TBSO	4	0.04	24	(88)	—	801



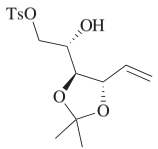


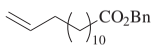
4 eq

Gr II (0.04 eq),
DCM, reflux, 24 h



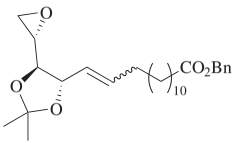
R^1	R^2		
TBSO	HO	(57)	801
PhthN	TBSO	(87)	801
MOMO	PhthN	(75)	802



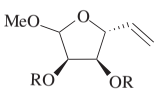


1.35 eq

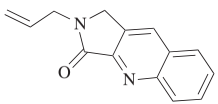
1. Gr II (0.02 eq),
DCM, reflux, 14 h
2. TBAF, THF, rt, 4 h



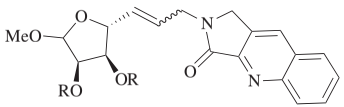
(72) 803



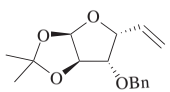
2 eq

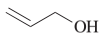


Gr I (0.1 eq),
$Ti(O\textit{i}\text{-}Pr)_4$ (0.3 eq),
DCM, 40°, 18 h

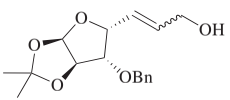


R		
H	(78)	804
Ac	(73)	
Me	(81)	





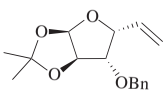
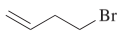
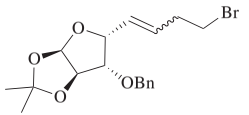
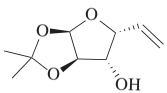
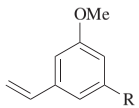
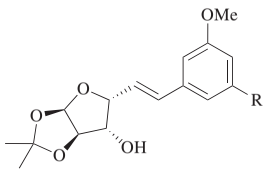
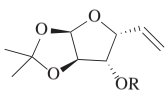
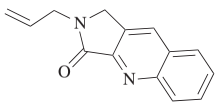
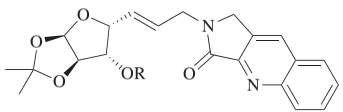
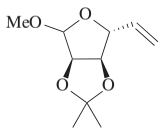
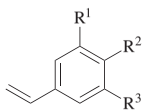
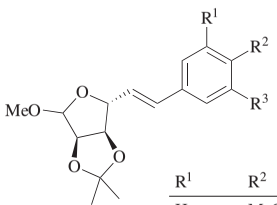
Gr II (0.074 eq),
Triton X 100,
H_2O, 25°, 48 h



(62) 805

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

B. ALLYLIC ETHERS (*Continued*)

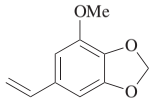
Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6 	 2 eq	Gr II (0.1 eq), DCM, rt, 24 h	 (71)	806
 1 eq		Gr II (0.05 eq), DCM, reflux, 18 h	 (*E*) only	807
 2 eq		Gr I (0.1 eq), $Ti(O\textit{i}\text{-}Pr)_4$ (0.3 eq), DCM, 40°, 18 h		804
 1 eq		Gr II (0.05 eq), DCM, 40°, 18 h	 (*E*) only	807

R		
H	(61)	
MeO	(53)	

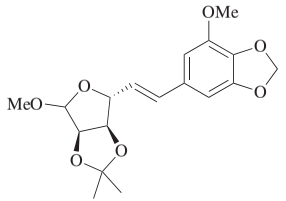
R		
H	(79)	
Ac	(75)	
Me	(83)	

R^1	R^2	R^3	
H	MeO	H	(66)
MeO	H	H	(65)
MeO	HO	H	(58)
MeO	H	MeO	(51)

1 eq

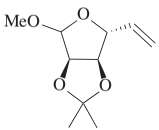


Gr II (0.05 eq), DCM, 40°, 18 h

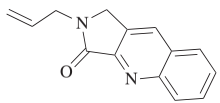


(67) (*E*) only

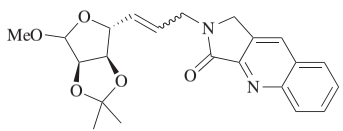
807



2 eq

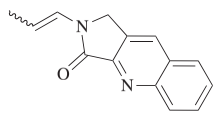


Gr II (0.1 eq), additive (*x* eq), DCM, 40°



I

+



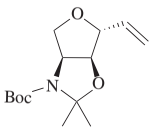
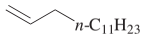
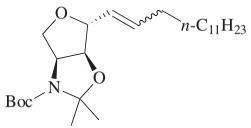
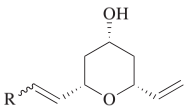
II

804

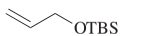
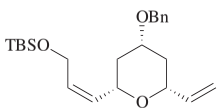
Additive	*x*	Time (h)	**I**	**II**
—	—	18	(31)	(27)
$AlCl_3$	1	2	(0)	(—)
$Sc(OTf)_3$	1	4	(0)	(—)
$TiCl_4$	1	2	(0)	(—)
$Ti(Oi\text{-}Pr)_4$	1	12	(72)	(—)
$Ti(Oi\text{-}Pr)_4$	0.5	16	(78)	(—)
$Ti(Oi\text{-}Pr)_4$	0.3	18	(86)	(—)
$Ti(Oi\text{-}Pr)_4$	0.1	24	(81)	(—)

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

B. ALLYLIC ETHERS (*Continued*)

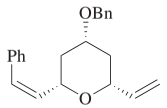
Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6 	 2.5 eq	Gr II (0.05 + 0.03 eq), DCM, 45°, 8 h	 (80)	470
C_7 	 20 eq	Ru cat **213** (0.05 eq), THF, 22°, 2.5 h		808

R	Conv. (%)[a]		er
Ph	>98	(68)	96.0:4.0
Cy	>98	(58)	59.0:41.0

		Mo cat **18** (0.05 eq), 22°, 1 h	 (45) $(Z)/(E)$ = 95:5, er 86.0:14.0	809

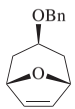


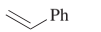
Catalyst (0.01 eq), 22°, 1 h



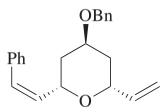
809

Catalyst		(*Z*)/(*E*)	er
Mo cat **12**	(80)	>98:2	95.0:5.0
Ru cat **212**	(85)	>98:2	98.5:1.5
Ru cat **213**	(87)	95:5	98.0:2.0



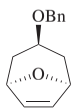


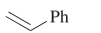
Mo cat **18** (0.02 eq), 22°



(—) (*Z*)/(*E*) = 95:5, er 91.0:9.0

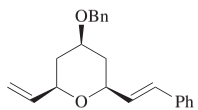
809





5 eq

Catalyst (*x* eq), solvent, 1 h



(*E*)/(*Z*) > 98:2

91

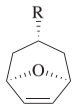
Catalyst	*x*	Solvent	Temp (°)		er
Ru cat **210**	0.02	—	22	(70)	98.0:2.0
Ru cat **213**	0.02	—	22	(90)	94.0:6.0
Ru cat **213**	0.02	—	–15	(87)	95.5:4.5
Mo cat **12**	0.05	benzene	22	(—)	—

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)
B. ALLYLIC ETHERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

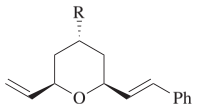
C_7





x eq

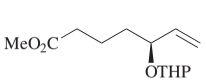
Catalyst (*y* eq), solvent

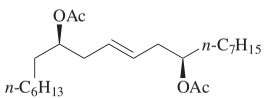


(*E*)/(*Z*) > 98:2

91

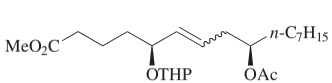
R	*x*	Catalyst	*y*	Solvent	Temp (°)	Time (h)		er
BnO	2	Ru cat **211**	0.02	—	22	36	(85)	95.0:5.0
BnO	2	Ru cat **213**	0.02	—	22	15	(70)	97.0:3.0
BnO	5	Ru cat **213**	0.02	—	–15	15	(84)	>99.0:1.0
BnO	10	Mo cat **12**	0.02	benzene	22	1	(81)	95.0:5.0
I	2	Ru cat **211**	0.02	—	22	5	(65)	96.5:3.5
I	2	Ru cat **213**	0.02	—	22	5	(70)	91.0:9.0
I	10	Mo cat **12**	0.05	benzene	22	1	(76)	98.5:1.5





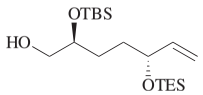
1.6 eq

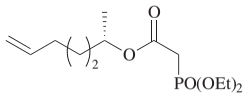
Ru cat **35** (0.15 eq), DCM, 100° (MW), 40 min



(66)

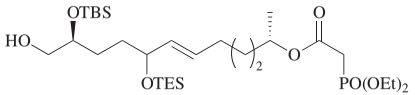
505





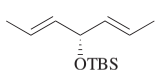
3 eq

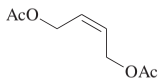
Gr II (0.05 eq), DCM, reflux, 9 h



(98) (*E*)/(*Z*) = 95:5

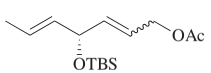
810





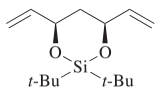
5 eq

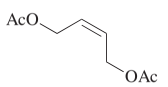
Ru cat **20** (0.05 eq), DCM, 40°, 6 h



(23) er 52.0:48.0

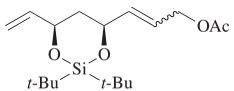
97





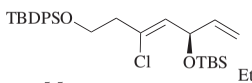
5 eq

Ru cat **20** (0.05 eq), DCM, 40°, 6 h

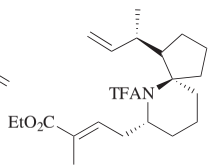


(48) er 68.5:31.5

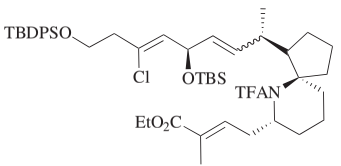
97



5.5 eq



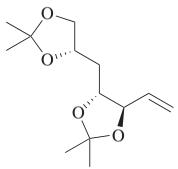
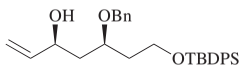
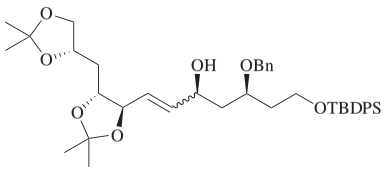
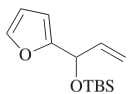
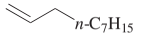
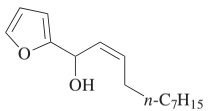
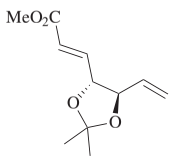
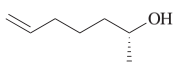
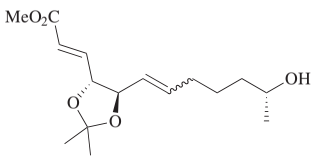
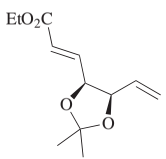
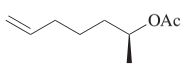
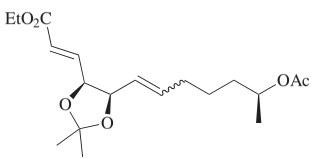
Gr II (0.8 eq), toluene, 90°

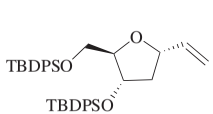


(40)

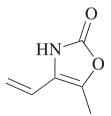
811

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)
B. ALLYLIC ETHERS (*Continued*)

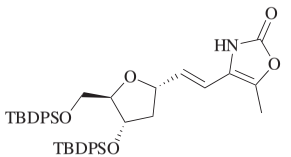
Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_7				
		Gr II, DCM, rt, 6 h	 (63)	812
	 3 eq	1. Mo cat **18** (0.03 eq), benzene, 7 torr, 22°, 8 h 2. $(n\text{-Bu})_4NF$ (2 eq), THF, 22°, 1 h	 (80) $(Z)/(E) = 95:5$	184
	 1.5 eq	Gr II (0.1 eq), DCM, reflux	 (60)	799
	 2.5 eq	Gr II (0.05 eq), DCM, reflux, 4 h	 (75)	250



1 eq

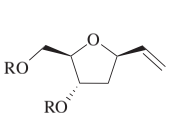


Catalyst (0.05 eq),
DCM, 40°, 8 h

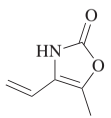


(*E*) only

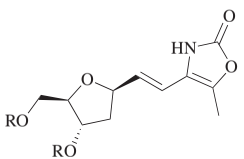
Catalyst		
Hov I	(67)	813
Hov II	(15)	
Gr I	(8)	
Gr II	(12)	



1 eq



Catalyst (0.05 eq),
solvent, 8 h



(*E*) only 813

R	Catalyst	Solvent	Temp (°)	
H	Hov I	DCM	40	—
H	Hov II	DCM	40	—
H	Gr I	DCM	40	—
H	Gr II	DCM	40	—
TBDPS	Hov I	DCM	40	(63)
TBDPS	Hov II	DCM	40	(18)
TBDPS	Gr I	DCM	40	(10)
TBDPS	Gr I	toluene	110	(5)
TBDPS	Gr II	DCM	40	(14)
TBDPS	Gr II	toluene	110	(5)

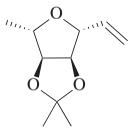
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

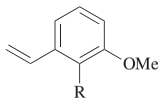
B. ALLYLIC ETHERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

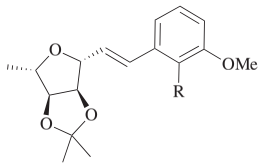
C_7



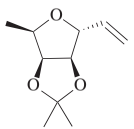


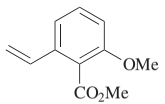
1.5 eq

Gr II (*x* eq),
DCM, reflux



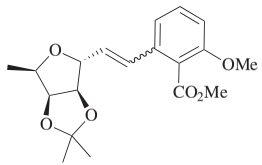
R	*x*	Time (h)		(*E*)/(*Z*)	
$HOCH_2$	0.06	32	(62)	(*E*) only	814
MeO_2C	0.05	12	(56)	—	815



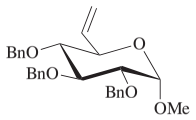


1.5 eq

Gr II (0.05 eq),
DCM, reflux, 12 h



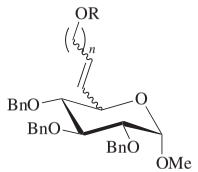
(62) 815





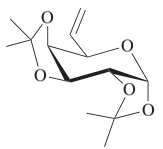
2 eq

Gr II (0.2 eq), solvent

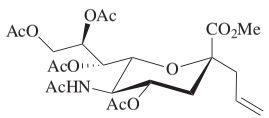


816

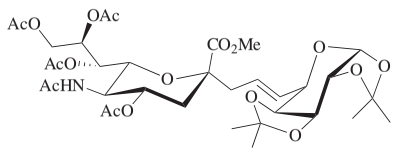
R	*n*	Solvent	Temp (°)	
H	1	DCM	23	(13)
H	1	DCM	40	(15)
H	3	DCE	83	(7)
Ac	3	DCM	23	(17)
Ac	4	DCM	40	(66)
Ac	3	DCM	40	(56)
Ac	2	DCM	40	(49)
Ac	1	DCM	40	(69)



6.25 eq



Gr II (0.23 eq),
DCM, reflux



660

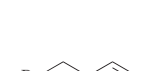
(95) (*E*)/(*Z*) = 75:25

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)
B. ALLYLIC ETHERS (*Continued*)

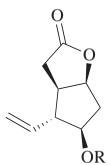
Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

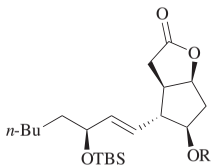
C_8



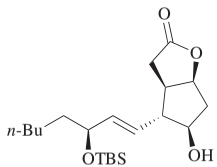
2 eq



Catalyst (0.06 eq),
DCM, 40°, 12 h



+

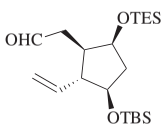


752

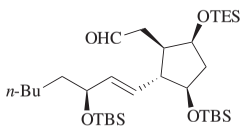
I **II**

R	Catalyst	**I**	(*E*)/(*Z*) **I**	**II**	(*E*)/(*Z*) **II**
H	Gr II	(70)	93:7	(—)	—
TBS	Gr II	(76)	86:14	(—)	—
TBS	Gr II	(84)	94:6	(—)	—
Bz	Gr II	(40)	88:12	(25)	86:14
Bz	Hov II	(25)	88:12	(15)	86:14

5 eq

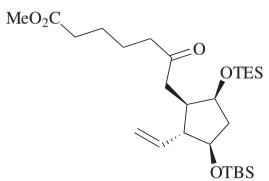


Hov II (0.1 eq),
DCE, reflux, 12 h

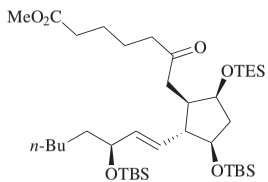


(64) (*E*)/(*Z*) > 95:5 817

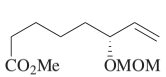
5 eq



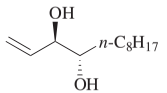
Hov II (0.1 eq),
DCM, reflux, 14 h



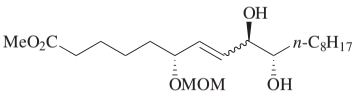
(64) (*E*)/(*Z*) > 95:5 817



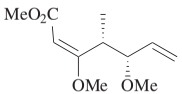
1.25 eq

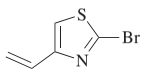


Gr II (0.05 eq), DCM, reflux, 12 h



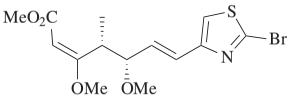
(70) 818



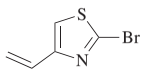


5 x 0.2 eq

Gr II (0.2 + 0.1 eq), DCM, 100° (MW), 5 x 1 h + 0.5 h

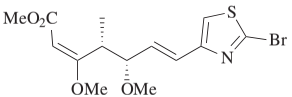


(55) (*E*)/(*Z*) = 95:5 819



x eq

Catalyst (*y* eq), solvent



820

x	Catalyst	*y*	Solvent	Temp (°)	Time (h)	Conv. (%)[a]		(*E*)/(*Z*)
1	Gr I	0.1	DCM	40	48	0	(—)	—
1	Gr II	0.1	DCM	40	48	27	(—)	>95:5
1	Hov II	0.1	DCM	40	48	18	(—)	>95:5
2	Gr II	0.2	DCM	40	60	50	(—)	>95:5
2	Gr II	0.2	benzene	60	60	26	(—)	>95:5
2	Gr II	0.2	DCM	20	72	5	(—)	>95:5
2	Gr II	0.3	DCM	40	60	68	(56)	>95:5
2	Gr II	0.4	DCM	40	60	72	(—)	>95:5

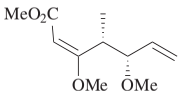
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

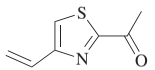
B. ALLYLIC ETHERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

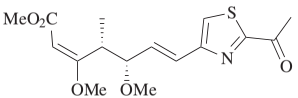
C_8





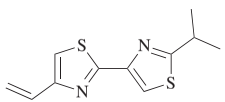
x eq

Catalyst (*y* eq),
solvent



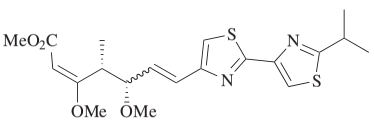
821

x	Catalyst	*y*	Solvent	Temp (°)	Time (h)	Conv. (%)[a]		(*E*)/(*Z*)
1	Gr I	0.1	DCM	40	48	0	(—)	—
1	Gr II	0.1	DCM	40	48	27	(—)	95:5
1	Hov II	0.1	DCM	40	48	18	(—)	95:5
2	Gr II	0.2	DCM	40	60	50	(—)	95:5
2	Gr II	0.2	benzene	60	60	26	(—)	95:5
2	Gr II	0.2	DCM	20	72	5	(—)	95:5
2	Gr II	0.3	DCM	40	60	68	(56)	95:5
2	Gr II	0.4	DCM	40	60	72	(—)	95:5



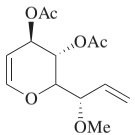
5 x 0.2 eq

Gr II (0.2 +0.1 eq),
CD_2Cl_2, MW



(25)

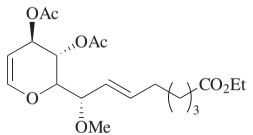
820





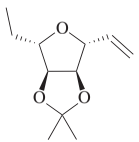
3.6 eq

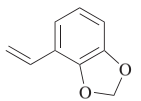
Gr II (0.05 eq),
DCM, reflux, 48 h



(55) (*E*) only

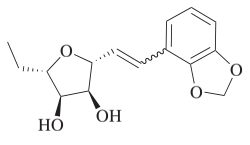
822





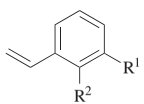
4 eq

1. Gr II (0.05 eq),
DCM, reflux, 24 h
2. HCl (2N), 30°, 12 h



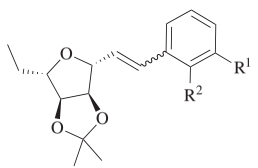
(44)

814



x eq

Gr II (0.05 eq),
DCM, reflux



814

R^1	R^2	*x*	Time (h)	
MeO	$HOCH_2$	0.67	12	(70)
EtO	MeO	4	18	(74)
EtO	EtO	4	18	(64)
Cl	Cl	4	24	(90)

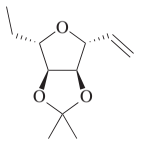
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

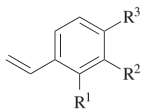
B. ALLYLIC ETHERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

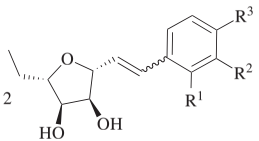
C_8





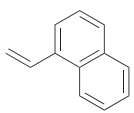
x eq

1. Gr II (0.05 eq), DCM, reflux, time 1
2. HCl (2N), 30°, time 2



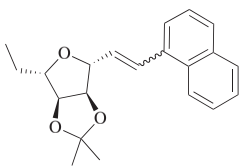
814

R^1	R^2	R^3	*x*	Time 1 (h)	Time 2 (h)	
MeO	MeO	MeO	4	18	12	(40)
MeO	MeO	H	4	24	8	(44)
$MeOCH_2$	MeO	H	0.67	12	8	(43)



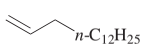
4 eq

Gr II (0.05 eq), DCM, reflux, 24 h



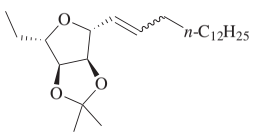
(81)

814



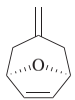
6 eq

Gr II (0.05 eq), DCM, reflux, 6 h



(81)

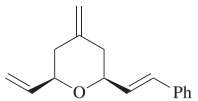
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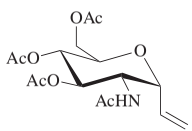
x eq

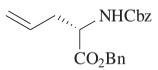
Catalyst (*y* eq),
solvent, 22°



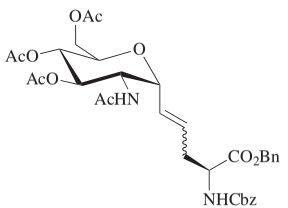
91

x	Catalyst	*y*	Solvent	Time (h)	Conv. (%)[a]		(*E*)/(*Z*)	er
5	Ru cat **211**	0.02	—	36	—	(50–60)	>98:2	97.0:3.0
5	Ru cat **213**	0.02	—	15	—	(50–60)	>98:2	>99.0:1.0
2	Mo cat **8**	0.05	pentane	4	>98	—	—	—
2	Mo cat **9**	0.05	pentane	4	<5	—	—	—
2	Mo cat **10**	0.05	pentane	4	50	—	—	—
2	Mo cat **12**	0.05	pentane	4	>98	—	>98:2	97.0:3.0
5	Mo cat **12**	0.05	benzene	1	—	(50–60)	>98:2	98.5:1.5
2	Mo cat **15**	0.05	pentane	4	<5	—	—	—





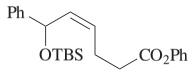
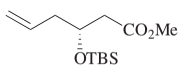
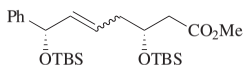
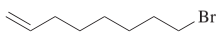
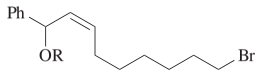
Gr II (0.2 eq),
DCM, rt, 48 h



(77)

423

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)
B. ALLYLIC ETHERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
	 2 eq	Mo cat **18** (0.03 eq), benzene, 7 torr, 22°, 8 h	 (72) (*Z*)/(*E*) = 95:5	184
 1.5 eq		Gr II (0.1 eq), DCM, rt, 24 h	 (60)	823
	 *x* eq	Catalyst (*y* eq), benzene, 7 torr, 22°, 8 h		184

R	*x*	Catalyst	*y*	Conv. (%)[a]		(*Z*)/(*E*)
TBS	1	Mo cat **18**	0.03	56	(45)	91:9
TBS	1.5	Mo cat **18**	0.03	67	(65)	90:10
TBS	2	Mo cat **18**	0.03	79	(69)	95:5
TBS	3	Mo cat **18**	0.03	72	(65)	95:5
TBS	10	Mo cat **18**	0.03	<2	(—)	—
TBS	2	Mo cat **1**	0.05	95	(80)	5:95
TBS	2	Hov II	0.05	98	(76)	5:95
TBS	2	Mo cat **5**	0.05	64	(62)	81:19
TBS	2	W cat **3**	0.05	25	(20)	>95:5
PMB	2	Mo cat **18**	0.03	90	(85)	>98:2

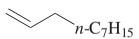
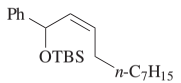
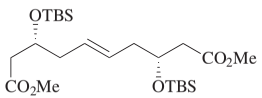
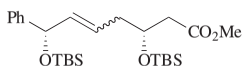
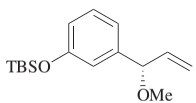
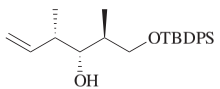
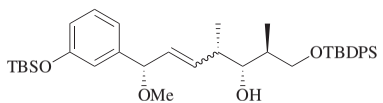
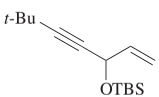
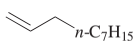
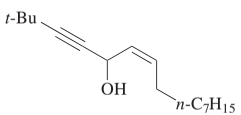
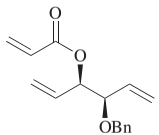
	 3 eq	Mo cat **18** (0.03 eq), benzene, 7 torr, 22°, 8 h		(86) (*Z*)/(*E*) = 95:5	184
 1.5 eq		Gr II (0.1 eq), DCM, rt, 24 h		(60)	823
 5 eq		Gr II (0.1 eq), DCM, reflux, 24 h		(94)	824
	 3 eq	1. Mo cat **18** (0.015 eq), benzene, 7 torr, 22°, 8 h 2. $(n\text{-Bu})_4NF$ (2 eq), THF, 22°, 1 h		(76), 84% conv.[a] (*Z*)/(*E*) = 90:10	184

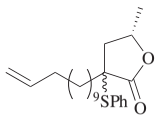
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)
B. ALLYLIC ETHERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

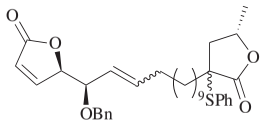
C_9



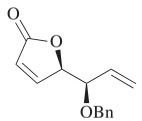


3 eq

Catalyst (0.1 eq), solvent, 20 h



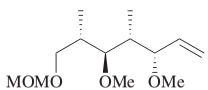
+



825

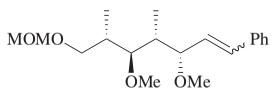
I **II**

Catalyst	Solvent	Temp (°)	**I**	**II**
Gr I	toluene	80	(0)	(45)
Gr II	toluene	80	(53)	(12)
Gr II	DCM	40	(60)	(19)
Hov I	toluene	80	(66)	(16)
Hov II	toluene	80	(68)	(0)
Hov II	DCM	40	(77)	(0)



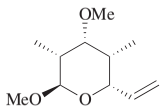


Gr II, benzene, 50°, 12 h



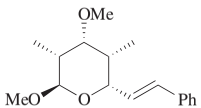
(92)

826



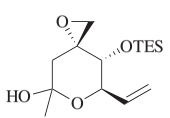


Gr II (0.1 eq), benzene, 55°

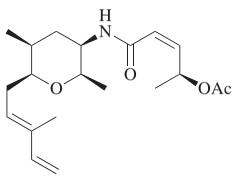


(81) (*E*)/(*Z*) = 98:2

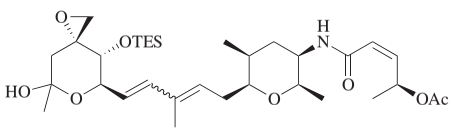
827



1 eq

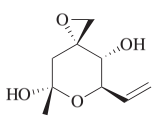


Gr II (0.2 eq), THF, 40°, 5 h

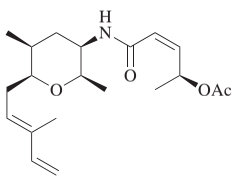


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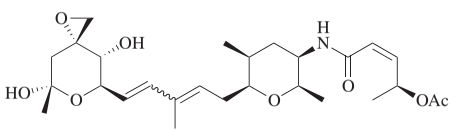
828



1.8 eq



Catalyst (3 x 0.025 eq), DCE, 10 h

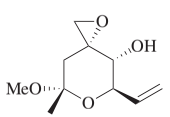
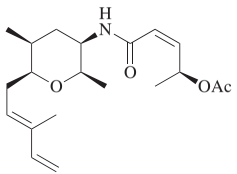
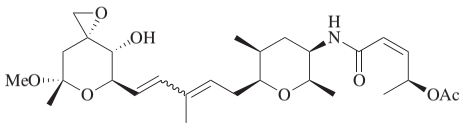
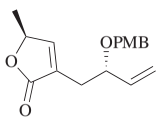
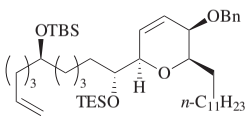
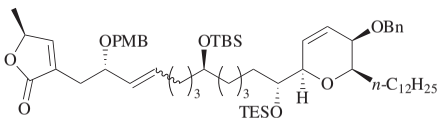
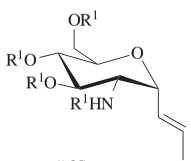
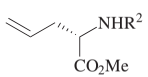
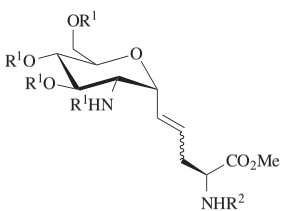


828

Catalyst	Temp (°)	
Gr II	43	(12)
Hov II	42	(13)
Ru cat **88**	23	(28)

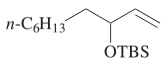
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

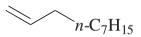
B. ALLYLIC ETHERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
 1.25 eq		Gr II (0.077 eq), DCM, reflux, 5 h	 (57)	829
 1 eq		Ru cat **190** (2 x 0.1 eq), DCM, 40°, 24 h	 (58)	830
 *x* eq		Catalyst (*y* eq), DCM, reflux		427

R^1	*x*	R^2	Catalyst	*y*	Time (h)	
Bn	2	Fmoc	Gr I	0.2	48	(—)
Bn	2	Boc	Gr I	0.2	48	(—)
Bn	2	Fmoc	Gr II	0.1	24	(82)
Bn	2	Boc	Gr II	0.1	48	(77)
Bn	1	Fmoc	Gr II	0.1	24	(68)
Ac	2	Fmoc	Gr II	0.2	48	(69)
Ac	2	Boc	Gr II	0.2	48	(77)

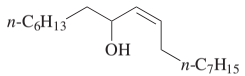
C_{10}



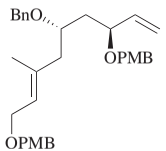


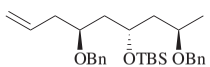
3 eq

1. Mo cat **18** (0.03 eq), benzene, 7 torr, 22°, 8 h
2. $(n\text{-Bu})_4NF$ (2 eq), THF, 22°, 1 h



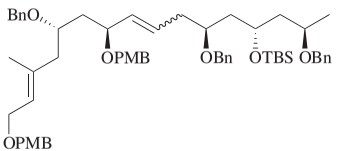
(61) $(Z)/(E)$ = 78:22 184



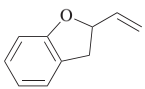


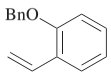
1.2 eq

Hov II (0.1 eq), DCM, rt, 6 h



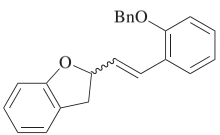
(57) 831



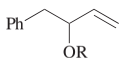


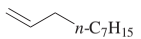
4.2 eq

Gr II (0.026 eq), DCM, reflux, 46 h



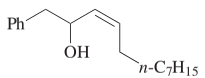
(71) 832





3 eq

1. Mo cat **18** (0.03 eq), benzene, 7 torr, 22°, 8 h
2. $(n\text{-Bu})_4NF$ (2 eq), THF, 22°, 1 h

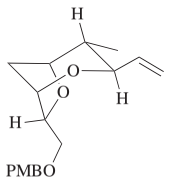
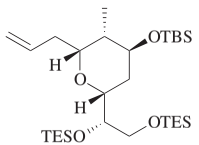
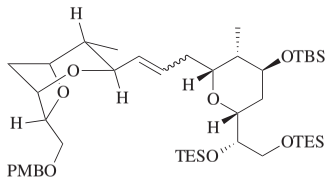
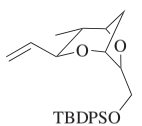
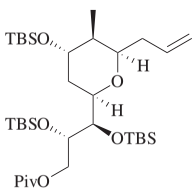
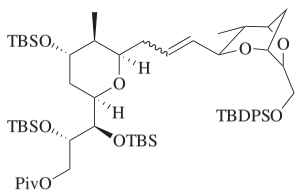
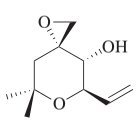
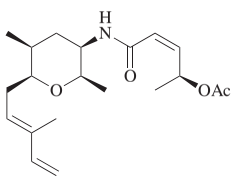
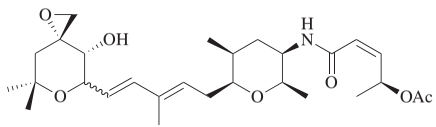


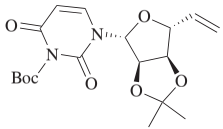
184

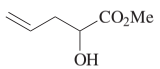
R	Conv. (%)[a]		$(Z)/(E)$
TBS	43	(37)	86:14
PMB	43	(39)	>98:2

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

B. ALLYLIC ETHERS (*Continued*)

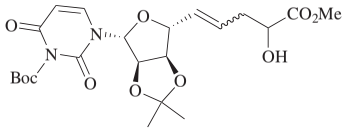
Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{10}				
 1.5 eq		Gr II (0.1 eq), toluene, rt, 18 h	 (77)	522
 2.5 eq		1. Gr II (0.084 eq), toluene, rt, 36 h 2. DIBAL-H, DCM, –78°, 0.5 h	 (60)	833
 2.5 eq		Ru cat **88** (0.1 eq), BQ (1.9 eq), DCE, 40°, 9 h	 (45)	828



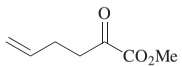


2.5 eq

Gr II (0.1 eq), DCM, reflux, 24.5 h

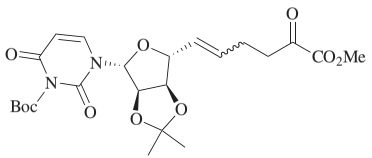


(85) 721



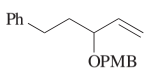
2.5 eq

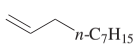
Gr II (0.15 + 0.05 eq), DCM, reflux, 24 h



(40) 721

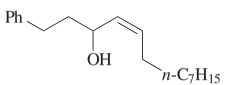
C_{11}





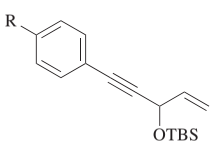
3 eq

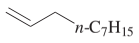
1. Mo cat **18** (0.03 eq), benzene, 7 torr, 22°, 8 h
2. DDQ (2 eq), DCM, H_2O, 22°, 1 h



(60), 66% conv.[a] $(Z)/(E) > 98:2$ 184

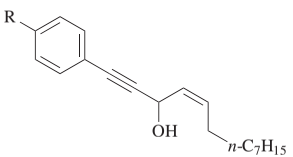
C_{11-12}





3 eq

1. Mo cat **18** (0.03 eq), benzene, 7 torr, 22°, 8 h
2. $(n\text{-Bu})_4NF$ (2 eq), THF, 22°, 1 h



$(Z)/(E) > 98:2$ 184

R	Conv. (%)[a]	
H	72	(68)
MeO	66	(60)
CF_3	73	(64)

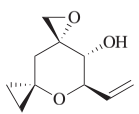
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

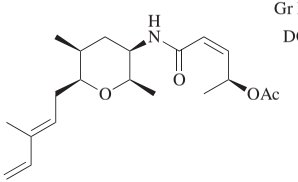
B. ALLYLIC ETHERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

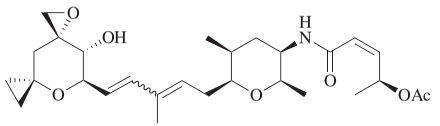
Please refer to the charts preceding the tables for the catalyst structures.

C_{11}



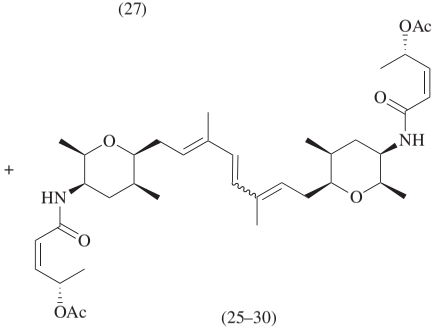


Gr II (0.15 eq),
DCM, 45°, 8 h

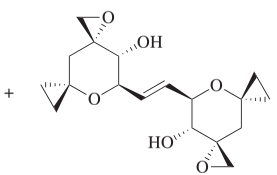


834

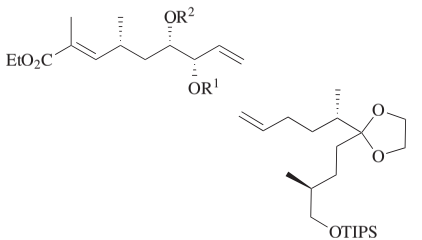
(27)



(25–30)

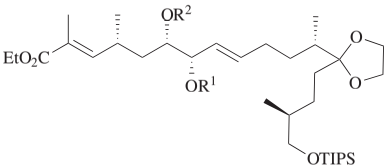


(25–30)



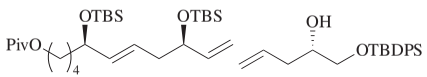
2 eq

Gr II, DCM, 45°



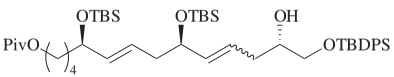
835

R^1	R^2		$(E)/(Z)$
TIPS	H	(25)	91:9
i-Pr	*i*-Pr	(73)	67:33



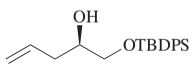
3 eq

Gr II (0.1 eq),
DCM, reflux, 3 h



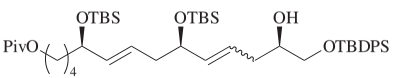
(78)

744



3 eq

Gr II (0.1 eq),
DCM, reflux, 3 h

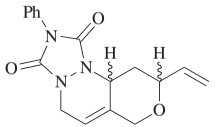
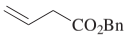
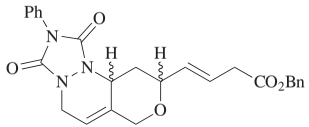
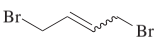
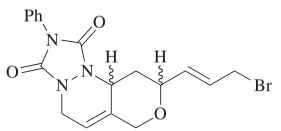
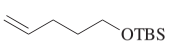
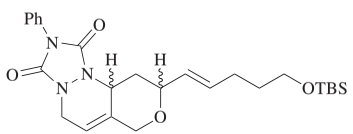
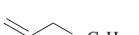
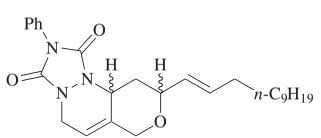


(67)

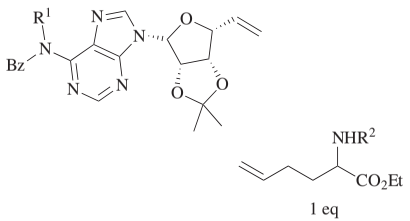
744

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

B. ALLYLIC ETHERS (*Continued*)

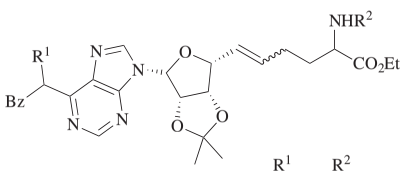
Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{11} 	 2 eq	Gr II (0.05 eq), DCM, 40°, 6 h		(66) (*E*) only 836
	 2 eq	Gr II (0.05 eq), DCM, 40°, 6 h		(52) (*E*) only 836
	 2 eq	Gr II (0.05 eq), DCM, 40°, 6 h		(74) (*E*) only 836
	 2 eq	Catalyst (0.05 eq), $Ti(O\textit{i}\text{-}Pr)_4$ (*x* eq), DCM, 40°, 6 h		(*E*) only 836

Catalyst	*x*	
Gr I	—	(56)
Gr I	0.3	(49)
Gr II	—	(81)



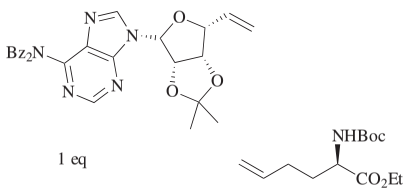
1 eq

Hov II (0.05 eq), DCM, 65°, overnight



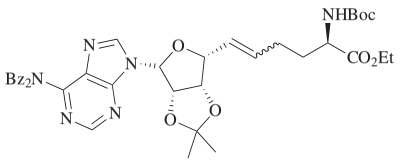
837

R^1	R^2	
H	Bz	(51)
H	Boc	(60)
Bz	Bz	(61)
Bz	Boc	(76)



1 eq

Hov II (0.05 eq), DCM, 65°, overnight



(77) 837

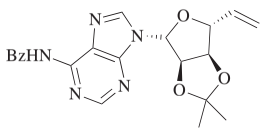
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

B. ALLYLIC ETHERS (*Continued*)

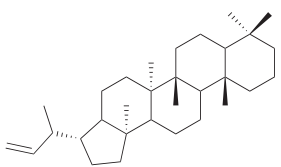
Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

C_{11}

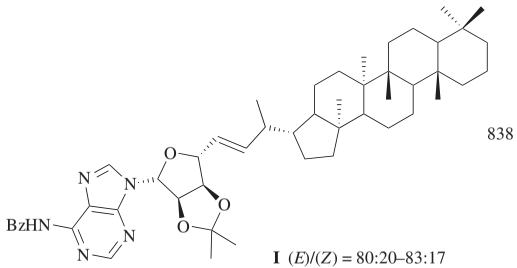


1 eq



x eq

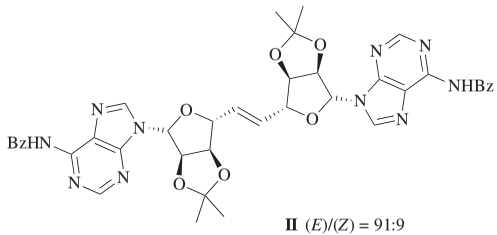
Catalyst (0.1 eq),
solvent



838

I (*E*)/(*Z*) = 80:20–83:17

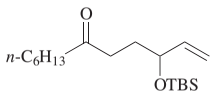
\+



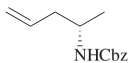
II (*E*)/(*Z*) = 91:9

x	Catalyst	Solvent	Temp (°)	Time (h)	**I**	**II**
1	Hov II	DCM	40	24	(0)	(0)
1	Hov II	DCM	75 (MW)	3	(13)	(43)
1	Ru cat **89**	DCM	75 (MW)	3	(12)	(45)
1	Gr II	DCM	75 (MW)	3	(6)	(0)
10	Ru cat **89**	DCM	75 (MW)	3	(59)	(40)
10	Hov II	DCM	75 (sealed tube)	overnight	(51)	(46)
10	Ru cat **89**	DCM	75 (sealed tube)	overnight	(52)	(43)
1	Hov II	C_6F_6	75 (MW)	3	(6)	(78)

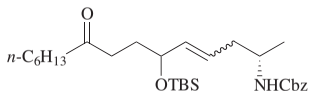
C_{12}



1.63 eq

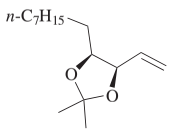


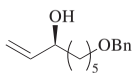
Hov II (0.05 eq), benzene, 75°



(60)

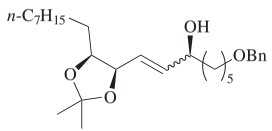
714





1.05 eq

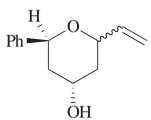
Gr II (0.05 eq), DCM, rt, 0.5 h



(70)

839

C_{13}

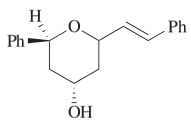


dr (*cis*/*trans*) 83:17



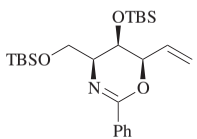
2 eq

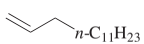
Gr II (0.1 eq), DCM, reflux, 8 h



(68) (*E*) only

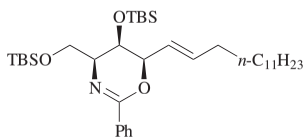
621





2 eq

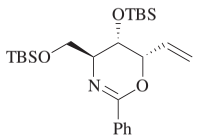
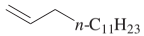
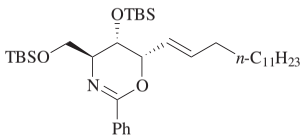
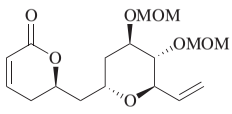
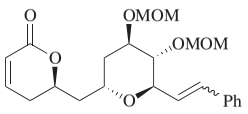
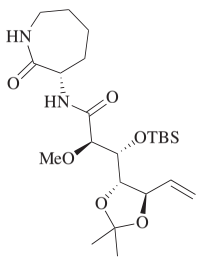
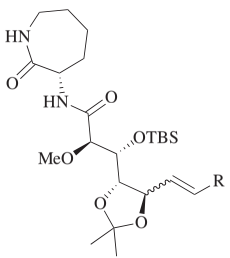
Gr II (0.05 eq), DCM, reflux, 8 h



(92) (*E*)/(*Z*) > 95:5

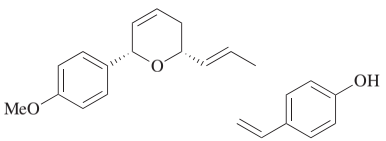
840

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)
B. ALLYLIC ETHERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{13} 	 2 eq	Gr II (0.05 eq), DCM, reflux, 12 h	 (94) (*E*)/(*Z*) > 95:5	841
		Gr II (0.1 eq), benzene, 8 h, 55°	 (87)	842
		Hov II (0.3 eq), DCM, 40°, 4 d		843

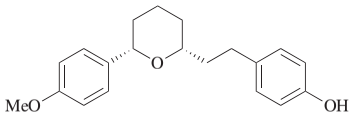
R	
i-Pr	(89)
t-Bu	(90)
s-Bu	(26)
i-Bu	(80)
t-BuCH$_2$	(74)
Ph	(94)
Cy	(77)

C_{14}



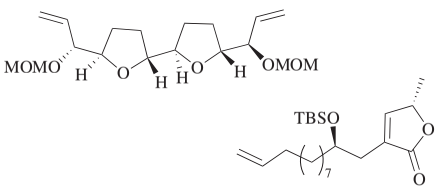
2 eq

1. Hov II (0.1 eq), toluene, rt, overnight
2. Pd/C (5%, 50 wt% water), H_2 (1 atm), rt, 4 d



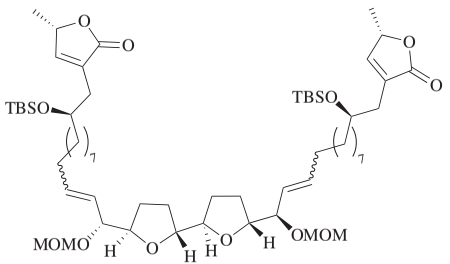
(50) er 99.0:1.0

844



2.05 eq

Gr II (0.05 eq), DCM, reflux, 16 h



(85)

845

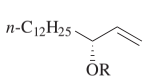
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

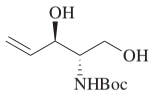
B. ALLYLIC ETHERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

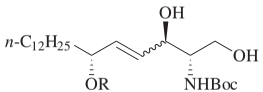
C_{15}





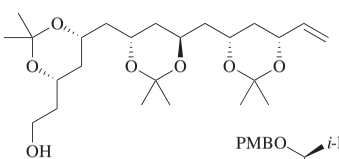
3 eq

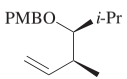
Gr II (0.2 eq), CuI (0.03 eq), solvent, 48 h



722

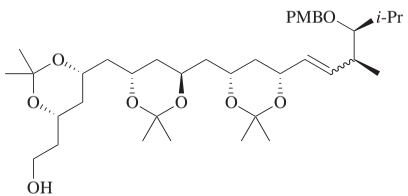
R	Solvent	Temp (°)	
H	DCM	40	(23)
H	DCE	80	(—)
Bz	DCM	40	(—)
TBS	DCM	40	(—)





3 eq

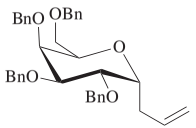
Hov II (0.1 eq), DCM, 40°, 24 h



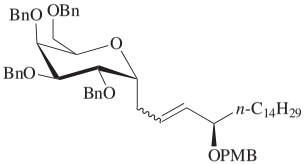
(53) 846

C_{17}

3 eq

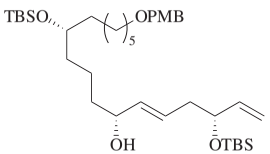


Gr II (0.25 eq),
DCM, 45°, 27 h

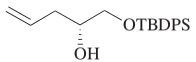


(34)

775

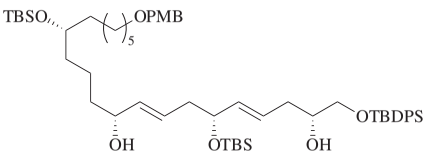


x eq



y eq

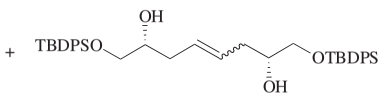
Catalyst (0.1 eq),
DCM, 45°, 3 h



I (*E*)/(*Z*) = 93:7

847

\+

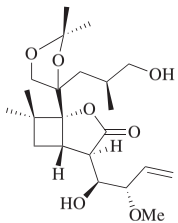
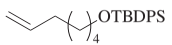
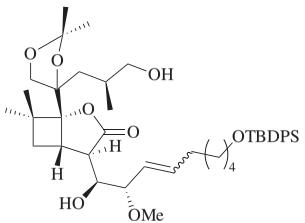
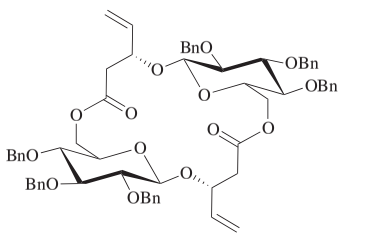
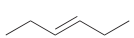
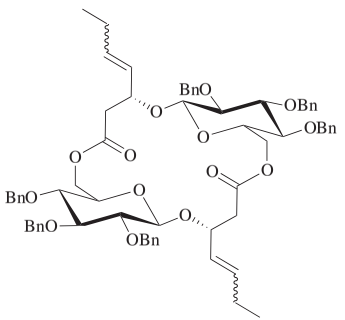


II

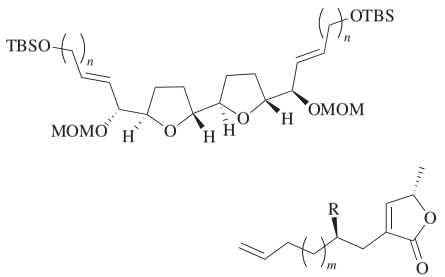
x	*y*	Catalyst	**I**	**II**
1	3	Gr II	(38)	(31)
1	3	Ru cat **89**	(26)	(34)
1.3	1	Gr II	(40)	(—)
3	1	Gr II	(70)	(—)

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

B. ALLYLIC ETHERS (*Continued*)

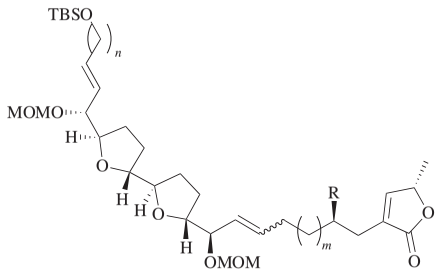
Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{18} 	 2.6 eq	Ru cat **89** (0.2 eq), toluene, 45°, 48 h	 (67)	848
C_{22} 	 4 x 10 eq	Gr II (4 x 0.02 eq), DCM, 40°, 4 d	 (89)	849

$C_{25–29}$



1.1 eq

Gr II (0.1 eq),
BQ (0.2 eq),
DCM, reflux



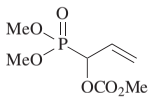
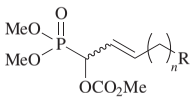
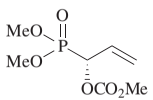
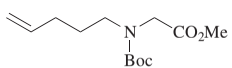
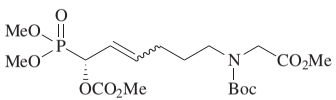
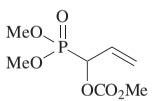
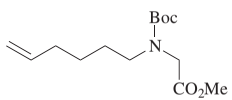
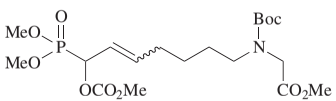
537

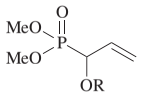
n	*m*	R	
4	7	TBSO	(41)
9	7	TBSO	(40)
9	6	H	(41)

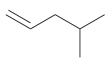
[a] The conversion was determined by ^{1}H NMR analysis.

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

C. ALLYLIC ESTERS

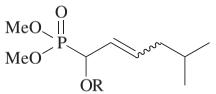
Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
	 *x* eq	Gr II (0.05 eq), solvent, 40°		221
 er 84.0:16.0	 2 eq	Gr II (3 x 0.025 eq), DCM, 40°	 (70) er 84.0:16.0	221
	 2 eq	Gr II (3 x 0.025 eq), DCM, 40°	 (94)	221



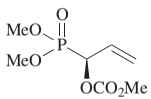


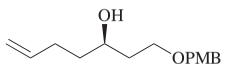
5 eq

Gr II (0.05 eq),
DCM, 40°



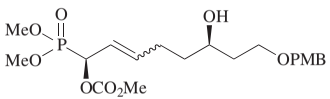
R		
MeO_2C	(92)	221
Ac	(90)	
TsHNCO	(88)	
TBS	(89)	
$AcCH_2CO$	(82)	





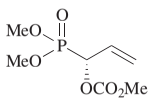
1 eq

Gr II (0.05 eq),
CuI (0.1 eq),
DCM, 40°, 10 h

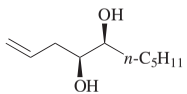


(78) 850

C_3

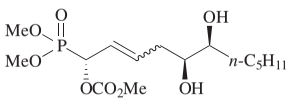


er ~ 100:0

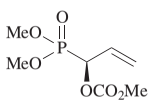


1 eq

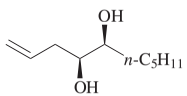
Gr II (0.05 eq),
DCM, 40°, 3 h



(74) 851

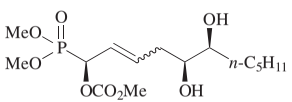


er > 97.5:2.5



1 eq

Catalyst (0.05 eq),
CuI (*x* eq)
DCM, 40°, 5 h

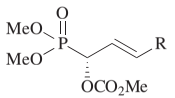
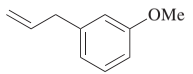
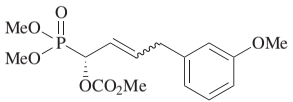
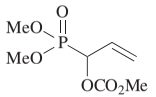
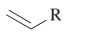
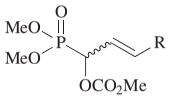
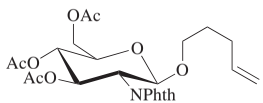
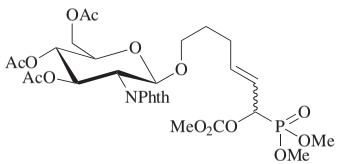


851

Catalyst	*x*	
Gr II	0.1	(20)
Hov II	—	(68)
Gr II	—	(74)

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

C. ALLYLIC ESTERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{3-9}				
 er 84.0:16.0	 1.5 eq	Gr II (0.05 eq), DCM, 40°	 er 84.0:16.0	221
C_3				
	 *x* eq	Gr II (0.05 eq), CuI (0.07 eq) DCM, 45°		852
3 eq		Gr II (0.05 eq), DCM, 40°		221

R	*x*		
n-$C_{10}H_{21}$	10	(79)	
n-$C_{12}H_{25}$	10	(76)	
n-$C_{16}H_{33}$	5	(70)	
n-$C_{18}H_{37}$	5	(70)	

R		
H	(69)	
Ph	(0)	

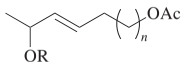
C_4





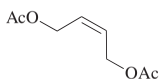
x eq

Catalyst (*y* eq),
DCM, reflux



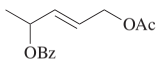
R	*n*	*x*	Catalyst	*y*	Time (h)	Conv. (%)[a]		(*E*)/(*Z*)	
Ac	3	—	Ru cat **149**	0.03	12	99	(—)	(*E*) only	853
Ac	4	—	Gr II	0.03	—	>95	(—)	95:5	854
Ac	4	—	Ru cat **33**	0.03	—	>95	(—)	75:25	854
Ac	4	—	Hov II	0.03	—	>95	(—)	95:5	854
Ac	4	—	Ru cat **223**	0.03	—	>95	(—)	95:5	854
Bz	2	3	Hov II	0.05	6	—	(82)	>95:5	177
Bz	2	3	Ru cat **271**	0.05	6	—	(93)	>95:5	177
Bz	3	2	Gr II	0.03	12	—	(82)	91:9	36





x eq

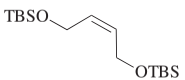
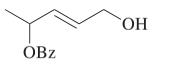
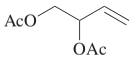
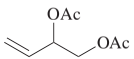
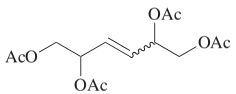
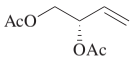
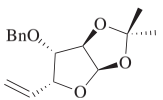
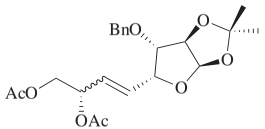
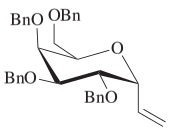
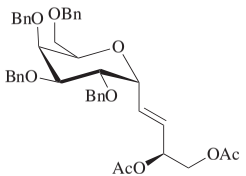
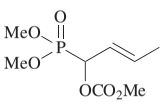
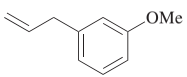
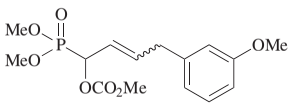
Catalyst (*y* eq), solvent



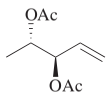
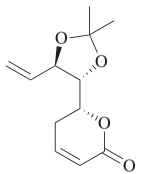
x	Catalyst	*y*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
1.8	Gr II	0.03	DCM	40	12	(38)	94:6	36
1.8	Gr II	0.03	benzene	reflux	6	(38)	—	177
1.8	Hov II	0.03	benzene	reflux	6	(59)	—	177
1.8	Ru cat **271**	0.03	benzene	reflux	6	(87)	—	177
2	Gr I	0.05	DCM	45	—	(30)	94:6	124

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

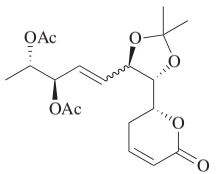
C. ALLYLIC ESTERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
	 2 eq	1. Gr I (0.05 eq), DCM, 45° 2. TBAF, THF	 (54) (*E*)/(*Z*) = 98:2	124
		Gr I (0.05 eq), DCM, reflux	 (27)	782
 2 eq		Gr II (0.036 eq), benzene, 16 h, reflux	 (64)	805
3.4 eq		Gr II (0.1 eq), DCM, 45°, 4 d	 (82) (*E*) only	855
	 2 eq	Gr II (0.05 eq), DCM, 40°, 24 h	 (36)	221

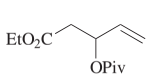
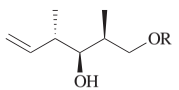
C_5

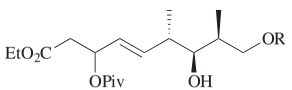
Gr II, DCM, reflux, 6 h



(67) 856

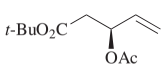
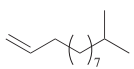



Gr II (*x* eq), DCM, MW



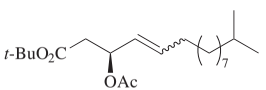
857

R	*x*	Temp (°)	Time (h)		(*E*)/(*Z*)
Tr	0.15	90	1	(—)	(*E*) only
TBS	0.20	70	2	(60)	—

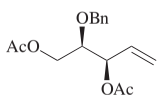
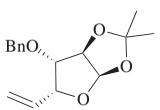



4 eq

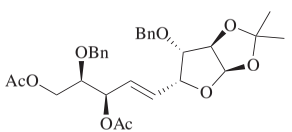
Gr II (0.05 eq), DCM, reflux, 24 h



(90) 858

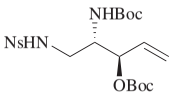
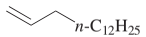
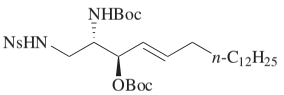
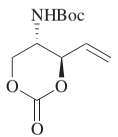
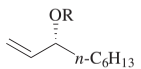
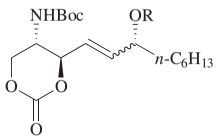
Gr II (0.035 eq), benzene, reflux, 37 h



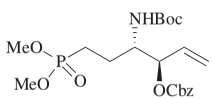
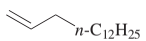
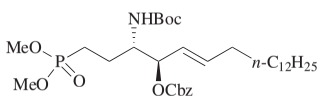
(62) (*E*) only 805

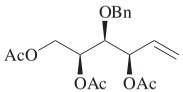
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

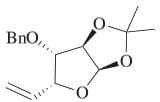
C. ALLYLIC ESTERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
	 4 eq	Gr II (0.03 eq), DCM, reflux, 7 h	 (72) (*E*) only	741
 3 eq		Catalyst (0.2 eq), CuI (*x* eq), solvent		722

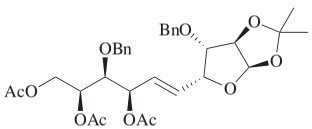
R	Catalyst	*x*	Solvent	Temp (°)	Time (h)	
H	Gr II	—	DCE	80	48	(—)
H	Hov II	—	DCM	40	70	(48)
H	Gr II	0.3	toluene	40	48	(78)
H	Gr II	0.3	Et_2O	rt	48	(83)
H	Gr II	—	DCM	40	48	(48)
Bz	Gr II	—	DCM	40	48	(—)
TBS	Gr II	—	DCM	40	48	(—)
PMP	Gr II	—	DCM	40	48	(37)
MOM	Gr II	—	DCM	40	66	(43)

C_6				
	 4 eq	Gr II (0.03 eq), DCM, reflux, 7 h	 (68) (*E*) only	741

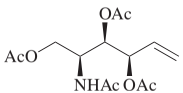


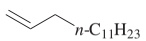


Gr II (0.07 eq), benzene, reflux, 48 h



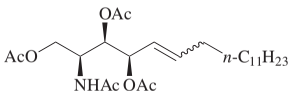
(51) (*E*) only 805



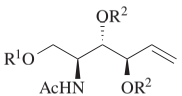


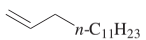
5 eq

Gr II (0.2 eq), DCM, reflux, 18 h



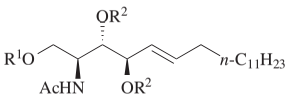
(73) 800





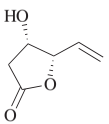
5 eq

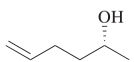
Gr II (0.2 eq), DCM, reflux, 18 h



800

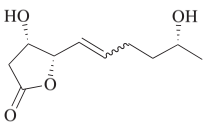
R^1	R^2		(*E*)/(*Z*)
H	Bz	(91)	93:7
Ac	Ac	(86)	—





1.5 eq

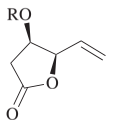
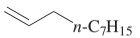
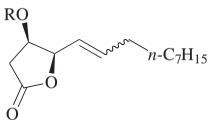
Gr II (0.02 eq), DCM, reflux, 48 h



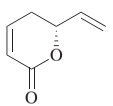
(78) 859

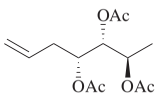
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

C. ALLYLIC ESTERS (*Continued*)

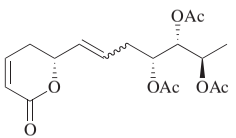
Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6 	 *x* eq	Catalyst (0.02 eq), DCM, reflux, 72 h		860

R	*x*	Catalyst	
H	1.5	Gr II	(90)
TBS	2	Hov II	(45)

C_7  *x* eq

 *y* eq

Gr II (*z* eq), DCM, reflux, 4 h



x	*y*	*z*		
1	5	0.32	(66)	1215
4	1	0.57	(55)	862

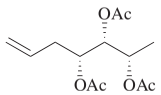
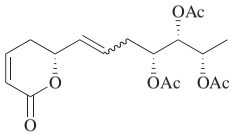
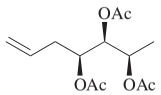
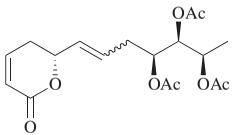
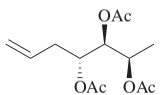
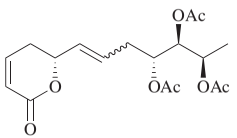
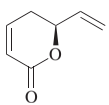
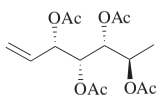
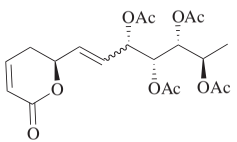
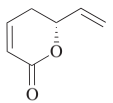
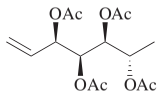
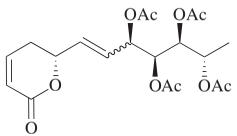
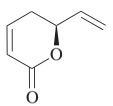
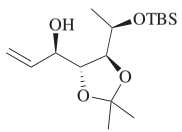
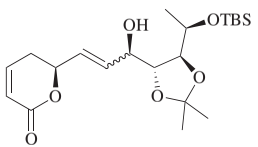
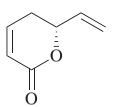
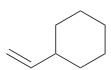
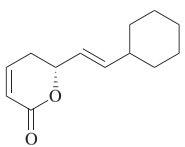
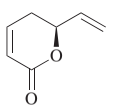
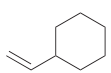
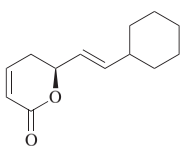
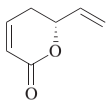
4.86 eq		Gr II (0.46 eq), DCM, reflux, 2 h		(67)	1215
4 eq		Gr II (0.5 eq), DCM, reflux, 4 h		(68)	863
4 eq		Gr II (0.5 eq), DCM, reflux, 4 h		(70)	863
 5 eq		Gr II (0.1 eq), DCM, reflux, 8 h		(62)	864

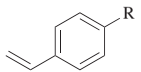
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

C. ALLYLIC ESTERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_7				
 2 eq		Gr II (0.02 eq), DCM, reflux, 5 h	 (68)	865
 2 eq		Gr II (0.02 eq), DCM, reflux, 5 h	 (82)	865
	 7.5 eq	Hov II (0.03 eq), DCM, 40°, 36 h	 (89) $(E)/(Z) > 95:5$	866
	 7.5 eq	Catalyst (0.03 eq), DCM, 40°, 36 h	 $(E)/(Z) > 95:5$	Catalyst / Gr II (88) / Hov II (93) 866

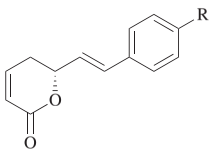


x eq

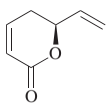


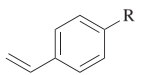
y eq

Catalyst (*z* eq), DCM



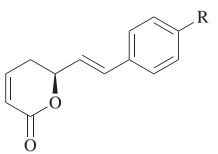
x	R	*y*	Catalyst	*z*	Temp (°)	Time (h)		(*E*)/(*Z*)	
21	H	1	Gr II	0.56	50	4	(70)	—	867
1	H	7.5	Hov II	0.03	40	36	(87)	>95:5	866
1	MeO	7.5	Hov II	0.03	40	36	(31)	>95:5	866





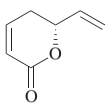
7.5 eq

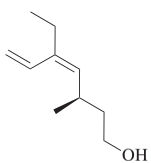
Catalyst (0.03 eq),
DCM, 40°, 36 h



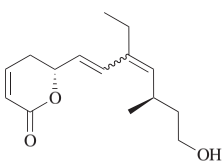
(*E*)/(*Z*) > 95:5

R	Catalyst		
H	Gr II	(46)	866
H	Hov II	(90)	
MeO	Gr II	(48)	
MeO	Hov II	(54)	





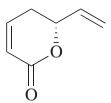
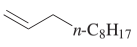
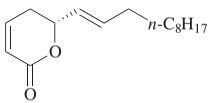
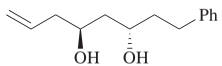
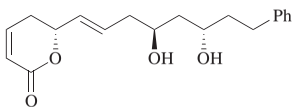
Gr II, benzene, 55°



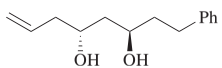
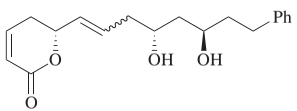
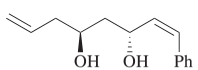
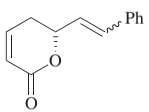
(48) 868

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

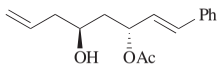
C. ALLYLIC ESTERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_7				
	 7.5 eq	Catalyst (0.03 eq), DCM, 40°, 36 h	 Catalyst (*E*)/(*Z*) Gr II (85) 89:11 Hov II (72) 50:50	866
x eq		Catalyst (*y* eq), DCM		

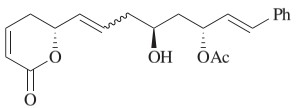
x	Catalyst	*y*	Temp (°)	Time (h)		(*E*)/(*Z*)	
5	Gr II	0.15	50	4	(63)	(*E*) only	720
5	Gr II	0.15	50	4	(66)	(*E*) only	869
0.25	Gr II	0.05	50	3	(55)	(*E*) only	870
0.5	Hov II	0.05	40	1.5	(77)	—	871

1.5 eq		Gr II (0.05 eq), DCM, reflux, 10 h		(65)	739
	 2 eq	Gr II (0.004 eq), DCM, 50°, 3 h		(82)	872

2 eq

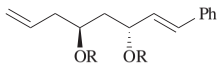


Gr II (0.01 eq),
DCM, 50°, 3 h

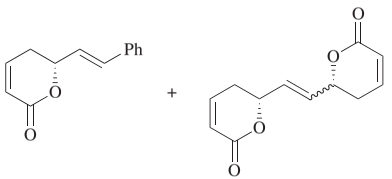


(71) 867

1.5 eq



Gr II (0.1 eq),
DCM, reflux

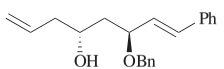


I **II**

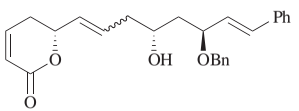
R	Time (h)	**I**	(*E*)/(*Z*) **I**	**II**
H	0.25	(0)	—	(90)
Ac	4	(80)	(*E*) only	(0)

873

1.2 eq



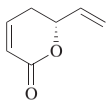
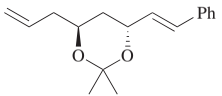
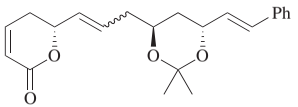
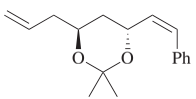
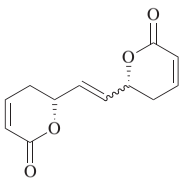
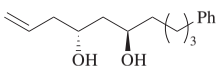
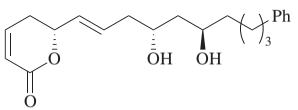
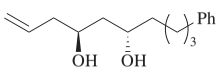
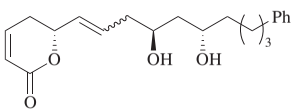
Gr II (0.03 eq),
DCM, reflux, 8 h



(74) 874

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

C. ALLYLIC ESTERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_7				
	 1.4 eq	Gr II (0.1 eq), DCM, reflux, 4 h	 (69)	875
	 2 eq	Gr II (0.004 eq), DCM, 50°, 4 h	 (70)	872
	 5 eq	Gr II (0.15 eq), DCM, 50°, 4 h	 (68) (*E*)/(*Z*) > 95:5	869
		Hov II (0.06 eq), DCM, 40°, 1.5 h	 (73)	871

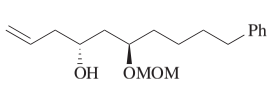
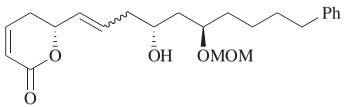
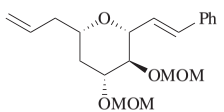
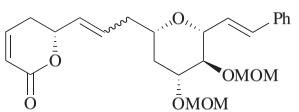
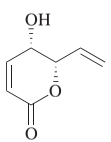
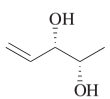
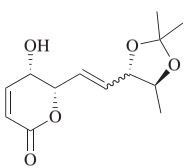
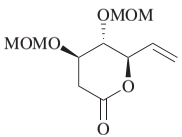
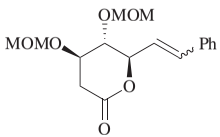
3 eq		Gr II (0.05 eq), DCM, 40°, 12 h		(74)	876
1.5 eq		Gr II (0.07 eq), DCM, reflux, 6 h		(87)	877
2 eq	 	1. Gr II (0.005 eq), DCM, 40° 2. PPTS, 2,2-DMP (5 eq), 0°, 1 h		(80)	380
 2.96 eq		Gr II (0.1 eq), benzene, 55°, 5 h		(87)	877

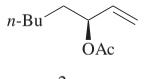
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

C. ALLYLIC ESTERS (*Continued*)

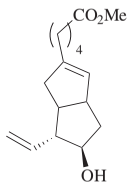
Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

C_8

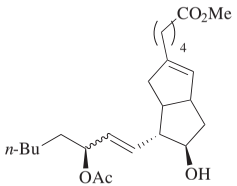


2 eq

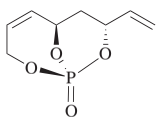


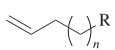
(±)

Hov II (0.1 eq), DCM, rt, 2 h



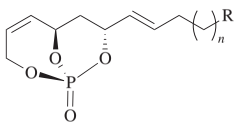
(±) (75) 878



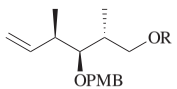


x eq

Hov II (*y* eq), solvent

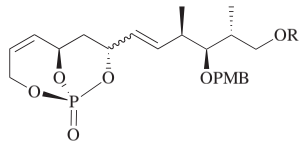


x	R	*n*	*y*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
1.1	BocHN	0	0.1	DCM	reflux	3–6	(69)	99:1	719
1.1	HO	0	0.1	DCM	reflux	3–6	(86)	99:1	719
1.1	TBSO	0	0.1	DCM	reflux	3–6	(87)	99:1	719
1.1	$(MeO)_2P(O)$	0	0.1	DCM	reflux	3–6	(80)	67:33	719
1.5	PMBO	2	0.06	DCE	90	2	(82)	>95:5	879, 880
1.1	Me	7	0.1	DCM	reflux	2	(72)	>99:1	881

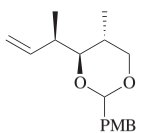


2 eq

Hov II (*x* eq), solvent, 6 h

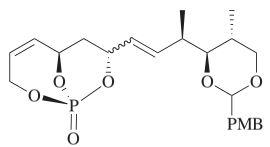


R	*x*	Solvent	Temp (°)		
TBDPS	0.06	toluene	60	(—)	882
TBDPS	0.06	toluene	90	(28)	882
TBDPS	0.12	toluene	90	(31)	882
TBS	0.06	DCM	50	(42)	882
TBS	0.06	toluene	90	(45)	882
TBS	0.12	toluene	90	(60)	882
TBS	0.06	DCE	90	(72)	879



2 eq

Hov II (0.06 eq),
solvent, 6 h

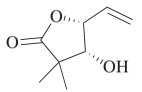
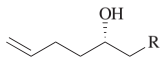
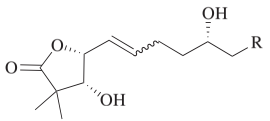
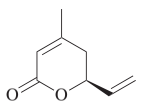
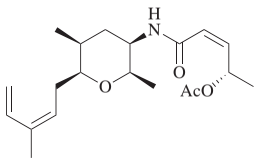
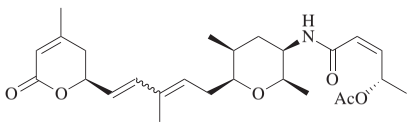
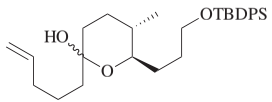
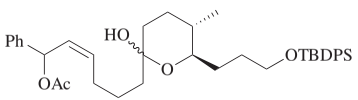
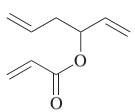
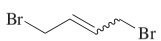
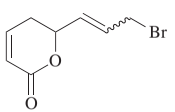


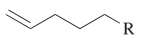
882

Solvent	Temp (°)	
DCM	50	(32)
toluene	90	(63)
DCE	90	(73)

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

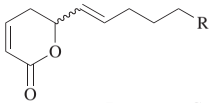
C. ALLYLIC ESTERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
	 1.3 eq	Gr II (0.02 eq), DCM, reflux, 12 h	 R: TsO (89); n-C_6H_{13} (77)	883
 1.5 eq		Gr II (0.1 eq), DCM, 40°, 5 h	 (71)	884
C_9				
 3 + 2 eq		1. Hov II (0.15 eq), DCM, 80° (MW), 105 min 2. CSA, THF, rt, 2 h	 (88)	885
	 5 eq	Gr II (0.05 eq), DCM, 50°, 8 h	 (40)	886



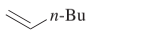
5 eq

Catalyst (0.05 eq),
DCM, 50°, 8 h



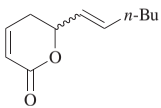
R	Catalyst	
Br	Gr I	(9)
Br	Gr II	(78)
TBSO	Gr II	(69)

886



5 eq

Gr II (0.05 eq),
DCM, 50°, 8 h



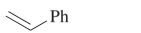
(17)

+



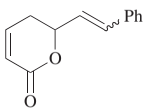
(52)

886



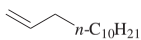
5 eq

Gr II (0.05 eq),
DCM, 50°, 8 h



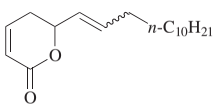
(61)

886



5 eq

Gr II (0.05 eq),
DCM, 50°, 8 h

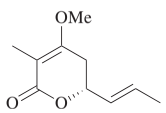
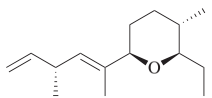
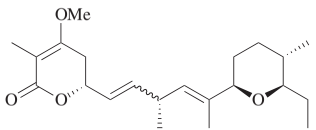
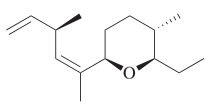
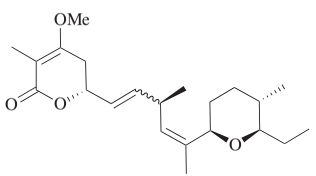
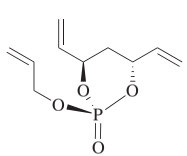
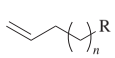
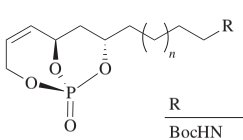


(73)

886

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

C. ALLYLIC ESTERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
 3.38 eq		Ru cat **88** (2 × 0.06 eq), $C_6F_5CF_3$, 88°, 4 h	 (98)	529
3 eq		Ru cat **88** (0.04 + 0.11 eq), $C_6F_5CF_3$, 70°, 4 h	 (76)	529
C_{10}				
 **I**	 1–1.5 eq	1. Hov II (0.06 eq), BQ, DCM, reflux, 0.75 h, 2. Hov II (0.04 eq), **I**, CuI, DCM, reflux, 2–3 h 3. *o*-NBSH (15 eq), Et_3N, rt, overnight		716

R	*n*	
BocHN	0	(59)
TBSO	0	(52)
$(PhO)_2P(O)$	0	(40)
PMBO	3	(43)
Me	6	(65)

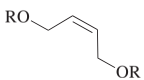
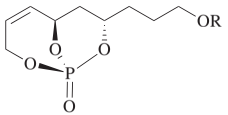
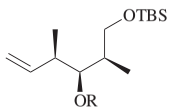
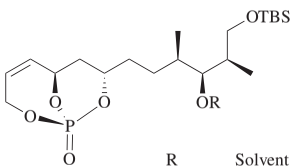
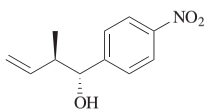
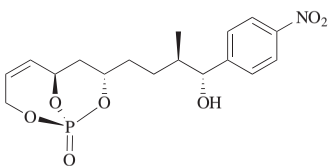
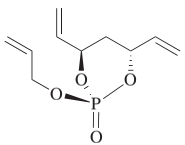
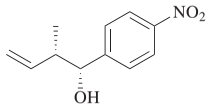
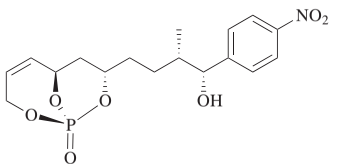
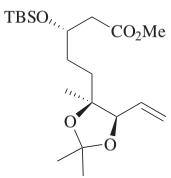
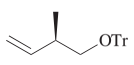
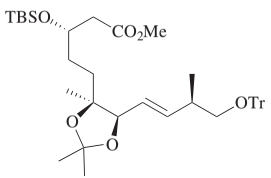
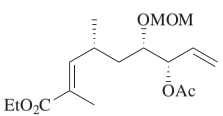
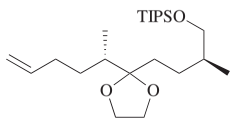
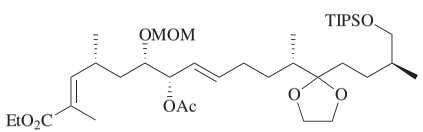
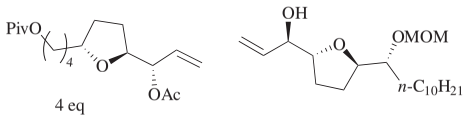
I	 1–1.5 eq	1. Hov II (0.06 eq), BQ, DCM, reflux, 0.75 h, 2. Hov II (0.04 eq), **I**, CuI, DCM, reflux, 2–3 h 3. *o*-NBSH (15 eq), Et_3N, rt, overnight		R H (64) Ac (56)	716
I	 2–4 eq	1. Hov II (0.06 eq), BQ, solvent, reflux, 0.75 h, 2. Hov II (0.04 eq), **I**, CuI, solvent, reflux, 4–6 h 3. *o*-NBSH (15 eq), Et_3N, rt, overnight		R Solvent H DCE (54) PMB DCM (30)	716
I	 2–4 eq	1. Hov II (0.06 eq), BQ, DCM, reflux, 0.75 h, 2. Hov II (0.04 eq), **I**, CuI, DCM, reflux, 4–6 h 3. *o*-NBSH (15 eq), Et_3N, rt, overnight		(85)	716

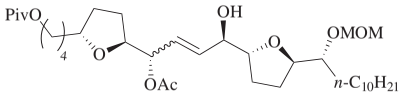
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

C. ALLYLIC ESTERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{10}				
 **I**	 2–4 eq	1. Hov II (0.06 eq), BQ, DCM, reflux, 0.75 h, 2. Hov II (0.04 eq), **I**, CuI, DCM, reflux, 4–6 h 3. *o*-NBSH (15 eq), Et_3N, rt, overnight	 (79)	716
	 4 eq	Hov II (0.2 eq), DCM, 40°	 (76) (*E*) only	887
C_{11}				
	 2.1 eq	Gr II (0.09 eq), DCM, 45°	 (86) (*E*)/(*Z*) = 83:17	835

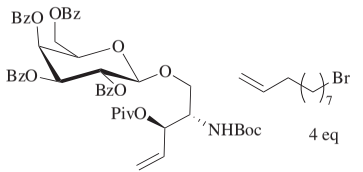


1. Gr II (0.1 eq), DCM, rt, 18 h
2. Gr II (0.1 eq), reflux, 4 h

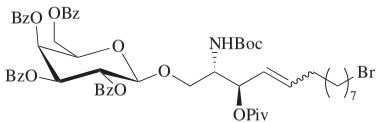


(98)

888



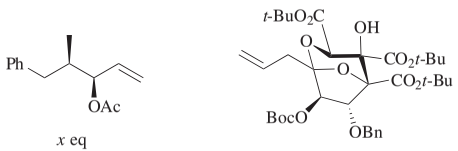
Gr II (0.3 eq), DCM, reflux, 16 h



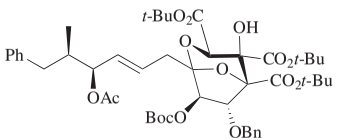
(63)

889

C_{12}



Catalyst (*y* eq), benzene



890

x	Catalyst	*y*	Temp (°)		(*E*)/(*Z*)
1.2	Gr II	0.05	70	(67)	(*E*) only
1.2	Gr II	0.1	70	(60)	(*E*) only
2	Gr II	0.1	70	(60)	(*E*) only
1.5	Hov II	0.05	70	(62)	(*E*) only
1.2	Ru cat **112**	0.05	60	(48)	89:11
1.2	Ru cat **112**	0.2	60	(46)	89:11
2	Ru cat **112**	0.2	60	(90)	89:11

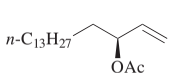
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

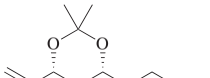
C. ALLYLIC ESTERS (*Continued*)

Allylic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

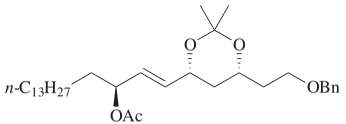
C_{17}





1.2 eq

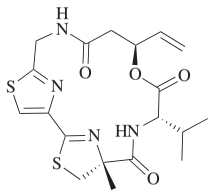
Gr II (0.04 eq),
DCM, 40°, 10 h

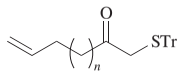


(78) (*E*) only

891

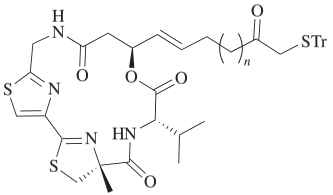
C_{19}



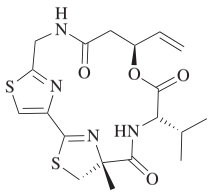


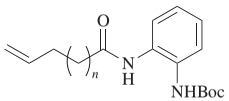
x eq

Catalyst (*y* eq), solvent



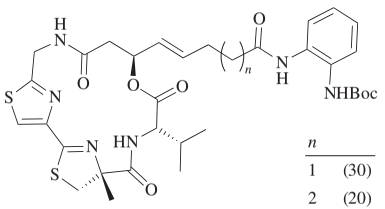
n	*x*	Catalyst	*y*	Solvent	Temp	Time (h)		
1	4 x 2	Hov II	4 x 0.2	toluene	reflux	4	(51)	893
2	4 x 2	Hov II	4 x 0.2	toluene	reflux	4	(62)	893
2	3.5	Ru cat **88**	0.15	DCE	90°	15	(52)	892





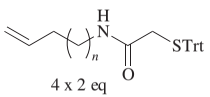
4 x 2 eq

Gr II (4 × 0.2 eq),
toluene, reflux, 4 h



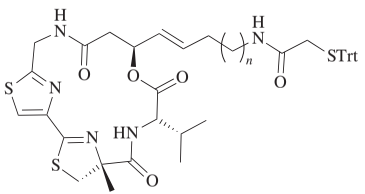
n	
1	(30)
2	(20)

893



4 x 2 eq

Catalyst (4 × 0.2 eq),
toluene, reflux, 4 h



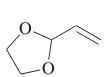
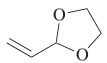
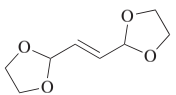
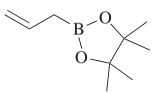
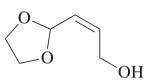
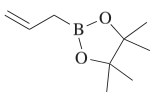
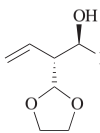
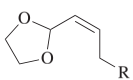
n	Catalyst	
0	Hov II	(42)
1	Gr II	(15)

893

[a] The conversion was determined by ^{1}H NMR analysis.

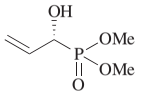
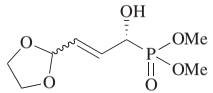
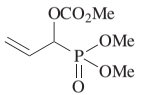
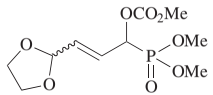
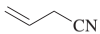
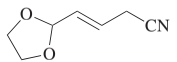
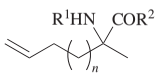
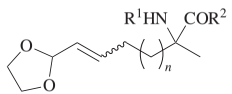
TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

D. ACETALS

Acetal	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
		Gr I (0.05 eq), DCM, 45°, 17 h	 (52) $(E)/(Z)$ = 90:10	124
	 4 eq	1. Ru cat **216** (0.02 eq), THF, 35°, 5 h 2. NaOH, H_2O_2	 (63) $(Z)/(E)$ = 95:5	461
3 eq		1.Gr II (x eq), DCM, reflux, 2–12 h 2. PhCHO (1.5 eq), 23°, 12–48 h		126
	 4 eq	Ru cat **216** (0.02 eq), THF (0.5 M), 35°		461

x		$anti/syn^a$
0.05	(68)	>95:5
0.02	(69)	>95:5

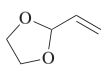
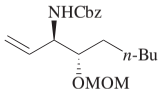
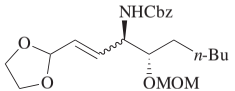
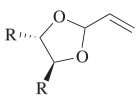
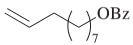
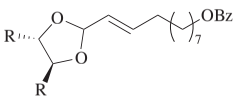
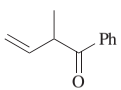
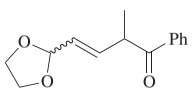
R	Time (h)		$(Z)/(E)$
BnPhN	5	(72)	89:11
$HO(CH_2)_2$	5	(74)	95:5
$Br(CH_2)_2$	5	(83)	95:5
Ph	3	(88)	95:5
$MeO_2C(CH_2)_7$	5	(84)	95:5
n-C_9H_{19}	5	(85)	95:5

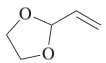
5 eq	 er 85.0:15.0	Gr II (0.05 eq), $CHCl_3$, 40°	 (30) er 85.0:15.0	221
5 eq		Gr II (0.05 eq), DCM, 40°	 (32)	221
2 eq		Gr II (0.05 eq), DCM, reflux, 2 h	 (26) $(E)/(Z)$ = 71:29	154
4 eq		Gr II (0.05 eq), toluene, rt, 17 h		457

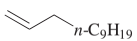
R^1	R^2	n	
Boc	H_2N	0	(74)
Boc	MeO	0	(45)
OHC	MeO	0	(49)
Boc	H_2N	1	(71)
Boc	MeO	1	(52)
Boc	MeO	2	(50)

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

D. ACETALS (*Continued*)

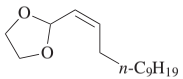
Acetal	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 3 eq		Gr II (0.1 eq), DCM, reflux, overnight	 (87)	894
 2 eq		Gr I (x eq), DCM, 45°, 12 h	 $(E)/(Z)$ = 88:12	124, 897
			R / x: H 0.01 (74); H 0.02 (87); H 0.025 (93); H 0.05 (91); EtO_2C 0.025 (86)	
10 eq		Ru cat **89** (0.05 eq), DCM, reflux, 48 h	 (68)	895





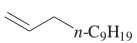
x eq

Ru cat **216** (*y* eq), THF, 35°



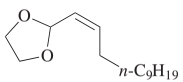
461

x	*y*	Conc (M)	Time (h)		(*Z*)/(*E*)
6	0.05	0.5	3	(84)	93:7
4	0.05	0.5	3	(87)	94:6
2	0.05	0.5	3	(80)	95:5
4	0.02	0.5	3	(83)	95:5
4	0.02	0.3	3	(92)	94:6
2	0.02	0.5	3	(80)	95:5
2	0.02	1.0	3	(66)	95:5
2	0.02	0.3	3	(82)	95:5
2	0.01	0.5	3	(74)	95:5
2	0.02	0.3	7	(87)	94:6



x eq

Ru cat **216** (0.02 eq),
THF (0.5 M), 35°

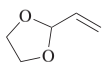
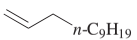
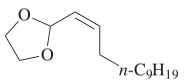
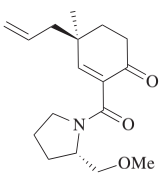
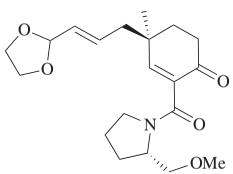
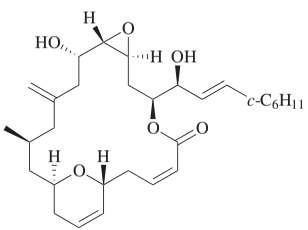
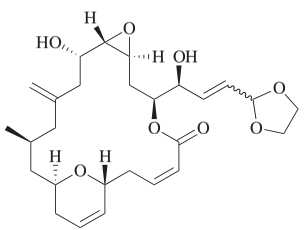


461

x	Time (h)		(*Z*)/(*E*)
2	3	(63)	93:7
4	3	(65)	91:9
0.5	3	(82)	95:5
0.25	3	(92)	94:6
2	7	(84)	92:8
4	7	(94)	91:9

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

D. ACETALS (*Continued*)

Acetal	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
	 4 eq	Catalyst (0.02 eq), THF (0.3 M), 35°, 3 h	 Catalyst (Z)/(E) Ru cat **215** (87) 76:24 Ru cat **216** (92) 94:6 Gr I (96) 10:90 Hov II (92) 5:95	461
3 eq		Hov II (0.025 eq), DCM, reflux, 7 h	 (86) (*E*) only	896
20 eq		Gr II (0.3 eq), DCM, rt, 4 h	 (41)	780

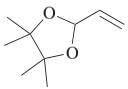
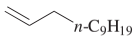
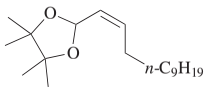
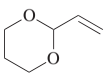
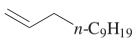
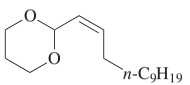
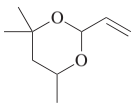
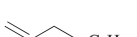
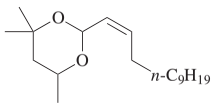
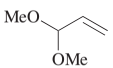
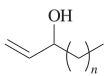
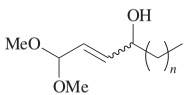
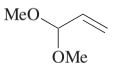
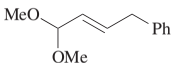
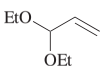
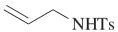
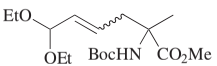
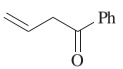
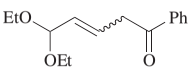
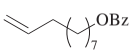
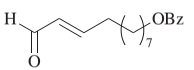
	 4 eq	Ru cat **216** (0.02 eq), THF, 35°, 5 h		(84)	(*Z*)/(*E*) = 95:5 461
	 4 eq	Ru cat **216** (0.02 eq), THF, 35°, 5 h		(79)	(*Z*)/(*E*) = 95:5 461
	 4 eq	Ru cat **216** (0.02 eq), THF, 35°, 5 h		(85)	(*Z*)/(*E*) = 95:5 461
 3 eq		Hov II (2 x 0.0125 eq), DCM, rt, 20 h		*n* 1 4 7	(55) (65) (50) 898

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

D. ACETALS (*Continued*)

Acetal	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 2 eq		Gr I (0.05 eq), DCM, reflux, 16 h	 (59) (*E*)/(*Z*) > 95:5	156
 5 eq		Hov II (0.05 eq), $(PhO)_3B$ (0.1 eq), toluene, 80°, 0.5 h	 (60)	899
4 eq		Gr II (0.05 eq), toluene, rt, 17 h	 (66)	457
10 eq		Ru cat **89** (0.05 eq), DCM, 40°, 48 h	 (50)	895
x eq		1. Gr I (0.05 eq), solvent, 45°, 12 h 2. HCO_2H, DCM	 (*E*)/(*Z*) = 96:4	897

x	Solvent	
4	DCM	(72)
2	DCM	(75)
65	—	(<10)

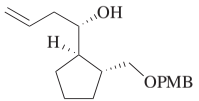
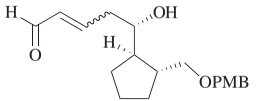
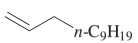
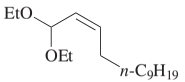
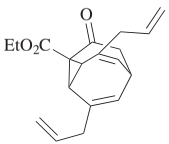
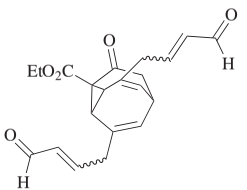
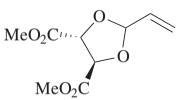
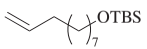
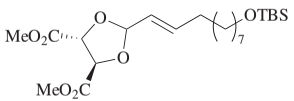
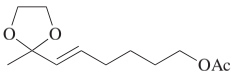
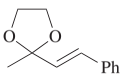
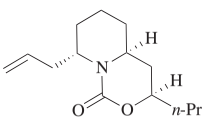
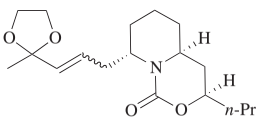
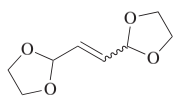
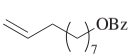
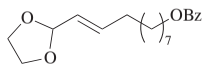
3 eq		1. Hov II (0.05 eq), DCM, 45°, 18 h 2. Acidic work-up		(75)	900
 4 eq		Ru cat **216** (0.02 eq), THF, 35°, 5 h		(70) (*Z*)/(*E*) = 95:5	461
21 eq		1. Gr II (0.15 eq), DCM, 40°, 12 h 2. HCl, THF		(46)	901
 2 eq		Gr I (0.05 eq), DCM, 45°, 12 h		(94) (*E*)/(*Z*) = 86:14	124

TABLE 13. CROSS-METATHESIS OF SECONDARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

D. ACETALS (*Continued*)

Acetal	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
		Gr II (*x* eq), DCM, 40°, 12 h		
			x (91) (*E*)/(*Z*)	
			0.037 (91) (*E*) only	36
			0.02 (95) —	902
2 eq		Gr II (*x* eq), DCM, 12 h		
			x Temp (°) (*E*)/(*Z*)	
			0.03 40 (70) (*E*) only	36
			0.05 reflux (71) >95:5	145
6 eq		Hov II (2 x 0.5 eq), toluene, 80° (MW), 2 x 0.5 h	 (80) dr 10:1	525
 2 eq		Gr I (0.05 eq), DCM, 45°, 17 h	 (44) (*E*)/(*Z*) = 91:9	124

[a] The ratio was determined by ^{1}H NMR analysis.

TABLE 14. CROSS-METATHESIS OF TERTIARY ALLYLIC ALCOHOLS AND DERIVATIVES

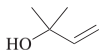
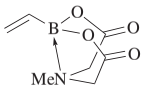
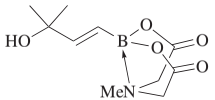
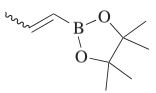
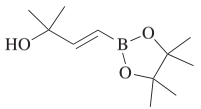
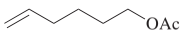
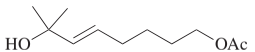
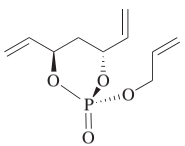
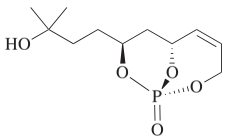
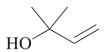
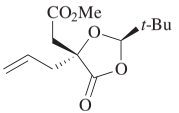
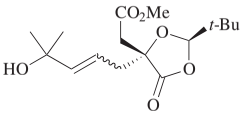
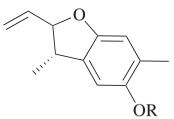
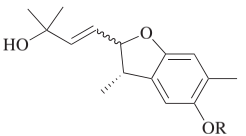
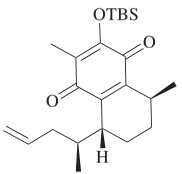
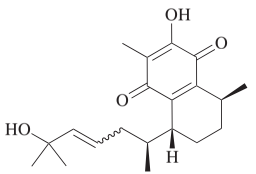
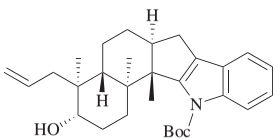
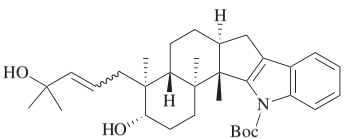
Tertiary Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
 2.5 eq		Gr II (0.1 eq), DCM, 40°, 12 h	 (94) (*E*)/(*Z*) > 95:5	701
	 2 eq	Gr II (0.05 eq), DCM, reflux	 (61) (*E*)/(*Z*) > 95:5	687
2.2 eq		Gr II (0.06 eq), DCM, 40°, 12 h	 (58) (*E*) only	36
2–4 eq		1. Hov II (0.06 eq), BQ, DCM, reflux, 0.75 h 2. Hov II (0.04 eq), allylic alcohol, CuI, DCE, reflux, 4–6 h 3. *o*-NBSH (15 eq), Et_3N, rt, overnight	 (72)	716

TABLE 14. CROSS-METATHESIS OF TERTIARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

Tertiary Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
 90 eq		Gr II (0.05 eq), 45°, 18 h	 (80)	903
5 eq		Gr II (0.1 eq), DCM, 40°, 20 h	 R: H (32); TBS (98)	904
5 eq		1. Gr II (0.1 eq), DCM, reflux 2. TBAF	 (60)	905
20 + 14 eq		Gr II (0.27 + 0.14 eq), DCM, reflux, 1.5 h	 (71)	906

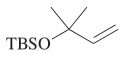
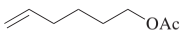
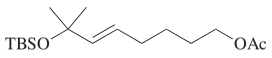
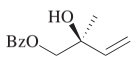
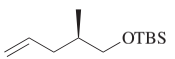
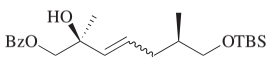
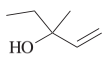
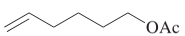
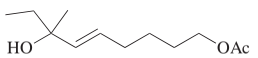
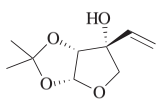
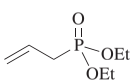
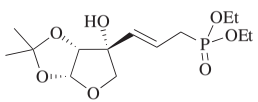
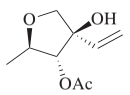
 2.2 eq		Gr II (0.06 eq), DCM, 40°, 12 h		(97) (*E*) only	36
	 1.2 eq	Hov II (0.06 eq), $PhCF_3$, 85°, 2 h		(62)	342
C_6						
 2 eq		Gr II (0.048 eq), DCM, 40°, 12 h		(93) (*E*) only	36
	 3 eq	Gr II (0.05 eq), DCM, reflux, overnight		(93) (*E*) only	907

TABLE 14. CROSS-METATHESIS OF TERTIARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

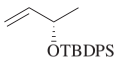
Tertiary Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

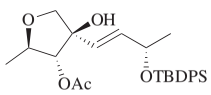
C_7



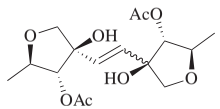
x eq



Hov II (0.1 eq), solvent



+



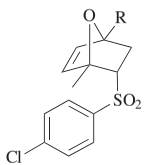
I (60), (*E*) only

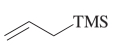
II

908

x	Solvent	Temp (°)	Time (h)	**II**
2	DCM	40	20	(10)
2	toluene	110	1	(10)
0.5	DCM	40	20	(5)
0.5	toluene	110	1	(5)

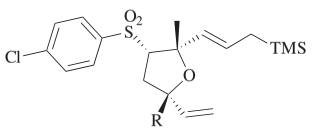
C_{7-8}





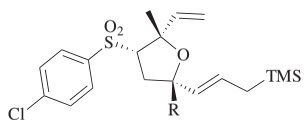
x eq

Hov II (*y* eq), additive, DCE, 12 h



I

+

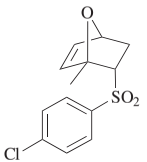


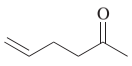
II

909

R	*x*	*y*	Additive	Temp (°)	**I** + **II**	**I**/**II**
H	10	0.01	—	70	(76)	92:8
Me	6	0.05	ethylene	0	(89)	**I** only
Me	10	0.025	—	25	(94)	**I** only

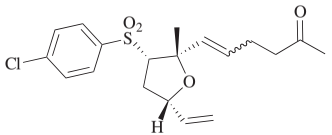
C_7





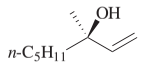
6 eq

Hov II (0.01 eq),
DCE, 84°

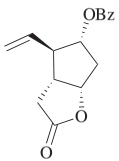


(59) 909

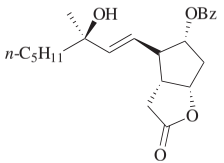
C_9



5 eq



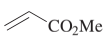
Gr II (0.1 eq),
DCM, rt, 16 h



(60) (*E*) only 910

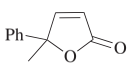
C_{10}



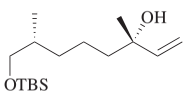


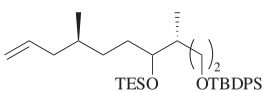
10 eq

1. Ru cat **163** (0.03 eq),
DCM, rt, hν (350 nm)
2. Phenanthrene
(2.3 eq),
DCM, rt, hν (254 nm)



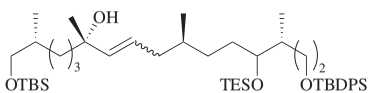
(52) 911





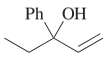
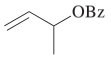
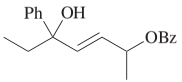
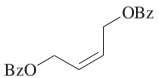
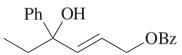
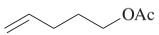
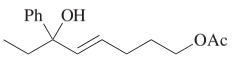
1.25 eq

Hov II (0.06 eq),
$PhCF_3$, 85°, 2 h

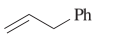


(60) 342

TABLE 14. CROSS-METATHESIS OF TERTIARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

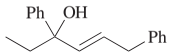
Tertiary Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)		Refs.
Please refer to the charts preceding the tables for the catalyst structures.					
C_{11}					
	 3 eq	Catalyst (0.05 eq), DCM, reflux, 6 h	 (*E*)/(*Z*) = 60:40	Catalyst Hov II (50) Ru cat **271** (66)	177
	 3 eq	Catalyst (0.05 eq), DCM, reflux, 6 h	 (*E*)/(*Z*) > 95:5	Catalyst Hov II (81) Ru cat **271** (98)	177
	 3 eq	Catalyst (*x* eq), solvent			

Catalyst	*x*	Solvent	Temp (°)	Time	Conv. (%)[a]		(*E*)/(*Z*)	
Hov II	0.05	DCM	40	6 h	—	(70)	60:40	177
Ru cat **271**	0.05	DCM	40	6 h	—	(89)	60:40	177
Ind II	3 x 0.02	$C_6F_5CF_3$	120	3 x 10 min	90	(—)	>95:5	40
Ind II	3 x 0.02	$C_6F_5CF_3$	120	3 x 10 min (MW)	95	(86)	>95:5	40



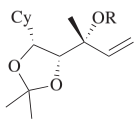
3 eq

Catalyst (*x* eq),
solvent



Catalyst	*x*	Solvent	Temp (°)	Time	Conv. (%)[a]		(*E*)/(*Z*)	
Hov II	0.05	DCM	40	6 h	—	(64)	60:40	177
Ru cat **271**	0.05	DCM	40	6 h	—	(91)	60:40	177
Ind II	3 x 0.02	$C_6F_5CF_3$	120	3 x 10 min	69	(—)	>95:5	40
Ind II	3 x 0.02	$C_6F_5CF_3$	120	3 x 10 min (MW)	91	(82)	>95:5	40

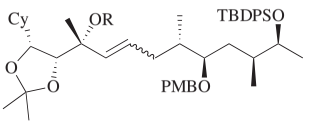
C_{12}



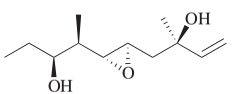
2 eq



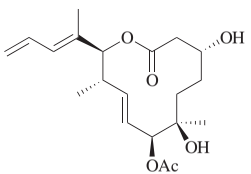
Hov II (0.08 eq),
DCM, reflux, 12 h



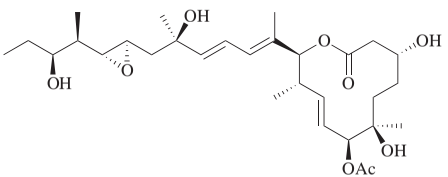
R		
H	(38)	912
PMB	(0)	



2 eq



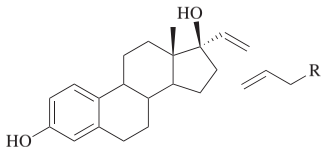
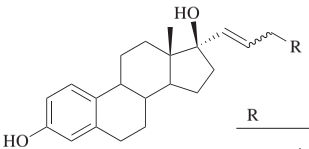
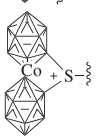
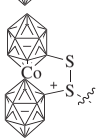
Gr II (0.05 eq),
DCM, reflux



(64) (*E*) only

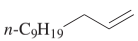
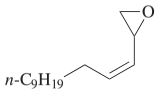
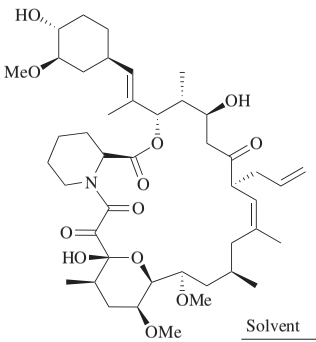
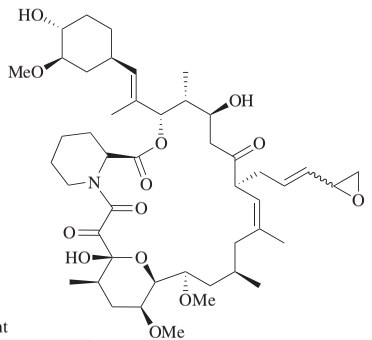
913

TABLE 14. CROSS-METATHESIS OF TERTIARY ALLYLIC ALCOHOLS AND DERIVATIVES (*Continued*)

Tertiary Alcohol	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{20}	 1 eq	Hov II (0.1 eq), DCM, reflux, 12 h	 R =  (37);  (38);  (41);  (29)	523

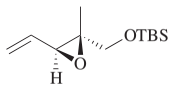
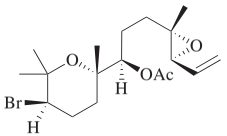
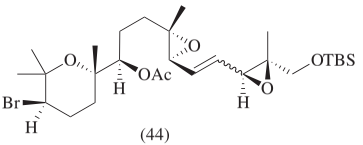
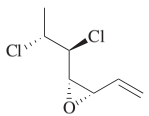
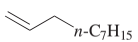
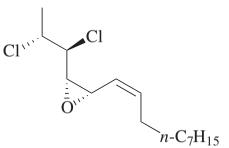
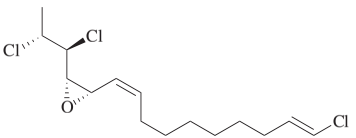
[a] The conversion was determined by ^{1}H NMR analysis.

TABLE 15. CROSS-METATHESIS OF VINYL EPOXIDES

Vinyl Epoxide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
	 4 eq	Ru cat **216** (0.02 eq), THF (0.5 M), 35°, 5 h	 (40) $(Z)/(E)$ = 95:5	461
20 eq		Gr II (0.1 eq), solvent, 150° (MW), 5 min		432

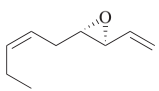
Solvent		Solvent	
1,2-DCB	(64)	*i*-PrOH	(42)
DCE	(61)	butan-1-ol	(18)
DCM	(tr)	EtOH	(5)
DMF	(20)	MeOH	(4)
MeCN	(3)	DMSO	(2)

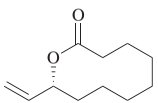
TABLE 15. CROSS-METATHESIS OF VINYL EPOXIDES (*Continued*)

Vinyl Epoxide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6				
 3 eq		Gr II (0.1 eq), DCM, 30°, 1 d	 (44)	914
C_7				
	 3 eq	Ru cat **215** (0.3 eq), DCE/DCM, 35°	 (83) $(Z)/(E) > 95:5$	191
	 *x* eq	Ru cat **215** (*y* eq), solvent, 35°		915, 191

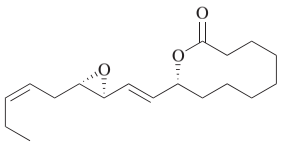
x	*y*	Solvent	Time (h)		$(Z)/(E)$
3	0.1	DCE/DCM	2	(10)	95:5
3	0.3	DCE/DCM	3	(32)	95:5
3	0.3	$PhCF_3$/DCM	3	(33)	95:5
3	0.5	$PhCF_3$/DCM	4	(34)	95:5
5	1	DCE	3	(39)	95:5

C_9



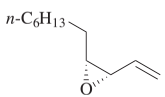


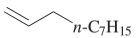
Gr II, DCM, 25°, 2 h



(40) (*E*) only 190

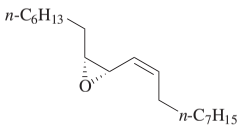
C_{11}





5 eq

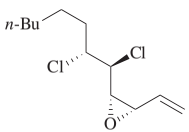
Ru cat **215** (*x* eq), DCE, 35°, 3 h



(*Z*) only

x		
0.1	(83)	915
0.01	(43)	

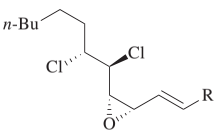
C_{12}





10 eq

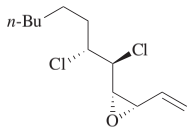
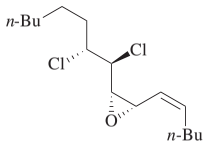
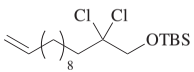
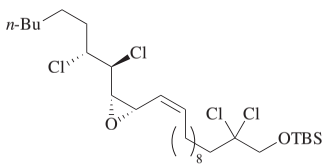
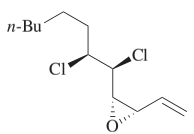
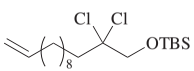
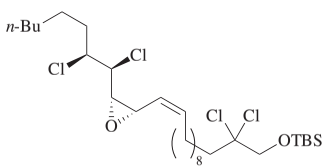
Catalyst (0.1 eq), solvent, rt



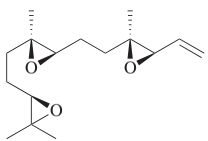
915

R	Catalyst	Solvent	Time (h)		(*E*)/(*Z*)
n-Bu	Hov II	toluene	19	(—)	—
n-C_8H_{17}	Gr II	DCM	6	(57)	82:18

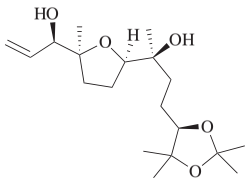
TABLE 15. CROSS-METATHESIS OF VINYL EPOXIDES (*Continued*)

Vinyl Epoxide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{12} 	 10 eq	Ru cat **215** (*x* eq), solvent, 35°, 1 h	 (*Z*) only	915
			x / Solvent / Conv. (%)[a]: 0.01 / THF / 12; 0.1 / DCE / 50–60	
	 2 eq	Ru cat **215** (*x* eq), additive, DCE, 35°	 (*Z*) only	915
			x / Additive / Time (h): 0.1 / — / 1 (19); 0.3 / — / 2 (29); 0.2 / static vacuum, 4 Å MS / 0.5 (16)	
	 3 eq	Ru cat **215** (0.3 eq), DCE, DCM, 35°, 3 h	 (19) (*Z*)/(*E*) > 95:5	915

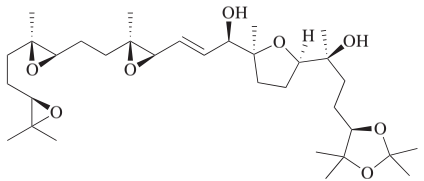
C_{16}



4.7 eq



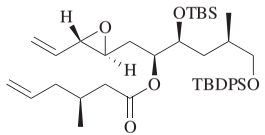
Gr II (0.1 eq),
DCM, 40°, 3 h

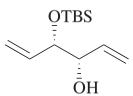


(87) (*E*) only

916

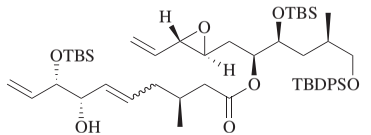
C_{18}



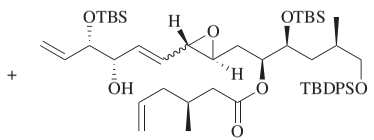


5 eq

Gr II (0.05 eq),
toluene, 50°, 3 h



I



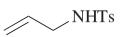
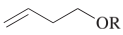
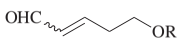
II

I + **II** (49)

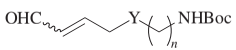
917

[a] The conversion was determined by ^{1}H NMR analysis.

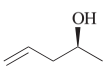
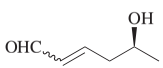
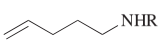
TABLE 16. CROSS-METATHESIS OF α,β-UNSATURATED ALDEHYDES

Aldehyde	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
5 eq		Hov II (0.05 eq), $(PhO)_3B$ (0.1 eq), toluene, 80°, 0.5 h	 (90)	899
x eq		Catalyst (*y* eq), DCM, rt		

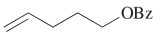
x	R	Catalyst	*y*	Time (h)		
4	H	Gr II	0.0078	24	(100)	918
3	TBDPS	Hov II	0.05	12	(85)	919

3 eq		Hov II (0.05 eq), DCM, rt, 15 h		920

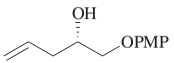
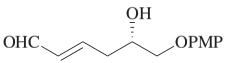
n	Y	
1	O	(56)
1	CbzN	(43)
1	S	(87)
2	O	(84)
2	CbzN	(44)
2	S	(60)

3 eq		Hov II (0.05 eq), DCM, rt, 2 h	 (85)	921
3 eq		Hov II (0.05 eq), DCM, rt		920

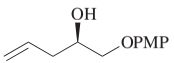
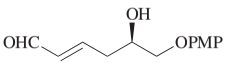
R	Time (h)	
Boc	7	(81)
Cbz	15	(83)

x eq  Catalyst (0.05 eq), solvent 

x	Catalyst	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
2	Hov II	DCM	40	—	(93)	50:50	922
2	Ru cat **191**	DCM	45	12	(86)	50:50	923
2	Ru cat **243**	DCM	45	12	(0)	—	923
—	Ru cat **185**	BMI•PF_6/toluene	rt	6	(92)	>95:5	924

3 eq  Hov II (0.025 eq), DCM, 25°, 36 h 

(41) (*E*)/(*Z*) > 95:5 157

3 eq  Hov II (0.025 eq), DCM, rt, 36 h 

(75) (*E*)/(*Z*) > 98:2 626

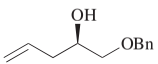
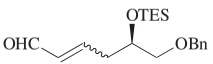
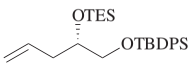
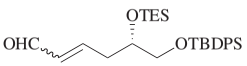
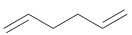
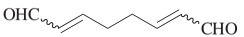
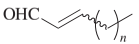
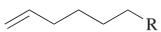
5 eq  1. Hov II (0.015 eq), DCM, reflux, 4 h
2. 2,6-Lutidine (2.5 eq), TESOTf (1.95 eq), –78°, 0.17 h  (98) 925

TABLE 16. CROSS-METATHESIS OF α,β-UNSATURATED ALDEHYDES (*Continued*)

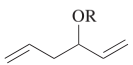
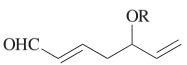
Aldehyde	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
		Hov II (0.05 eq), DCM, 35°, 5 h	 (72)	847
3 eq				
3 eq		Ru cat **93** (4 x 0.01 eq), $CDCl_3$, 100° (MW), 2.5 h	 (50)	926
x eq		Catalyst (*y* eq), solvent, rt, 8 h		927

x	*n*	Catalyst	*y*	Solvent	
1	3	HovII	0.2	DCM	(60)
1	5	Hov II	0.2	DCM	(75)
1	7	Gr I	0.1	DCM	(3)
1	7	Gr II	0.1	DCM	(48)
1	7	Hov II	0.1	DCM	(70)
1	7	Ru cat **126**	0.1	DCM	(59)
1	7	HovII	0.14	DCM	(80)
1	7	Hov II	0.07	DCM	(71)
1	7	Hov II	0.035	DCM	(69)
1	7	Hov II	0.014	DCM	(68)
1	7	Hov II	0.01	DCM	(63)
1	7	Hov II	0.0035	DCM	(39)

x	*n*	Catalyst	*y*	Solvent	
1	7	Hov II	0.035	DCE	(67)
1	7	Hov II	0.035	EtOAc	(56)
1	7	Hov II	0.035	pentane	(40)
1	7	Hov II	0.035	THF	(37)
1	7	Hov II	0.035	MeOH	(5)
1	7	Hov II	0.035	*i*-PrOH	(12)
2	7	Hov II	0.035	DCM	(72)
5	7	Hov II	0.035	DCM	(74)
1	7	Hov II	0.035	EtOAc	(60)
1	7	Hov II	0.035	EtOAc	(49)
1	7	Hov II	0.035	EtOAc	(42)

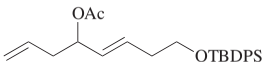
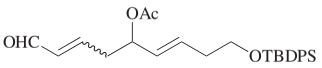
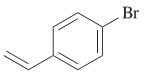
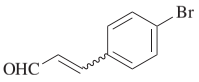
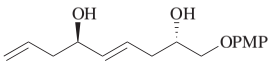
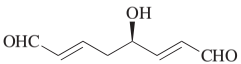
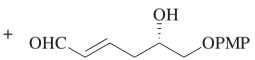
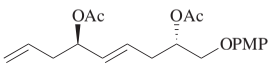
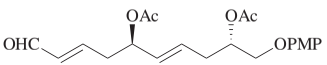
x eq  Catalyst (*y* eq), HCl/ether (*z* eq), solvent 

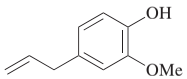
x	R	Catalyst	*y*	*z*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
3	BocHN	Hov II	0.05	—	DCM	rt	7	(60)	—	920
3	CbzHN	Hov II	0.05	—	DCM	rt	14	(70)	—	920
3	AcO	Hov II	0.025	—	DCM	rt	24	(80)	>98:2	626
2.6	AcO	Gr II	0.05	0.25	benzene/THF	45	14	(52)	>95:5	928
2	TBSO	Ru cat **286**	0.02	—	DCM	40	8	(48)	>95:5	161
2	TBSO	Ru cat **41**	0.01	—	DCM	rt	5	(12)	>95:5	562
2	TBSO	Ru cat **44**	0.01	—	DCM	rt	5	(31)	>95:5	562
2	TBSO	Ru cat **45**	0.01	—	DCM	rt	5	(25)	>95:5	562
2	TBSO	Ru cat **316**	0.02	—	toluene	80	2	(57)	>95:5	591

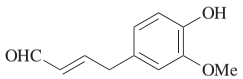
3 eq  Hov II (0.05 eq), DCM 

R	Temp (°)	Time (h)		(*E*)/(*Z*)	
Ac	rt	12	(73)	>95:5	157
TBDPS	40	—	(56)	95:5	169
TBS	40	—	(52)	95:5	169

TABLE 16. CROSS-METATHESIS OF α,β-UNSATURATED ALDEHYDES (*Continued*)

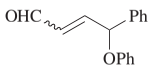
Aldehyde	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 3 eq		Hov II (0.05 eq), DCM, rt, 12 h	 (62)	919
5 eq		Ru cat **88** (5 x 0.024 eq), $C_6F_5CF_3$, 120° (MW), 50 min	 (65)	929
3 eq		Hov II (0.05 eq), DCM, 25°, 12 h	 (43) (*E*)/(*Z*) > 95:5  (31) (*E*)/(*Z*) > 95:5	157
3 eq		Hov II (0.05 eq), DCM, 25°, 12 h	 (63) (*E*)/(*Z*) = >95:5	157

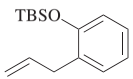
2 eq 

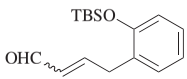
Catalyst (x eq), solvent 

Catalyst	x	Solvent	Temp (°)	Time (h)		(E)/(Z)	
Ru cat **286**	0.05	DCM	40	8	(37)	>91:9	161
Ru cat **316**	0.02	toluene	80	5	(62)	86:14	591

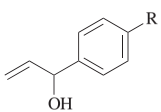
2 eq 

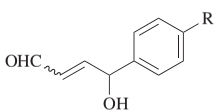
Hov II (0.05 eq), toluene, 80°, 6 h  (63) 930

3 eq 

Gr II (0.02 eq), $KHSO_4$ (x eq) solvent, 22°, 8 h,  931

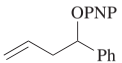
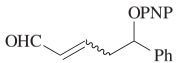
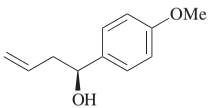
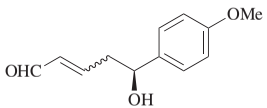
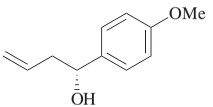
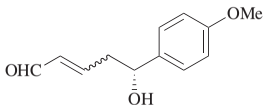
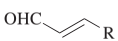
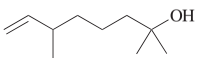
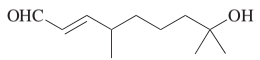
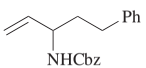
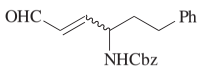
Solvent	x	
DCM	—	(9)
PTS (2.5% aq.)	—	(43)
PTS (2.5% aq.)	0.03	(70)

3 eq 

Hov II (0.05 eq), DCM, rt  919

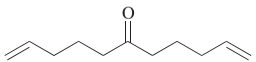
R	Time (h)	
H	16	(90)
MeO	12	(90)

TABLE 16. CROSS-METATHESIS OF α,β-UNSATURATED ALDEHYDES (*Continued*)

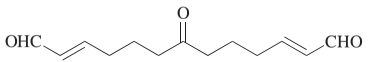
Aldehyde	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 3 eq		Hov II (0.02 eq), DCM, 40°, 15 h	 (55)	932
6 eq		Hov I (0.05 eq), DCM, rt, 2 h	 (84)	933
6 eq		Hov I (0.05 eq), DCM, rt, 2 h	 (86)	933
C_{3-4}				
 *x* eq		Ru cat **170** (*y* eq), EtOAc, 60°		751
C_3				
 5 eq		Hov II (0.1 eq), DCM, 40°, 48 h	 (56)	934

R	*x*	*y*	Time (h)		(*E*)/(*Z*)
H	1	0.005	16	(80)	94:6
Me	1.2	0.01	23	(53)	95:5

5 eq



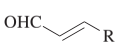
Ru cat **190** (2 x 0.025 eq), DCM, rt, 120 h



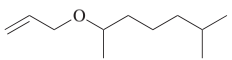
(63) (*E*) only

231

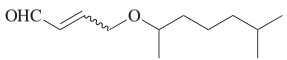
C_{3-4}



1 eq



Hov II (0.02 eq), DCM, rt, 8 h



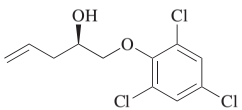
927

R	
H	(33)
Me	(15)

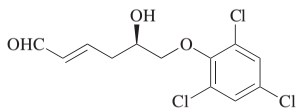
C_3



3 eq



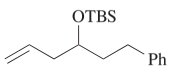
Hov II (0.025 eq), DCM, rt, 36 h



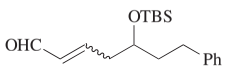
626

(90) (*E*)/(*Z*) > 98:2

2 eq



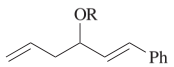
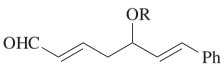
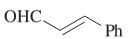
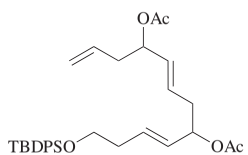
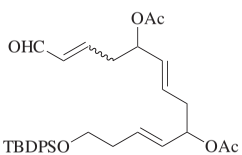
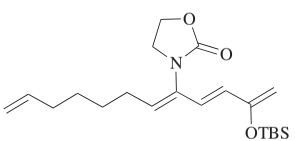
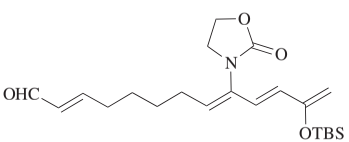
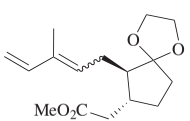
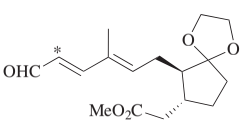
Catalyst (0.1 eq), DCM, reflux



541

Catalyst	Conv. (%)	
Gr I	—	(0)
Gr II	54	(—)
Hov II	—	(75)

TABLE 16. CROSS-METATHESIS OF α,β-UNSATURATED ALDEHYDES (*Continued*)

Aldehyde	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 3 eq		Hov II (0.05 eq), DCM, 25°, 12 h	 **I** (*E*)/(*Z*) > 95:5 +  **II**	157
			R: H — **I**: (41) — **II**: (37) — (*E*)/(*Z*) **II**: >95:5 R: Ac — **I**: (71) — **II**: (—) — (*E*)/(*Z*) **II**: —	
3 eq		Hov II (0.05 eq), DCM, rt, 12 h	 (80)	919
4 eq		Hov II (0.1 eq), DCM, 23°, 10 min	 (85) (*E*)/(*Z*) > 95:5	938
3 eq		Hov II (0.05 eq), DCM, 45°, 3 h	 (23) *(*E*)/(*Z*) = 80:20	939

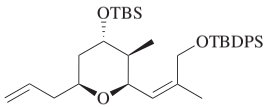
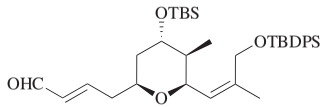
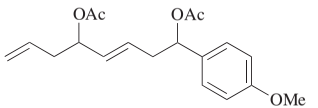
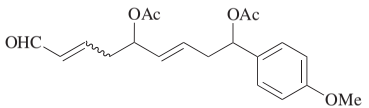
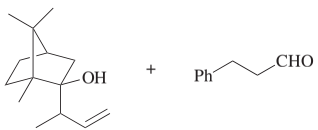
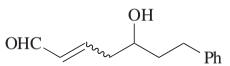
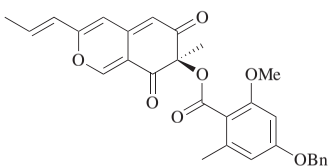
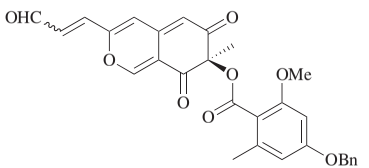
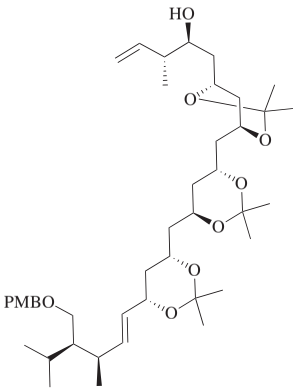
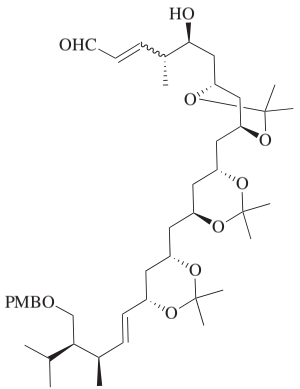
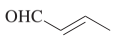
2 eq		Gr II (0.05 eq), DCM, 50°, 16 h	 (72) (*E*)/(*Z*) = 94:6		935
3 eq		Hov II (0.05 eq), DCM, rt, 16 h	 (61)		919
3 eq	 3 eq	1. CSA (0.1 eq), DCM, 25°, 144 h 2. Gr II (0.2 eq), DCM, 4 h		(46) er 97.0:3.0	936
2 x 3 eq		Hov II (2 x 0.1 eq), DCM, reflux, 2 x 12 h	 (76)		937

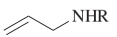
TABLE 16. CROSS-METATHESIS OF α,β-UNSATURATED ALDEHYDES (*Continued*)

Aldehyde	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3	 5 eq		Hov II (0.075 eq), DCE, 60°, 24 h	 (52)	846

C_4



5 eq



Catalyst (x eq), additive (y eq), solvent



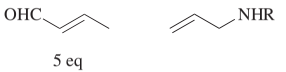
R	Catalyst	x	Additive	y	Solvent	Temp (°)	Time (h)	
Ts	Gr II	0.1	—	—	DCM	40	48	(5)
Ts	Ru cat **88**	0.05	—	—	DCM	40	36	(32)
Ts	Hov II	0.05	—	—	DCM	40	36	(60)
Ts	Gr I	0.1	—	—	toluene	80	48	(5)
Ts	Gr II	0.1	—	—	toluene	80	48	(8)
Ts	Ind I	0.1	—	—	toluene	80	48	(6)
Ts	Ind II	0.1	—	—	toluene	80	48	(16)
Ts	Ru cat **88**	0.05	—	—	toluene	80	36	(35)
Ts	Hov II	0.05	—	—	toluene	80	36	(60)
Ts	Hov II	0.05	LiCl	1	toluene	80	2	(5)
Ts	Hov II	0.05	$AlCl_3$	1	toluene	80	2	(5)
Ts	Hov II	0.05	$Ti(O\textit{i}\text{-}Pr)_4$	1	toluene	80	2	(20)
Ts	Hov II	0.05	$Zn(OTf)_2$	1	toluene	80	1	(60)
Ts	Hov II	0.05	$RuCl_3{\bullet}(H_2O)_n$	1	toluene	80	0.75	(60)
Ts	Hov II	0.05	ClBcat	1	toluene	80	1.5	(60)
Ts	Hov II	0.05	$PhBCl_2$	1	toluene	80	1.5	(70)
Ts	Hov II	0.05	$(PhO)_3B$	1	toluene	80	0.5	(93)
Ts	Hov II	0.05	$(PhO)_3B$	0.5	toluene	80	0.5	(93)
Ts	Hov II	0.05	$(PhO)_3B$	0.2	toluene	80	0.5	(92)
Ts	Hov II	0.05	$(PhO)_3B$	0.1	toluene	80	0.5	(92)
Boc	Hov II	0.05	$(PhO)_3B$	0.1	toluene	80	0.5	(60)

TABLE 16. CROSS-METATHESIS OF α,β-UNSATURATED ALDEHYDES (*Continued*)

Aldehyde	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

C_4

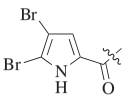
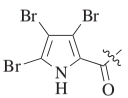
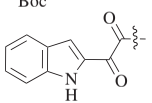


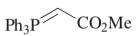
5 eq

Hov II (0.05 eq), $(PhO)_3B$ (0.1 eq), solvent, 80°

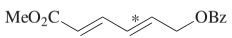


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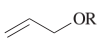
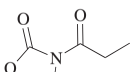
R	Solvent	Time (h)	
$MeOC_6H_4O_2S$	toluene	0.5	(91)
	toluene	1.25	(60)
	toluene	1.25	(60)
	toluene	1.5	(43)
	toluene	0.85	(57)
	DCE	1.5	(15)

3 eq  + 
I

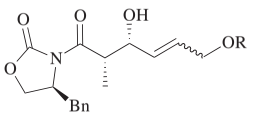
1. Gr II (0.05 eq), DCM, 40°, 3 h
2. **I** (1.2 eq), DCM, rt to 40°, 15 + 1 h


(60) *(*E*)/(*Z*) = 89:11

940

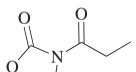
3 eq  + 
I

1. Hov II (0.05 eq), DCM, 40°, 12 h
2. **I** (1 eq), Bu_2OTf (1.1 eq), Et_3N (1.4 eq), DCM, –78 to 0°, 2 h

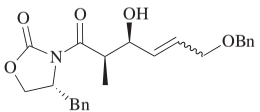


R		dr
TBS	(48)	>95:5
PMB	(64)	>95:5

940

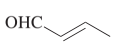
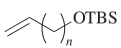
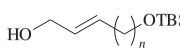
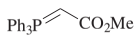
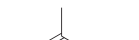
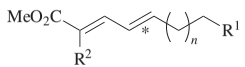
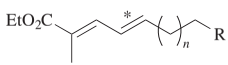
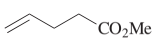
3 eq  + 
I

1. Hov II (0.05 eq), DCM, 40°, 12 h
2. **I** (1 eq), Bu_2OTf (1.1 eq), Et_3N (1.4 eq), DCM, –78 to 0°, 2 h


(52) dr > 95:5

940

TABLE 16. CROSS-METATHESIS OF α,β-UNSATURATED ALDEHYDES (*Continued*)

Aldehyde	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 3 eq		1. Gr II (0.05 eq), DCM, reflux, 3 h 2. DIBAL-H, DCM, –78°, 2 h	 (*E*)/(*Z*) > 95:5 *n*: 2 (72); 3 (74)	941
3 eq	 +  **I**  **II**	1. Gr II (0.05 eq), DCM, 40°, 3 h 2. Additive (1.2 eq), DCM, rt to 40°, 15 + 1 h		940
			R^1 / *n* / Additive / R^2 / / *(*E*)/(*Z*) MeO_2C / 1 / **I** / H / (57) / 90:10 MeO_2C / 1 / **II** / Me / (50) / 83:17 TBSO / 2 / **I** / H / (77) / 90:10	
3 eq	 + **I**	1. Gr II (0.05 eq), DCM, 40°, 3 h 2. **I** (1.4 eq), NaH (1.4 eq), THF, 0° to rt, 0.5 h + 15 h		940
			n / R / / *(*E*)/(*Z*) 1 / MeO_2C / (69) / 83:17 2 / TBSO / (83) / 95:5	
10 eq		Hov II (0.03 eq), DCM, 40°, 2 h	 (93)	942

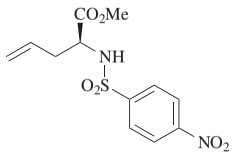
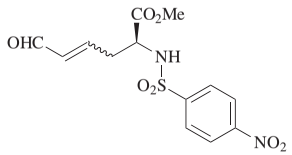
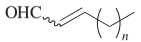
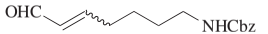
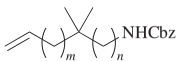
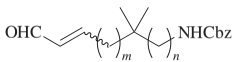
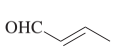
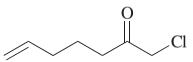
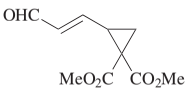
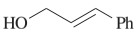
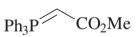
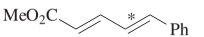
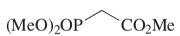
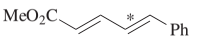
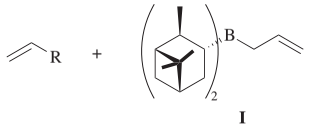
4 eq		Gr II (0.1 eq), DCM, reflux, 0.5 h		(—)	943
1 eq		Hov II (0.02 eq), DCM, rt, 8 h		n: 3 (55); 5 (51); 7 (71)	927
5 eq		Gr II (0.05 eq), DCM, 45°, 48 h		(78)	944
5 eq		Gr II (0.05 eq), DCM, 45°, 48 h		m n: 1 1 (72); 2 0 (65); 2 1 (81); 3 0 (72)	944

TABLE 16. CROSS-METATHESIS OF α,β-UNSATURATED ALDEHYDES (*Continued*)

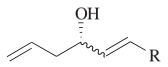
Aldehyde	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 1.5 eq		Gr II (0.025 eq), DCM, 45°, 9 h	 (80)	945
1.4 eq		Gr II (0.01 eq), DCM, reflux	 (69) (*E*) only	407
3 eq		1. Gr II (0.05 eq), DCM, reflux, 3 h 2. DIBAL-H, DCM, –78°, 2 h	 (70) (*E*)/(*Z*) > 95:5	941
3 eq	 +  **I**	1. Gr II (0.05 eq), DCM, 40°, 3 h 2. **I** (1.2 eq), DCM, rt to 40°, 15 + 1 h	 (48) *(*E*)/(*Z*) = 92:8	940
3 eq	 +  **I**  **II**	1. Gr II (0.05 eq), DCM, 40°, 3 h 2. **I** or **II** (1.4 eq), NaH (1.4 eq), THF, 0° to rt, 0.5 + 15 h	 Additive (55) *(*E*)/(*Z*) 95:5 **I** (55) 95:5 **II** (63) 13:87	940

2 eq



I

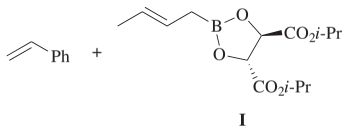
1. Hov II (0.05 eq), DCM, 40°, 12 h
2. **I** (1.9 eq), Et_2O, −78°, 1.17 h



R		er
Ph	(74)	91.5:8.5
4-FC_6H_4	(71)	91.5:8.5
Cy	(72)	91.0:9.0

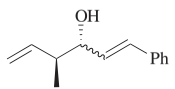
940

2 eq



I

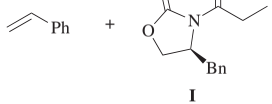
1. Hov II (0.05 eq), DCM, 40°, 12 h
2. **I** (1.5 eq), toluene, −78°, 5 h



(80) er 83.5:16.5, dr > 95:5

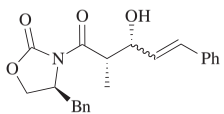
940

3 eq



I

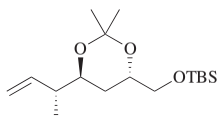
1. Hov II (0.05 eq), DCM, 40°, 12 h
2. **I** (1 eq), Bu_2OTf (1.1 eq), Et_3N (1.4 eq), DCM, −78 to 0°, 2 h



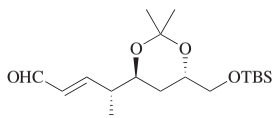
(60) dr > 95:5

940

5 eq



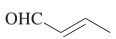
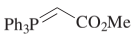
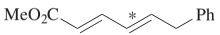
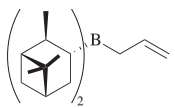
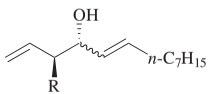
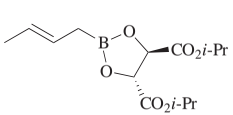
Gr II (0.15 eq) toluene, 60°, 6 h



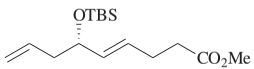
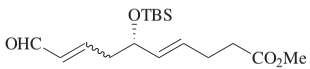
(60) (*E*) only

946

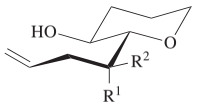
TABLE 16. CROSS-METATHESIS OF α,β-UNSATURATED ALDEHYDES (*Continued*)

Aldehyde	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 3 eq	 +  **I**	1. Gr II (0.05 eq), DCM, 40°, 3 h 2. **I** (1.2 eq), DCM, rt to 40°, 15 + 1 h	 (73) *(*E*)/(*Z*) = 90:10	940
2 eq	+  **I**	1. Hov II (0.05 eq), DCM, 40°, 12 h 2. **I** or **II** (*x* eq), solvent, −78°, time		940
	 **II**			

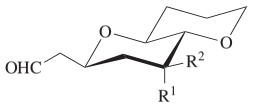
Additive	*x*	Solvent	Time (h)	R		dr	er
I	1.9	Et_2O	1.17	H	(75)	94:6	—
II	1.5	toluene	5	Me	(82)	>95:5	93.0:7.0

3 eq		Hov II (0.05 eq), DCM, 40°, 2 h		(86)	942

3–10 eq



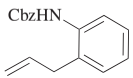
Hov II (0.1 eq),
additive (0.03–0.1 eq),
solvent



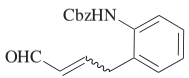
947

R^1	R^2	Additive	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)
H	HO	—	toluene	80–100	11–24	(60)	86:14
H	HO	CSA	DCM	25–35	—	(70)	>95:5
HO	H	—	toluene	80–100	11–24	(54)	94:6
HO	H	CSA	DCM	25–35	—	(48)	80:20

3 eq



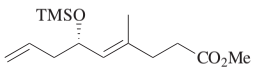
Gr II (0.05 eq),
DCM, 45°, 48 h



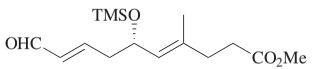
(52)

944

3 eq



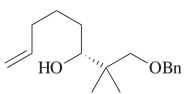
Hov II (0.05 eq),
DCM, 40°, 2 h



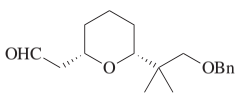
(86) (*E*) only

942

5 eq

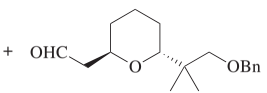


Hov II (0.05 eq),
toluene, 110°, 18 h



I

\+

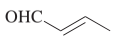
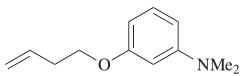
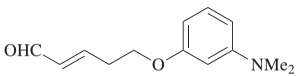
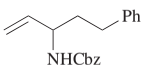
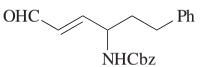
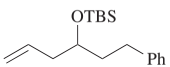
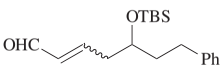
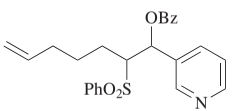
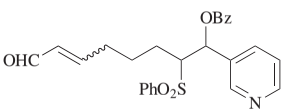


II

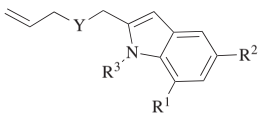
I + **II** (60–77), **I**/**II** = 4–5:1

948

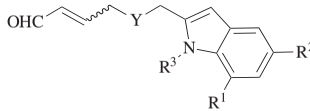
TABLE 16. CROSS-METATHESIS OF α,β-UNSATURATED ALDEHYDES (*Continued*)

Aldehyde	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 2 eq		Gr II (0.03 eq), DCM, 40°, 82 h	 (88) (*E*) only	949
10 eq		Hov II (0.1 eq), DCM, 55°, 48 h	 (58) (*E*) only	934
2 eq		Catalyst (0.1 eq), DCM, reflux	 Catalyst: Gr I (16); Gr II (91); Hov II (94)	541
		Gr II, toluene, 60°, 3 h	 (78)	638

10 eq



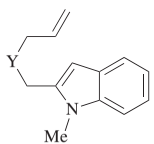
Gr II (0.03 eq),
DCM, 40°



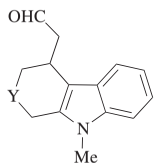
(*E*) only 949

R^1	R^2	R^3	Y	Time (h)	
H	H	Me	O	18	(55)
H	H	Bn	O	17	(57)
H	F	Me	O	36	(43)
H	F	Bn	O	18	(53)
H	Cl	Me	O	39	(33)
H	Br	Me	O	39	(44)
H	MeO	Bn	O	17	(51)
H	Me	Bn	O	41	(54)
H	H	Bn	TsN	82	(50)
Cl	H	Me	O	39	(56)

5 eq

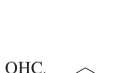
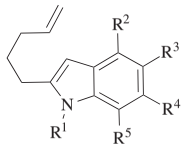
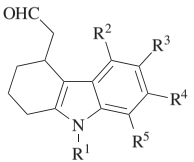


Hov II (0.03 eq),
DCE, reflux

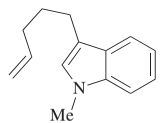
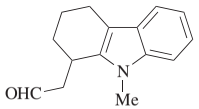
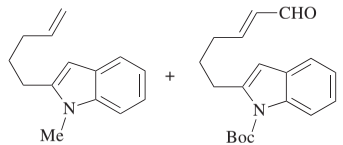
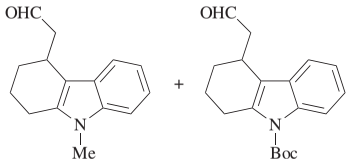
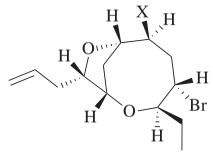
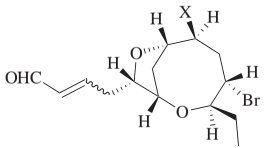


Y	Time (h)		
O	48	(74)	950
TsN	24	(85)	

TABLE 16. CROSS-METATHESIS OF α,β-UNSATURATED ALDEHYDES (*Continued*)

Aldehyde	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4  *x* eq		Catalyst (*y* eq), solvent		950, 949

x	R^1	R^2	R^3	R^4	R^5	Catalyst	*y*	Solvent	Temp (°)	Time (min)	
10	Me	H	H	H	H	Gr I	0.03	DCM	40	60	(5)
10	Me	H	H	H	H	Hov I	0.03	DCM	40	60	(15)
10	Me	H	H	H	H	Hov II	0.03	DCM	40	60	(90)
10	Me	H	H	H	H	Gr II	0.03	DCM	40	69	(79)
10	Me	H	H	H	H	Hov II	0.03	toluene	110	40	(90)
10	Me	H	H	H	H	Hov II	0.03	DCE	80	30	(97)
5	Me	H	H	H	H	Hov II	0.03	DCE	80	40	(93)
10	Me	H	H	H	H	Hov II	0.01	DCE	80	720	(63)
5	H	H	H	H	H	Hov II	0.03	DCE	80	70	(82)
5	Me	H	H	H	H	Hov II	0.03	DCE	80	40	(93)
5	Me	Me	H	H	H	Hov II	0.03	DCE	80	40	(95)
5	H	Me	H	H	H	Hov II	0.03	DCE	80	40	(82)
5	Me	Cl	H	H	H	Hov II	0.03	DCE	80	90	(86)
5	Me	F	H	H	H	Hov II	0.03	DCE	80	90	(90)
5	Me	H	Me	H	H	Hov II	0.03	DCE	80	40	(90)
5	Me	H	MeO	H	H	Hov II	0.03	DCE	80	90	(88)
5	Me	H	F	H	H	Hov II	0.03	DCE	80	90	(95)
5	Me	H	H	Me	H	Hov II	0.03	DCE	80	30	(88)
5	Me	H	H	Cl	H	Hov II	0.03	DCE	80	55	(81)
5	Me	H	H	H	Me	Hov II	0.03	DCE	80	30	(96)
5	Me	H	H	H	Et	Hov II	0.03	DCE	80	60	(80)
5	Me	H	Me	H	Me	Hov II	0.03	DCE	80	30	(91)
5	Me	H	Me	H	Cl	Hov II	0.03	DCE	80	40	(99)
10	Bn	H	H	H	H	Gr II	0.03	DCM	40	90	(61)

5 eq		Hov II (0.1 eq), DCE, reflux, 24 h		(80)	950
5 eq		Hov II (0.03 eq), DCE, reflux, 4 h	 (89) (51)		950
n eq		1. Gr II (*x* eq), DCM, 40°, time 2. DMSO, rt, 12 h			570

n	X	*x*	Time (h)	
20	Cl	0.1	1	(83)
10	Br	0.29	1.5	(86)

TABLE 16. CROSS-METATHESIS OF α,β-UNSATURATED ALDEHYDES (*Continued*)

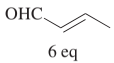
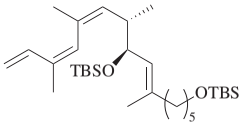
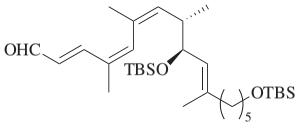
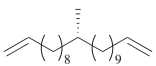
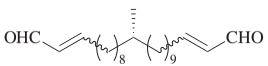
Aldehyde	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 6 eq		Catalyst, toluene, 60°		760
			Catalyst (*E*)/(*Z*) Gr II 50:50 Hov II 50.50	
30 eq		Hov II (0.06 eq), DCM, rt, 0.5 h; then 60°, 2.5 h	 (98)	951

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES

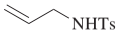
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{4-7}				
 2.65 eq		Hov II (0.05 eq), $B(OPh)_3$ (0.1 eq), toluene, 80°	 

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

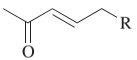
Please refer to the charts preceding the tables for the catalyst structures.

C_4





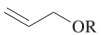
Catalyst (*y* eq), solvent



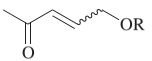
x eq

x	R	Catalyst	*y*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
8	CbzHN	Hov II	0.1	DCM	40	48	(61)	—	934
2	BzHN	Ru cat **41**	0.01	DCM	rt	6	(8)	>95:5	562
2	BzHN	Ru cat **44**	0.01	DCM	rt	6	(17)	>95:5	562
2	BzHN	Ru cat **45**	0.01	DCM	rt	6	(15)	>95:5	562
3	Ts	Hov II	0.03	DCE	reflux	0.5–1	(67)	—	953
3	Ph_2PO	Gr II	0.02–0.06	DCM	40	20–48	(46)	100:0	214

3 eq



Ru cat **129** (*x* eq), CuI (0.03 eq), Et_2O, 35°, 16 h



R	*x*		Refs.
H	0.001	(0)	954
H	0.0025	(5)	
Ac	0.001	(95)	
Ac	0.0025	(>99)	

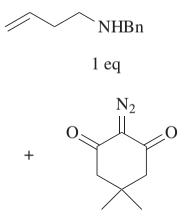
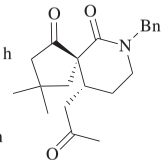
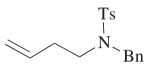
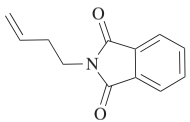
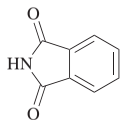
1 eq 1 eq +		1. DCM, 300 W, 0.25 h 2. Hov II (0.04 eq), 100°, 0.5 h 3. IPr (0.2 eq), rt, 20 h		(77)	(*E*)/(*Z*) > 95:5	955
3 eq		1. Hov II (0.02 eq), DCM, 40°, 15 h 2. NaH (2 eq), DMF, 22°, 1 h		(96)		956
3 eq		1. Hov II (0.02 eq), DCM, 40°, 15 h 2. NaH (2 eq), DMF, 22°, 1 h		(95)		956

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

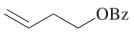
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

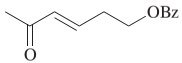
C_4



x eq

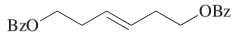


Catalyst (*y* eq), DCM



I (*E*)/(*Z*) > 95:5

+



II

x	Catalyst	*y*	Temp (°)	Time (h)	**I**	**II**	(*E*)/(*Z*) **II**	
2	Ru cat **93**	0.01	25	0.5	(76)	(—)	—	957
2	Ru cat **169**	0.01	25	0.5	(74)	(—)	—	957
2	Ru cat **170**	0.01	25	0.5	(64)	(34)	80:20	957
2	Ru cat **171**	0.01	25	0.5	(62)	(31)	80:20	957
5	Ru cat **170**	0.01	25	1	(92)	(—)	—	957
2	Ru cat **286**	0.02	40	8	(57)	(—)	—	161

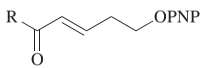
C_{4-5}



3 eq



Catalyst (*x* eq), DCM, 15 h



(*E*) only

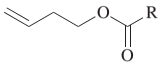
932

R	Catalyst	*x*	Temp (°)	
Me	Hov II	0.02	40	(92)
Et	Hov II	0.05	40	(99)
Et	Hov II	0.02	40	(95)
Et	Hov II	0.02	22	(72)
Et	Ru cat **1**	0.05	40	(88)
Et	Gr II	0.05	40	(38)
Et	Gr II	0.05	20	(29)
Et	Gr II	0.05	40	(68)
Et	Hov II	0.02	40	(95)

C_4



3 eq



1. Hov II (0.02 eq), DCM, 40°, 15 h
2. DBU (2 eq), 22°, 1 h



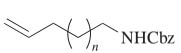
R	
Ph	(95)
4-MeC_6H_4	(94)
$Ph(CH_2)_2$	(91)
n-$C_{11}H_{23}$	(92)
1-Naph	(90)
(*Z*)-HNCH=CHBn	(90)

956

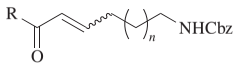
C_{4-8}



x eq

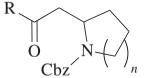


Catalyst (*y* eq), additive (0.01 eq), solvent



I

+



II

958

R	*x*	*n*	Catalyst	*y*	Additive	Solvent	Temp (°)	Time (h)	**I**	**II**
Me	1.64	1	Gr II	0.1	—	DCM	reflux	5	(45)	(—)
Me	1.64	1	Hov II	0.05	—	DCM	reflux	5	(71)	(3)
Me	1.64	1	Hov II	0.05	—	toluene	reflux	5	(35)	(21)
Me	1.64	1	Hov II	0.05	BF_3•Et_2O	DCM	45	96	(—)	(99)
Me	1.64	1	Hov II	0.05	BF_3•Et_2O	DCM	100 (MW)	0.33	(—)	(96)
Me	2	1	Hov II	0.05	BF_3•Et_2O	DCM	45	96	(—)	(99)
Me	2	1	Hov II	0.05	BF_3•Et_2O	DCM	100 (MW)	0.33	(—)	(96)
Me	2	2	Hov II	0.05	BF_3•Et_2O	DCM	45	96	(—)	(82)
Me	2	2	Hov II	0.05	BF_3•Et_2O	DCM	100 (MW)	0.33	(—)	(93)
n-Pr	2	1	Hov II	0.05	BF_3•Et_2O	DCM	45	96	(—)	(73)
n-Pr	2	1	Hov II	0.05	BF_3•Et_2O	DCM	100 (MW)	0.33	(—)	(65)
n-Pr	2	2	Hov II	0.05	BF_3•Et_2O	DCM	45	96	(—)	(81)
n-Pr	2	2	Hov II	0.05	BF_3•Et_2O	DCM	100 (MW)	0.33	(—)	(70)
n-Pn	2	1	Hov II	0.05	BF_3•Et_2O	DCM	45	96	(—)	(79)
n-Pn	2	1	Hov II	0.05	BF_3•Et_2O	DCM	100 (MW)	0.33	(—)	(72)
n-Pn	2	2	Hov II	0.05	BF_3•Et_2O	DCM	45	96	(—)	(83)
n-Pn	2	2	Hov II	0.05	BF_3•Et_2O	DCM	100 (MW)	0.33	(—)	(61)

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

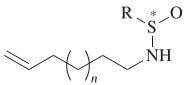
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

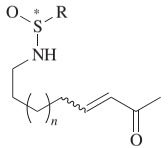
C_4



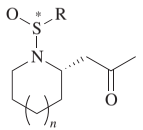
5 eq



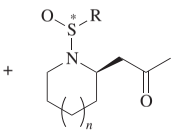
Catalyst (0.1 eq),
Ti(O*i*-Pr)$_4$ (0.1 eq),
solvent



I



II

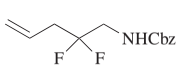


III

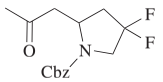
959

R	*n*	Catalyst	Solvent	Temp (°)	Time (h)	**I**	**II + III**	dr **II/III**
(S_s) *p*-Tol	0	Ru cat **35**	DCM	reflux	2	(70)	(12)	—
(R_s) *t*-Bu	0	Ru cat **35**	DCM	reflux	2	(>99)	(—)	—
(S_s) *p*-Tol	0	Ru cat **35**	DCM	reflux	6	(50)	(28)	85:15
(S_s) *p*-Tol	0	Ru cat **35**	toluene	reflux	48	(10)	(70)	88:12
(S_s) *p*-Tol	0	Ru cat **190**	DCM	reflux	48	(—)	(95)	89:11
(S_s) *p*-Tol	0	Ru cat **190**	DCM	reflux	12	(23)	(10)	80:20
(S_s) *p*-Tol	0	Ru cat **190**	DCM	100 (MW)	1	(21)	(20)	81:19
(S_s) *p*-Tol	0	Ru cat **190**	DCM	60 (MW)	7	(14)	(60)	88:12
(R_s) *t*-Bu	0	Ru cat **35**	DCM	reflux	48	(9)	(74)	9:91
(R_s) *t*-Bu	0	Ru cat **190**	DCM	reflux	48	(—)	(92)	8:92
(S_s) *p*-Tol	1	Ru cat **35**	DCM	reflux	2	(72)	(—)	—
(R_s) *t*-Bu	1	Ru cat **35**	DCM	reflux	2	(>99)	(—)	—
(S_s) *p*-Tol	1	Ru cat **190**	DCM	reflux	48	(54)	(30)	70:30
(S_s) *p*-Tol	1	Ru cat **190**	DCE	reflux	48	(41)	(25)	71:29
(R_s) *t*-Bu	1	Ru cat **190**	DCM	reflux	48	(63)	(22)	24:76
(R_s) *t*-Bu	1	Ru cat **190**	DCE	reflux	48	(77)	(15)	24:76

2 eq

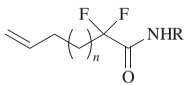


Hov II (0.05 eq),
BF_3•Et_2O (0.01 eq),
DCM

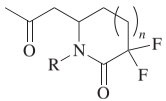


Temp (°)	Time (h)		
100 (MW)	0.33	(55)	958
45	96	(60)	

3 eq

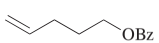


Hov II (0.05 eq),
$Ti(O\textit{i}\text{-}Pr)_4$ (0.1 eq),
DCM, reflux

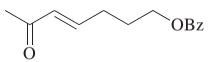


n	R	Time (h)		
0	PMP	8	(61)	960
0	MeO	10	(58)	
0	SAMP	8	(58)	
1	PMP	8	(51)	
1	MeO	10	(49)	
1	SAMP	8	(62)	

x eq

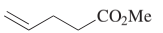
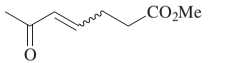
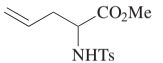
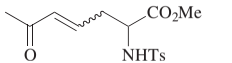
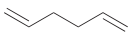
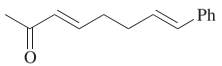
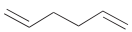
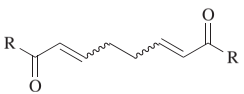
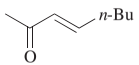


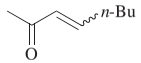
Catalyst (*y* eq),
solvent



x	Catalyst	*y*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
2	Hov II	0.05	DCM	40	—	(85)	>95:5	922
2	Ru cat **243**	0.05	DCM	45	12	(68)	>95:5	923
2	Ru cat **191**	0.05	DCM	45	12	(97)	>95:5	923
—	Ru cat **185**	0.05	BMI•PF_6/toluene	rt	6	(88)	>95:5	924
2	Ru cat **170**	0.01	DCM	25	1	(95)	>95:5	957
2	Ru cat **110**	0.01	DCM	rt	0.33	(98)	(*E*) only	961
2	Ru cat **112**	0.01	DCM	rt	0.33	(82)	99:1	962

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

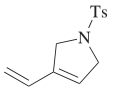
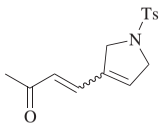
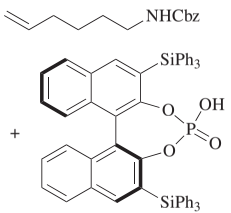
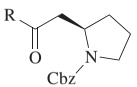
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4  3 eq		Hov II (0.03 eq), DCE, reflux, 0.5–1 h	 (63)	953
5 eq		Hov II (0.075 eq) DCM, 55°, 48 h	 (88)	335
 2 eq		1. Gr II (0.05 eq), DCM, 40°, 3 h 2. Gr II (0.05 eq), styrene (3 eq), DCM, 40°, 12 h	 (47) (*E*,*E*) only	36
C_{4-9}  3 eq		Ru cat **93** (0.025 eq), $CDCl_3$, 100°, (MW), 1 h		R: Me (85); Ph (70) — 926
C_4  3 eq		Catalyst (*x* eq), CuI (0.03 eq), Et_2O, 35°, 16 h	 (*E*) only	Catalyst / *x*: Ru cat **129** 0.005 (>99); Ru cat **131** 0.005 (<2); Ru cat **139** 0.005 (45); Hov II 0.005 (48); Ind II 0.005 (>99); Ind II 0.0025 (96); Ru cat **129** 0.0025 (>99); Ru cat **129** 0.001 (>99); Ru cat **129** 0.0005 (>98); Ru cat **129** 0.00025 (73) — 963

3 eq  Catalyst (x eq), additive (0.03 eq), Et_2O, 35°, 16 h 

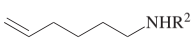
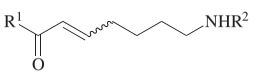
954

Catalyst	x	Additive	Conc (M)	Conv (%)[a]
Ru cat **139**	0.01	CuI	0.05	>99
Ru cat **139**	0.01	CuI	0.1	>99
Ru cat **139**	0.01	CuI	0.2	>99
Ru cat **139**	0.01	CuI	0.5	66
Ru cat **139**	0.01	CuCl	0.2	80
Ru cat **139**	0.01	—	0.2	33
Gr II	0.005	CuI	0.2	>99
Ind II	0.005	CuI	0.2	>99
Hov II	0.005	CuI	0.2	48
Ru cat **139**	0.005	CuI	0.2	45
Ru cat **285**	0.005	CuI	0.2	80
Ru cat **173**	0.005	CuI	0.2	>99
Ru cat **129**	0.005	CuI	0.2	99
Gr II	0.0025	CuI	0.2	73
Ind II	0.0025	CuI	0.2	96
Ru cat **173**	0.0025	CuI	0.2	98
Ru cat **129**	0.0025	CuI	0.2	>99
Ind II	0.001	CuI	0.2	88
Ru cat **173**	0.001	CuI	0.2	71
Ru cat **129**	0.001	CuI	0.2	>99
Ru cat **129**	0.0005	CuI	0.2	98
Ru cat **129**	0.0005	—	0.2	48
Ru cat **129**	0.00025	CuI	0.2	76

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4  3 eq		Hov II (0.05 eq), DCM, 45°, 3 h	 (85)	939
$C_{4–10}$  3 eq	 + 0.1 eq	Hov II (0.05 eq), DCM, 0°		964

R	Time (h)		er
Me	14	(74)	95.0:5.0
Et	18	(76)	97.0:3.0
Bn	20	(61)	96.0:4.0

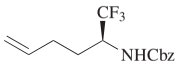
 3 eq		Hov II (0.05 eq), DCM, rt, 12 h		964

R^1	R^2		
Me	Boc	(69)	
Me	Cbz	(89)	
Et	Cbz	(85)	
Bn	Cbz	(68)	

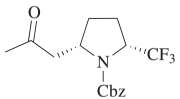
C_4



2 eq

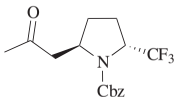


Hov II (0.05 eq),
BF_3•Et_2O (0.01 eq),
DCM



I

\+



II

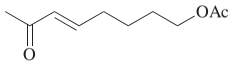
958

Temp (°)	Time (h)		**I/II**
45	96	(76)	5:1
100 (MW)	0.33	(97)	1:3

2.6 eq



Gr II (0.05 eq),
additive (0.25 eq),
benzene, THF, 45°



(*E*)/(*Z*) = 93:7

928

Additive	Time (h)	
—	48	(92)
HCl/Et_2O	14	(90)
$CuCl_2$	14	(12)
CuCl	24	(42)
$B(C_6F_5)_3$	14	(47)
$Ni(COD)_2$	<1	(0)
$AlCl_3$	14	(67)

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

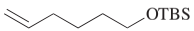
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

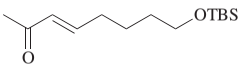
C_4



x eq



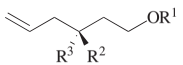
Catalyst (*y* eq), DCM



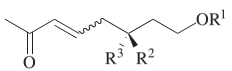
x	Cat	*y*	Temp (°)	Time (h)		(*E*)/(*Z*)	
2	Ru cat **112**	0.025	20	0.66	(91)	99:1	962
2	Ru cat **93**	0.01	25	0.5	(86)	>95:5	957
2	Ru cat **169**	0.01	25	0.5	(48)	>95:5	957
2	Ru cat **170**	0.01	25	0.5	(>98)	>95:5	957
2	Ru cat **171**	0.01	25	0.5	(>98)	>95:5	957
—	Ru cat **93**	0.01	rt	0.5	(86)	>95:5	550
2	Ru cat **286**	0.02	25	5	(59)	>95:5	161
2	Ru cat **286**	0.02	40	8	(77)	>95:5	161
2	Ru cat **41**	0.01	rt	3	(70)	>95:5	562
2	Ru cat **44**	0.01	rt	3	(85)	>95:5	562
2	Ru cat **45**	0.01	rt	3	(80)	>95:5	562
2	Ru cat **112**	0.01	20	0.67	(90)[b]	(*E*) only	609
2	Ru cat **88**	0.025	25	0.5	(82)	(*E*) only	609
2	Ru cat **138**	0.01	25	5	(57)[b]	(*E*) only	609
2	Ru cat **115**	0.01	25	0.5	(50)[b]	(*E*) only	609
2	Ru cat **115**	0.01	25	1	(82)	(*E*) only	609
2	Ru cat **116**	0.01	25	0.67	(65)[b]	(*E*) only	609
—	Ru cat **106**	0.025	20	3	(93)	99:1	216
—	Ru cat **112**	0.01	25	0.67	(90)	99:1	216

—	Ru cat **88**	0.025	25	3	(95)	99:1	216
2	Ru cat **98**	0.01	rt	0.5	(81)	95:5	965
2	Ru cat **99**	0.01	rt	0.5	(88)	95:5	965
2	Ru cat **100**	0.01	rt	0.5	(86)	95:5	965
2	Ru cat **101**	0.01	rt	0.5	(83)	95:5	965
2	Ru cat **102**	0.01	rt	0.5	(80)	95:5	965
2	Ru cat **88**	0.025	25	0.5	(82)	99:1	171
2	Ru cat **88**	0.025	25	3	(95)[b]	99:1	171
2	Ru cat **88**	0.025	rt	0.5	(82)	95:5	160
2	Ru cat **112**	0.01	rt	0.67	(90)	95:5	160

2 eq

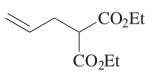


Gr II (0.05 eq),
DCM, reflux, 6 h

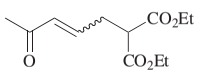


R^1	R^2	R^3		
TBDPS	H	MOMO	(81)	781
Bn	MeO	H	(86)	966

3 eq

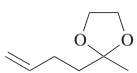


Hov II (0.03 eq)
DCE, reflux,
0.5–1 h

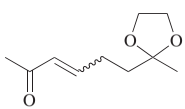


(70) 953

3 eq



Hov II (0.03 eq)
DCE, reflux,
0.5–1 h



(90) 953

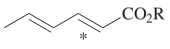
TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

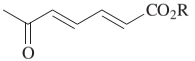
Please refer to the charts preceding the tables for the catalyst structures.

C_4

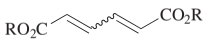




Hov II (0.05 eq), DCM



+

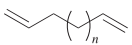


x eq

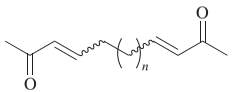
I **II**

x	R	*(*E*)/(*Z*)	Temp (°)	Time (h)	**I**	(*E*)/(*Z*) **I**	**II**	
5	Me	(*E*) only	rt	48	(13)	(*E*) only	(—)	549
3	Et	50:50	45	3	(24)	—	(6)	939

6 eq



Ru cat **129** (*x* eq),
CuI (0.03 eq),
Et_2O, 35°, 16 h



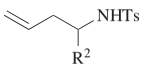
954

n	*x*	Conv. %
2	0.001	80
2	0.0025	>99
3	0.001	5
3	0.02	>99
5	0.0005	94
5	0.001	>99

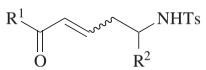
C_{4-8}



5 eq



Hov II (0.075 eq),
DCM, 55°, 48 h

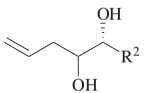


R^1	R^2	
Me	*i*-Pr	(85)
Me	4-$MeOC_6H_4$	(95)
Me	*c*-C_6H_{11}	(76)
Me	4-$CF_3C_6H_4$	(88)
c-C_5H_{11}	Ph	(76)

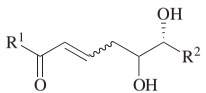
335

C_{4-10}





Hov II (0.025 eq),
DCM, rt, 6 h



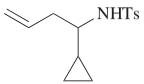
R^1	R^2	
Me	Et	(80)
Me	Ph	(62)
Me	Bn	(75)
Et	Et	(76)
Bn	Et	(95)

967

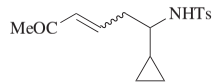
C_4



5 eq



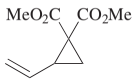
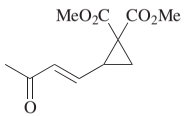
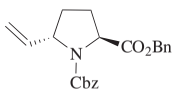
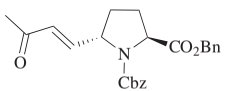
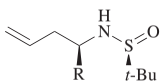
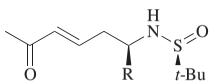
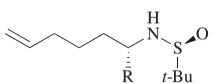
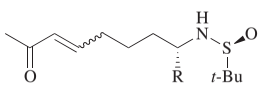
Hov II (0.075 eq)
DCM, 55°, 72 h



(94)

335

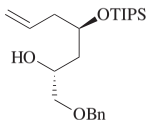
TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 1.4 eq		Gr II (0.01 eq), DCM, reflux	 (82) (*E*) only	407
1 eq		Hov II (0.05 eq), toluene, 80°, 4 h	 (61) (*E*) only	968
3.3 eq		Hov II (0.1 eq), DCM, 45°, 60 h	 (*E*) only	969
			R: *n*-Pr (85); *n*-C_9H_{19} (72); *n*-$C_{11}H_{23}$ (75); Ph (85)	
5 eq		Ru cat **190** (0.1 eq), Ti(O*i*-Pr)$_4$ (0.1 eq), DCM, reflux, 2 h		959
			R: Me (99); CF_3 (99)	

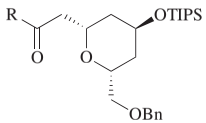
C_{4-9}



1.5 eq



Hov II (0.1 eq),
DCM, 100° (MW),
0.5 h



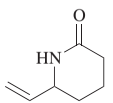
dr < 5:95

R		
Me	(95)	970
Ph	(79)	

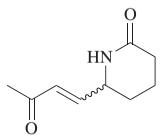
C_4



10 eq



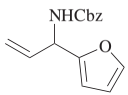
Hov II (0.1 eq),
DCM, 40°, 48 h



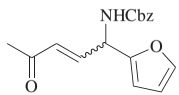
(65)

934

5 eq



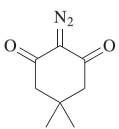
Hov II (0.1 eq),
DCM, 40°, 48 h



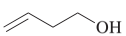
(69)

934

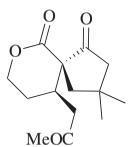
1 eq



+



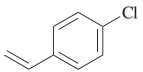
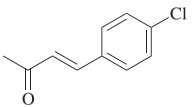
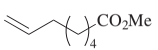
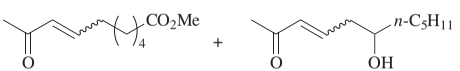
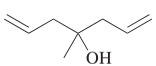
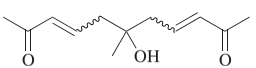
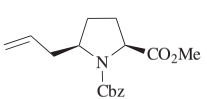
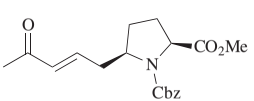
1. DCM,
300 MW, 0.25 h
2. Hov II (0.04 eq),
100°, 0.5 h
3. IPr (0.2 eq), rt, 20 h



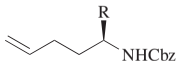
(44) dr > 20:1

955

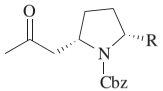
TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 2 eq		Ru cat **286** (0.02 eq), DCM, 40°, 8 h	 (58) (*E*)/(*Z*) > 95:5	161
6 eq		Ru cat **129** (0.005 eq), CuI (0.03 eq), Et_2O, 35°, 16 h	 **I** (>98), **I/II** = 1:1 **II**	954
3 eq		Hov II (0.03 eq) DCE, reflux, 0.5–1 h	 (60)	953
1 eq		Hov II (0.05 eq), DCM, rt, 12 h	 (81) (*E*) only	968

2 eq

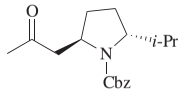


Hov II (0.05 eq),
BF_3•Et_2O (0.01 eq),
DCM



I

+

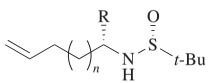


II

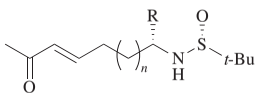
958

R	Temp (°)	Time (h)	**I + II**	**I/II**
i-Pr	45	96	(97)	3:1
i-Pr	100 (MW)	0.33	(81)	1:4
Ph	45	96	(98)	6:1
Ph	100 (MW)	0.33	(86)	1:2
PMP	45	96	(78)	4:1
PMP	100 (MW)	0.33	(97)	1:2

5 eq



Ru cat **190** (0.1 eq),
$Ti(Oi\text{-}Pr)_4$ (0.1 eq),
DCM, reflux, 2 h



(*E*) only

R	*n*		
i-Pr	1	(>99)	959
i-Pr	2	(93)	
Ph	1	(82)	
Ph	2	(84)	

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

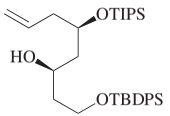
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

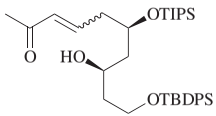
C_4



1.5 eq

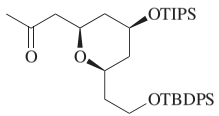


Catalyst (0.1 eq), 2,6-Cl_2-BQ (*x* eq), solvent



I

+

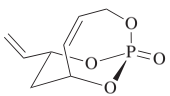


II

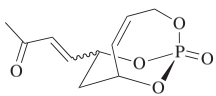
970

Catalyst	*x*	Solvent	Temp (°)	Time (h)	**I**	**II**	*cis*/*trans* **II**
Hov II	—	DCM	35	12	(88)	(0)	—
Hov II	—	DCE	80	15	(0)	(80)	90:10
Gr II	—	DCE	80	15	(19)	(31)	40:60
Hov II	—	DCM	100 (MW)	0.5	(0)	(94)	88:12
Hov II	0.2	DCM	100 (MW)	0.5	(17)	(73)	—

x eq

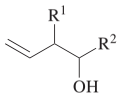


Catalyst (0.01 eq), DCM, reflux

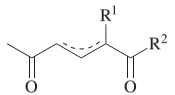


719

x	Catalyst	Conc (M)	
3	Gr I	0.05	(<5)[c]
3	Gr II	0.05	(25)[c]
3	Gr II	0.1	(26)[c]
3	Hov II	0.05	(75)
4	Hov II	0.1	(71)

5 eq 

1. Ru cat **89** (*x* eq), DCM, 55°, 48 h
2. DMP, 0°

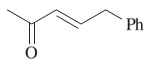


362

R^1	R^2	*x*	
H	Ph	0.05	(78)
Me	Ph	0.02	(73)
EtO	Ph	0.05	(45)
H	$Ph(CH_2)_2$	0.02	(61)
H	4-$MeOC_6H_4$	0.05	(62)
Me	2-furyl	0.05	(54)
Me	3-BrC_6H_4	0.02	(60)
H	3-$CF_3C_6H_4$	0.05	(45)

x eq 

Catalyst (*y* eq), solvent, reflux



(*E*) only

x	Catalyst	*y*	Solvent	Time (h)		
3	Hov II	0.03	DCE	0.5–1	(81)	953
0.4	Gr II	0.025	DCM	12	(99)	971
0.4	Hov II	0.025	DCM	12	(99)	971
0.4	Ru cat **86**	0.025	DCM	12	(99)	971

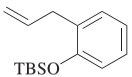
TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

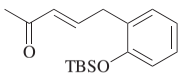
Please refer to the charts preceding the tables for the catalyst structures.

C_4





Catalyst (*x* eq),
additive (y eq),
solvent



3 eq

Catalyst	*x*	Additive	*y*	Solvent	Temp (°)	Time (h)	Conv. (%)		(*E*)/(*Z*)	
Gr II	0.02	—	—	2.5% aq. PTS	22	4	64	(—)	—	972
Gr II	0.02	—	—	2.5% aq. TPGS-550-M	22	4	50	(—)	—	972
Gr II	0.02	—	—	2.5% aq. TPGS-600	22	4	60	(—)	—	972
Gr II	0.02	—	—	2.5% aq. TPGS-750-W	22	4	74	(—)	—	972
Gr II	0.02	—	—	2.5% aq. TPGS-1000	22	4	35	(—)	—	972
Gr II	0.02	—	—	2.5% aq. PTS	22	12	—	(70)	—	972
Gr II	0.02	—	—	2.5% aq. TPGS-750-W	22	12	—	(74)	—	972
Gr II	0.02	$KHSO_4$	0.04	2.5% aq. TPGS-750-W	22	4	—	(93)	—	972
Gr II	0.02	$KHSO_4$	0.04	2.5% aq. PTS	22	4	—	(91)	—	972
Gr II	0.02	CuCN	0.03	DCM	22	15	24	(—)	—	167
Gr II	0.02	CuOAc	0.03	DCM	22	15	<5	(—)	—	167
Gr II	0.02	$Cu(OTf)_2$	0.03	DCM	22	15	0	(—)	—	167
Gr II	0.02	$Cu(BF_4)_2$	0.03	DCM	22	15	15	(—)	—	167
Gr II	0.02	$Cu(NO_3)_2$	0.03	DCM	22	15	0	(—)	—	167
Gr II	0.02	$Cu(ClO_4)_2$	0.03	DCM	22	15	22	(—)	—	167
Gr II	0.02	$Cu(CF_3CO_2)_2$	0.03	DCM	22	15	0	(—)	—	167
Gr II	0.02	$Cu(CH_3CN)_4PF_6$	0.03	DCM	22	15	27	(—)	—	167
Gr II	0.02	CuCl	0.03	DCM	22	15	35	(—)	—	167
Gr II	0.02	CuBr	0.03	DCM	22	15	43	(—)	—	167
Gr II	0.02	CuI	0.03	DCM	22	15	64	(—)	—	167
Gr II	0.02	—	0.03	DCM	22	15	45	(—)	—	167

Catalyst	*x*	Additive	*y*	Solvent	Temp (°)	Time (h)	Conv. (%)		(*E*)/(*Z*)	
Gr II	0.02	CuI	0.06	DCM	22	15	63	(—)	—	167
Gr II	0.03	CuI	0.06	DCM	22	15	68	(—)	—	167
Gr II	0.02	CuI	0.03	toluene	22	15	54	(—)	—	167
Gr II	0.02	CuI	0.03	THF	22	15	70	(—)	—	167
Gr II	0.02	CuI	0.03	Et_2O	22	15	71	(—)	—	167
Gr II	0.02	—	—	Et_2O	22	15	43	(—)	—	167
Gr II	0.02	—	—	Et_2O	35	3	57	(—)	—	167
Gr II	0.02	CuI	0.03	Et_2O	35	3	99	(98)	>95:5	167
Gr II	0.02	NaI	0.03	Et_2O	35	3	100	(—)	—	167
Ru cat **13**	0.02	CuI	0.03	Et_2O	22	15	59	(—)	—	167
Ru cat **13**	0.02	—	—	Et_2O	22	15	22	(—)	—	167
Ind II	0.02	CuI	0.03	Et_2O	22	15	71	(—)	—	167
Ind II	0.02	—	—	Et_2O	22	15	32	(—)	—	167
Gr II	0.02	CuI	0.03	2.5% aq. TPGS-750-W	22	12	—	(93)	—	167
Gr II	0.02	—	—	2.5% aq. TPGS-750-W	22	12	—	(74)	—	167
Gr II	0.02	—	—	2.5% aq. PTS	22	4	64	(—)	—	931
Gr II	0.02	NaCl	0.03	2.5% aq. PTS	22	4	75	(—)	—	931
Gr II	0.02	—	—	2.5% PTS, H_2O:MeOH 19:1	22	4	59	(—)	—	931
Gr II	0.02	—	—	2.5% PTS, H_2O:EtOH 19:1	22	4	54	(—)	—	931
Gr II	0.02	—	—	2.5% aq. solutol	22	4	33	(—)	—	931
Gr II	0.02	—	—	95% EtOH	22	4	22	(—)	—	931
Gr II	0.02	—	—	AcOH	22	4	20	(—)	—	931
Gr II	0.02	—	—	DCM	22	4	30	(—)	—	931
Gr II	0.02	—	—	10% PTSA in 95% EtOH	22	4	<5	(—)	—	931

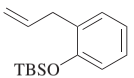
TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

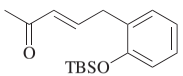
Please refer to the charts preceding the tables for the catalyst structures.

C_4





Catalyst (*x* eq), additive (y eq), solvent



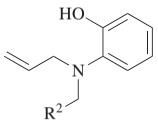
3 eq

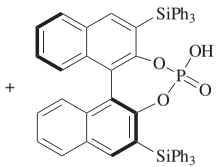
Catalyst	*x*	Additive	*y*	Solvent	Temp (°)	Time (h)	Conv. (%)		(*E*)/(*Z*)	
Gr II	0.02	—	—	2.5% PTS in 95% EtOH	22	4	28	(—)	—	931
Gr II	0.02	$KHSO_4$	0.04	2.5% aq. PTS	22	4	95	(—)	—	931
Ind II	0.02	$KHSO_4$	0.04	2.5% aq. PTS	22	4	94	(—)	—	931
Gr II	0.02	$KHSO_4$	0.04	2.5% PTS in 95% EtOH	22	4	<5	(—)	—	931
Gr II	0.02	—	—	2.5% aq. PTS	22	12	—	(74)	—	931
Gr II	0.02	CuI	0.03	2.5% aq. PTS	22	12	—	(92)	—	931
Ru cat **80**	0.02	$KHSO_4$	0.04	2.5% aq. PTS	22	4	0	(—)	—	931
Ru cat **80**	0.02	—	—	2.5% aq. PTS	22	4	0	(—)	—	931
Ru cat **89**	0.02	$KHSO_4$	0.04	2.5% aq. PTS	22	4	88	(—)	—	931
Ru cat **89**	0.02	—	—	2.5% aq. PTS	22	4	90	(—)	>95:5	931
Ind II	0.02	—	—	2.5% aq. PTS	22	4	64	(—)	—	931
Hov II	0.02	$KHSO_4$	0.04	2.5% aq. PTS	22	4	61	(—)	—	931
Hov II	0.02	—	—	2.5% aq. PTS	22	4	62	(—)	—	931

C_{4-6}



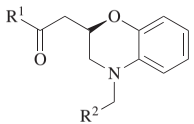
1.5 eq





0.05 eq

Hov II (0.05 eq),
DCM, 40°



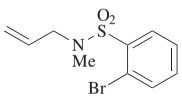
973

R^1	R^2	Time (h)		er
Me	Ph	5	(76)	88.0:12.0
Et	Ph	12	(81)	89.0:11.0
n-Pr	Ph	12	(67)	91.0:9.0
Me	1-Naph	12	(58)	89.5:10.5
Me	2-Naph	14	(63)	82.0:18.0

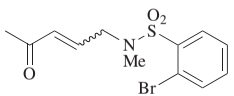
C_4



3 eq



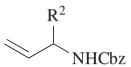
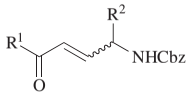
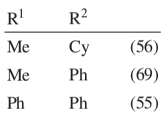
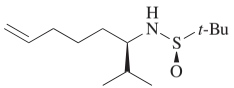
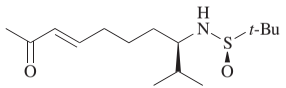
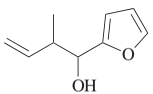
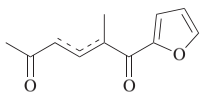
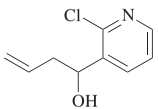
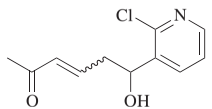
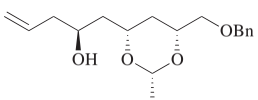
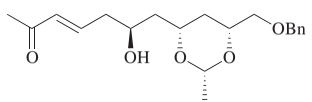
Catalyst (0.05 eq),
DCM



634

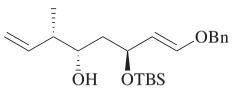
Catalyst	Temp (°)	Time (h)	
Gr II	40	3	(76)
Gr II	110 (MW)	4	(46)
Hov II	110 (MW)	2	(57)

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

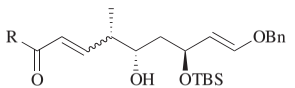
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{4-9}  5 eq		Hov II (0.1 eq), DCM, 40°, 48 h	 	934
C_4  5 eq		Ru cat **190** (0.1 eq), Ti(O*i*-Pr)$_4$ (0.1 eq), DCM, reflux, 2 h	 (93) (*E*) only	959
5 eq		1. Ru cat **89** (0.05 eq), DCM, 40°, 48 h 2. DMP (3.0 eq), DCM, H_2O	 (71) rr = 67:33	895
3 eq		Hov II (0.1 eq), DCM, 50°, 24 h	 (78)	603
5 eq		Hov II (0.01 eq), DCM, 40°, 2 h	 (87) (*E*)/(*Z*) > 95:5	925



3 eq



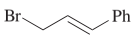
Hov II
(0.27 + 0.27 eq),
DCE, reflux,
12 + 16 h



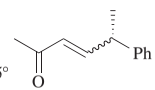
R		
Me	(94)	974
$TBSOCH_2$	(91)	



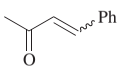
5 eq



1. MeMgBr (1.2 eq),
(*R*,*R*)-Taniaphos
(0.012 eq),
CuBr•SMe_2
(0.01 eq), DCM, –75°
2. Hov II (0.02 eq),
DCM, rt



+



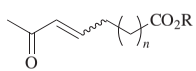
I (80), er 99.5:0.5 **I/II** > 97:3 **II**

975

x eq



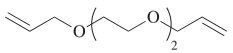
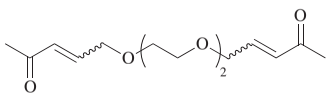
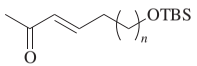
Ru cat **129** (*y* eq),
CuI (0.03 eq),
Et_2O, 35°, 16 h



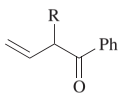
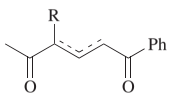
954

x	R	*n*	*y*	
6	Me	6	0.002	(25)
6	Me	6	0.005	(98)
3	Bu	7	0.001	(99)

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
		Hov II (0.03 eq) DCE, reflux, 0.5–1 h	 (63)	953
3 eq				
3 eq		Catalyst (0.02 eq), CuI (*x* eq), solvent, 22°, 12 h		

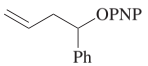
n	Catalyst	*x*	Solvent		(*E*)/(*Z*)	
7	Gr II	—	2.5 % aq. PTS	(89)	(*E*) only	976
8	Ru cat **109**	—	H_2O	(80)	(*E*) only	341
8	Gr II	—	2.5 % aq TPGS-750-M	(76)	—	167
8	Gr II	0.03	2.5 % aq TPGS-750-M	(90)	—	167

5 eq		Ru cat **89** (0.05 eq), DCM, 55°		R	Time (h)		rr	895
				H	96	(63)	77:23	
				Me	48	(14)	83:17	

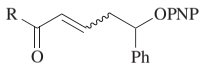
C_{4-5}



3 eq



Catalyst (x eq), $KHSO_4$ (y eq), solvent

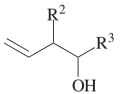


R	Catalyst	x	y	Solvent	Temp (°)	Time (h)		
Me	Hov II	0.02	—	DCM	40	15	(95)	932
Et	Hov II	0.02	—	DCM	40	15	(97)	932
Et	Gr II	0.04	0.04	2.5 % aq. PTS	22	8	(75)	931

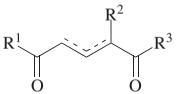
C_{4-9}



3 eq



1. Ru cat **89** (0.05 eq), DCM, 55°, 48 h
2. DMP (3.0 eq), DCM, H_2O



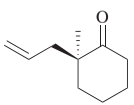
895

R^1	R^2	R^3		rr
Me	H	Ph	(75)	77:23
Me	Me	Ph	(83)	83:17
Et	EtO	4-BrC_6H_4	(44)	91:9
Ph	Me	Ph	(54)	91:9

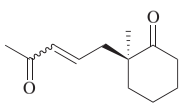
C_4



2.5 eq



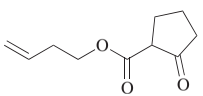
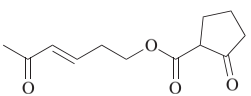
Gr II (0.05 eq), DCM, 40°, 18 h



(78)

977

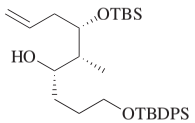
TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions		Product(s) and Yield(s) (%)		Refs.
Please refer to the charts preceding the tables for the catalyst structures.						
C_4						
 3 eq		1. Hov II (0.02 eq), DCM, 40°, 15 h 2. DBU (2 eq), 22°, 1 h	ArOH	Ar Ph (98) 4-$MeOC_6H_4$ (92) 4-$O_2NC_6H_4$ (91) 4-IC_6H_4 (92) 2-MeO-4-MeC_6H_3 (98) 3-$MeOC_6H_4$ (93) 4-BzC_6H_4 (90) 4-$OHCC_6H_4$ (86) 4-PhC_6H_4 (97) 4-*t*-BuC_6H_4 (90) 4-NCC_6H_4 (40) 4-$TBSOC_6H_4$ (92) 4-$AcOC_6H_4$ (85) 4-$BnOC_6H_4$ (94)		956
1 eq		Hov II (0.03 + 0.01 eq), DCM, 100° (MW), 0.33 + 0.17 h			(66) (*E*)/(*Z*) = 91:9	955

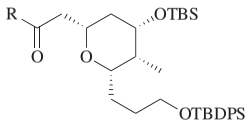
C_{4-9}



1.5 eq



Hov II (0.1 eq),
DCM,
100° (MW), 0.5 h



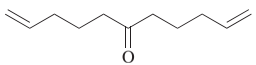
(*E*)/(*Z*) > 95:5

R		
Me	(97)	970
$PMBO(CH_2)_3$	(94)	
Ph	(77)	

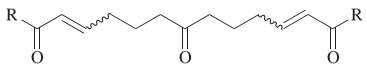
C_{4-5}



3 eq



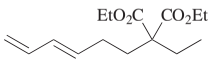
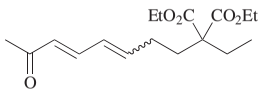
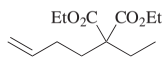
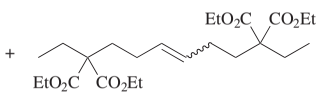
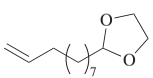
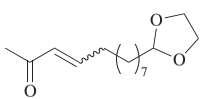
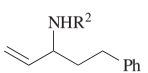
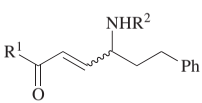
Ru cat **190**
(2 x 0.025 eq),
DCM, rt, 120 h



231

R	Temp (°)	Time (h)	
Me	120 (MW)	3.5	(76)
Et	rt	120	(87)

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

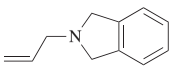
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 3 eq	 (*E*)/(*Z*) = 50:50	Hov II (0.05 eq), DCM, 45°, 3 h	 (38) +  (11) +  (13)	939
3 eq		Gr II (0.02 eq), $KHSO_4$ (0.03 eq), 2.5 % aq PTS, 22°, 4 h	 (90)	931
C_{4-9}				
 5 eq		Hov II (0.1 eq), DCM, 40°, 48 h		934

R^1	R^2	
Me	Cbz	(72)
Me	Ts	(73)
Me	Boc	(73)
Me	$COCF_3$	(60)
Et	Cbz	(71)
Ph	Cbz	(59)

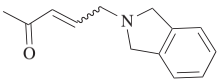
C_4



1 eq



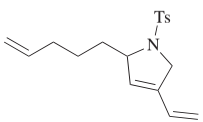
Hov II (*x* eq), additive (0.1 eq), solvent, 12 h



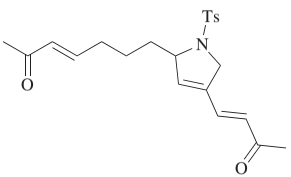
952

x	Additive	Solvent	Temp (°)	
0.05	—	toluene	80	(40)
0.05	ClBcat	toluene	80	(42)
0.05	Cy_2BCl	toluene	80	(99)
0.01	Cy_2BCl	toluene	80	(70)
0.05	Cy_2BCl	DCM	40	(99)

3 eq

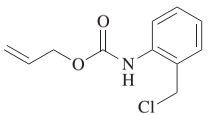
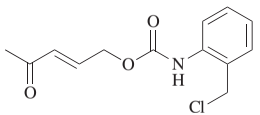
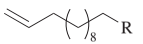
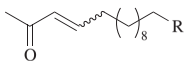
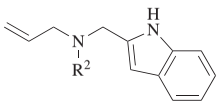
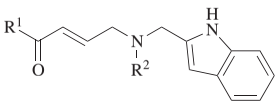


Hov II (0.05 eq), DCM, 45°, 3 h



(84) (*E*)/(*Z*) > 95:5 939

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

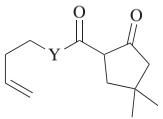
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 1 eq		Hov II (0.05 + 0.02 eq), DCM, 40°, 3 h + overnight	 (80) (*E*) only	618
3 eq		Hov II (0.03 eq), DCE, reflux, 0.5–1 h	 R: H (92); HO (86)	953
C_{4-9}				
 6 eq		Gr II, DCM, 40°, 16 h		978

R^1	R^2		(*E*)/(*Z*)
Me	Cbz	(34)	>98:2
Me	MeO_2C	(50)	>98:2
Me	CF_3CO	(41)	>98:2
Me	Bn	—	—
Ph	Boc	(38)	>98:2
Me	Boc	(65)	>98:2

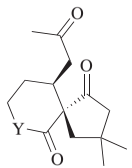
C_4



1 eq

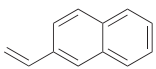


1. Hov II (0.03 + 0.01 eq), DCM, 100° (MW), 20 + 10 min
2. IPr (0.2 eq), 24°, 20 h



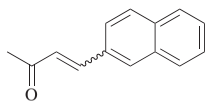
(*E*)/(*Z*) > 95:5

Y		
BnN	(79)	979
O	(44)	



3 eq

Hov II (0.03 eq), DCE, reflux, 0.5–1 h

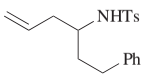


(81) 953

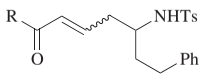
C_{4-5}



5 eq



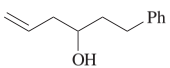
Hov II (0.075 eq), DCM, 55°, 48 h



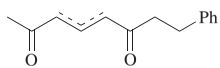
R		
Me	(79)	335
Et	(71)	



5 eq

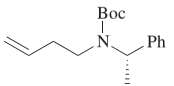
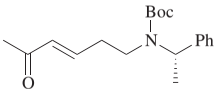
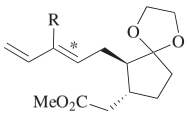
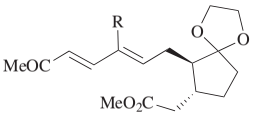
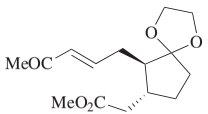
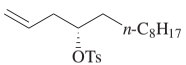
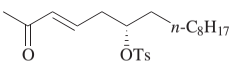


1. Ru cat **89** (0.05 eq), DCM, 40°, 48 h
2. DMP (3 eq), DCM, H_2O



(71) rr = 53:47 895

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 2 eq		Ru cat **185** (0.05 eq), solvent		(*E*)/(*Z*) > 95:5	924
			Solvent / Temp (°) / Time (h): BMI•PF_6/toluene, rt, 6, (80); BMI•PF_6/DCM, 40, 3, (94)		
 3 eq		Hov II (0.05 eq), DCM, 45°, 3 h	 **I** +  **II**		939
			R / *(*E*)/(*Z*) / **I** / (*E*)/(*Z*) **I** / **II** / (*E*)/(*Z*) **II**: H, 50:50, (35), 50:50, (38), 50:50; Me, 80:20, (73), 80:20, (0), —		
 5 eq		Gr II (0.05 eq), DCM, 40°, 6 h		(84) (*E*) only	980

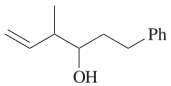
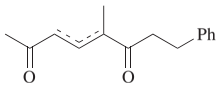
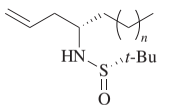
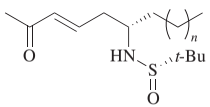
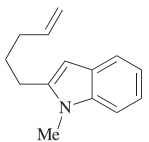
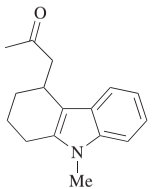
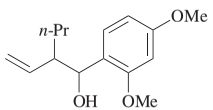
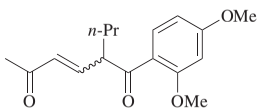
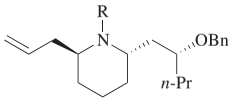
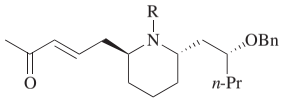
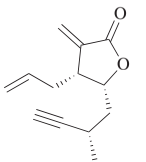
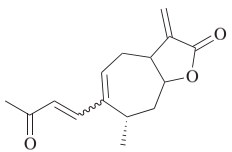
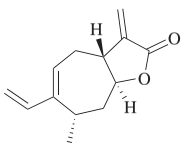
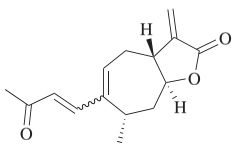
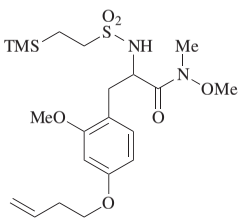
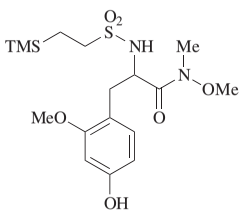
5 eq		1.Ru cat **89** (0.05 eq), DCM, 40°, 48 h 2. DMP (3 eq), DCM, H_2O		(73) dr 50:50	895
3.3 eq		Hov II (0.1 eq), DCM, 45°, 48 h	 (*E*) only	n 7 (72) 9 (75)	969
5 eq		Hov II (0.03 eq), DCE, reflux, 0.5 h		(98)	950
5 eq		1. Ru cat **89** (0.05 eq), DCM, 40°, 48 h 2. DMP (3 eq), DCM, H_2O		(52)	895

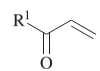
TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 6 eq		Hov II (*x* eq), additive, toluene, 80°		389

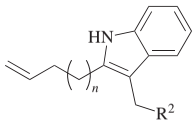
R	*x*	Additive	Time (h)		(*E*)/(*Z*)
Bn	0.1	Ti(O*i*-Pr)$_4$	—	(0)	—
MeO_2C	2 x 0.15	—	2 x 0.5	(41)	100:0

10 eq		Hov II (0.2 eq), DCM, 45°, 13 h		(83)	531
		Hov II, DCM, reflux		(49)	981
3 eq		1. Hov II (0.02 eq), DCM, 40°, 15 h 2. DBU (2 eq), 22°, 1 h		(90)	956

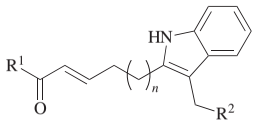
C_{4-13}



1.5 eq



Ru cat **89** (0.03 eq), DCM, 45°



$(E)/(Z) > 98:2$

982

R^1	R^2	n	
Me	H	2	(94)
Ph	H	1	(36)
Ph	H	2	(45)
Ph	Me	2	(68)
Ph	$HOCH_2$	2	(79)
Ph	Et	2	(73)
Ph	$AcCH_2$	2	(67)
Ph	$BzCH_2$	2	(79)
Ph	Ph	2	(81)
4-BrC_6H_4	H	2	(36)
4-ClC_6H_4	H	2	(57)
4-MeC_6H_4	H	2	(55)
4-$MeOC_6H_4$	H	2	(46)
1-Naph	H	2	(53)

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

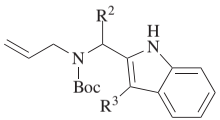
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

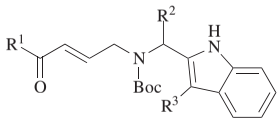
C_{4-9}



x eq



Catalyst (*y* eq), DCM

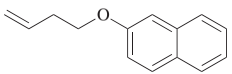


R^1	*x*	R^2	R^3	Catalyst	*y*	Temp (°)	Time (h)		(*E*)/(*Z*)	
Me	—	Ph	H	Gr II	—	40	16	(43)	—	978
Ph	1.5	H	Me	Ru cat **89**	0.03	45	—	(69)	>98:2	982
Ph	1.5	H	Ph	Ru cat **89**	0.03	45	—	(43)	>98:2	982

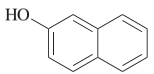
C_4



3 eq

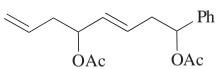


1. Hov II (0.02 eq), DCM, 40°, 15 h
2. DBU (2 eq), 22°, 1 h

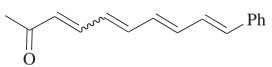


(93) 956

3 eq



1. Hov II (0.05 eq), DCM, rt, 16 h
2. TBAF, THF, rt, 24 h



(51) 919

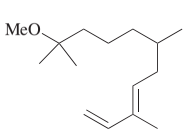
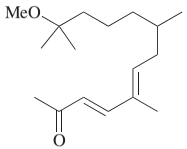
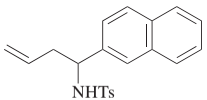
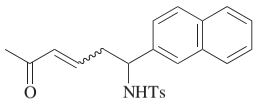
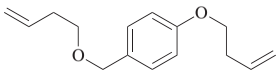
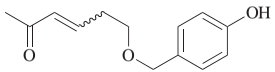
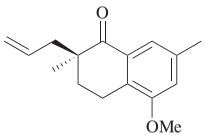
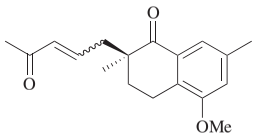
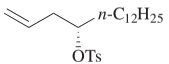
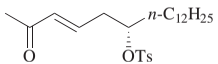
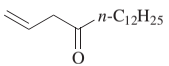
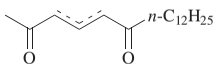
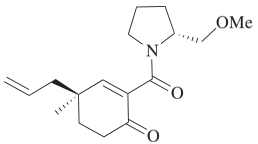
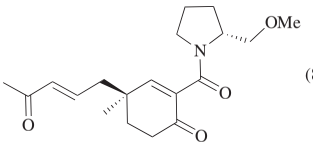
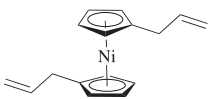
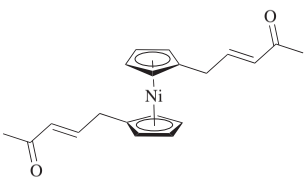
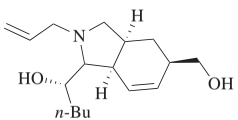
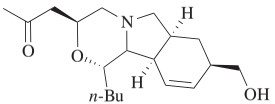
3 eq	 (*E*)/(*Z*) = 80:20	Hov II (0.05 eq), DCM, 45°, 3 h		(77) (5*E*)/(5*Z*) = 80:20	939
5 eq		Hov II (0.075 eq) DCM, 55°, 48 h		(81)	335
6 eq		1. Hov II (0.04 eq), DCM, 40°, 15 h 2. DBU (2 eq), 22°, 1 h		(91)	956
10 eq		Hov II (0.1 eq), benzene, 40°, 5 h		(66)	983
5 eq		Gr II (0.05 eq), DCM, 40°, 6 h		(84) (*E*) only	980
5 eq		Ru cat **89** (0.05 eq), DCM, 40°, 48 h		(73) rr = 50:50	895

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 10 eq		Hov II (0.025 eq), DCM, reflux, 7 h	 (87) (*E*)/(*Z*) = 89:11	896
6 eq		Gr II (0.06 eq), DCM, reflux, 3 h	 (82) (*E*) only	984
10 eq		1. Hov II (0.1 eq), TsOH (1 eq), DCM 2. 100° (MW), 4 h	 (64)	985

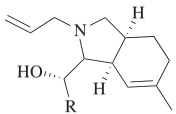
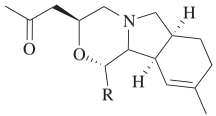
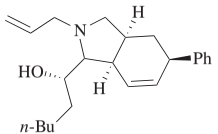
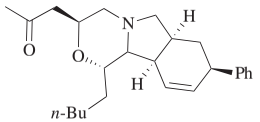
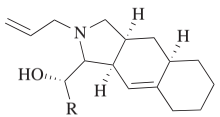
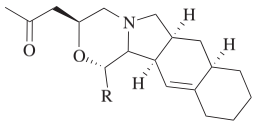
10 eq		1. Hov II (0.1 eq), TsOH (1 eq), DCM 2. 100° (MW), 4 h		R *i*-Bu (82) n-C_5H_{11} (55) Bn (84)	985
10 eq		1. Hov II (0.1 eq), TsOH (1 eq), DCM 2. 100° (MW), 4 h		(71)	985
10 eq		1. Hov II (0.1 eq), TsOH (1 eq), DCM 2. 100° (MW), 4 h		R *i*-Bu (65) n-C_5H_{11} (56)	985

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

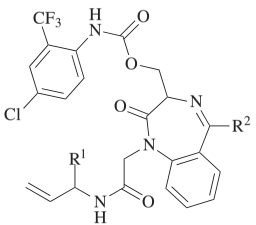
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

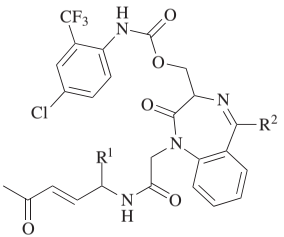
C_4



10 eq



Hov II (*x* eq), DCM, 100° (MW)

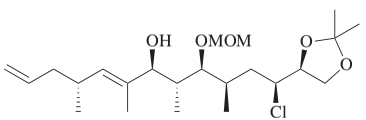


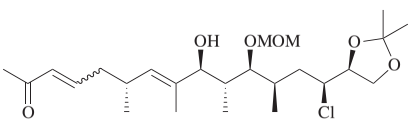
(*E*) only

R^1	R^2	*x*	Time (h)		Refs.
H	Me	0.1	2	(80)	986
H	Ph	0.2	1	(70)	987
$Ph(CH_2)_2$	Ph	0.2	1	(99)	987

5 eq

Ru cat **363** (0.051 eq), DCM, 60°, 41 h





(65)

988

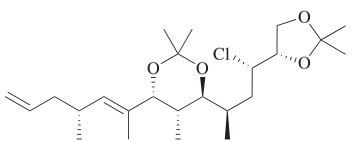
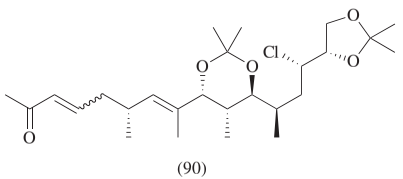
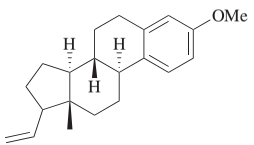
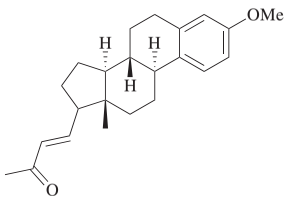
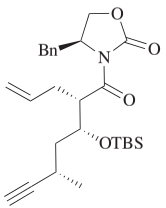
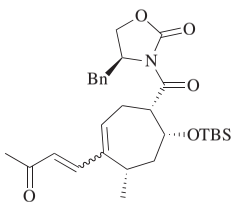
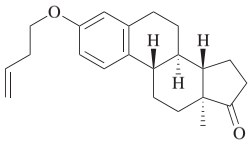
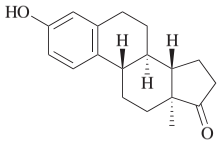
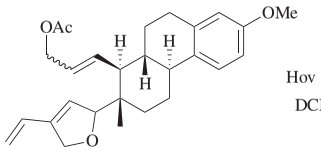
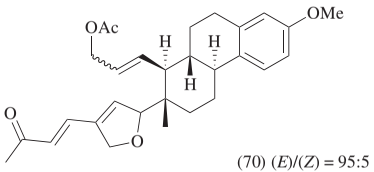
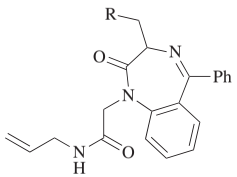
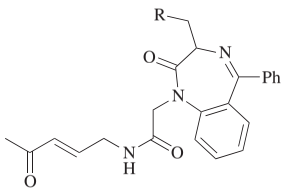
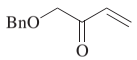
5 eq		Ru cat **363** (0.05 eq), DCM, 60°, 42.5 h	 (90)		988
3 eq		Hov II (0.05 eq), DCM, 45°, 24 h		(39) (*E*)/(*Z*) = 95:5	939
5 eq		Hov II (0.2 eq), DCM, 45°		(62)	531

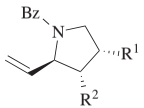
TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 3 eq		1. Hov II (0.02 eq), DCM, 40°, 15 h 2. DBU (2 eq), 22°, 1 h	 (88)	956
3 eq		Hov II (0.05 eq), DCM, 45°, 24 h	 (70) (*E*)/(*Z*) = 95:5	939
10 eq		Hov II (0.1 eq), DCM, 100° (MW), 2 h	 (*E*) only	986

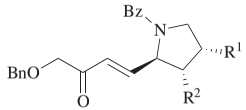
R	
4-morpholinyl	(85)
1-piperidinyl	(83)
i-BuHN	(87)



x eq



Hov II (0.05 eq),
DCM, reflux, 60 h

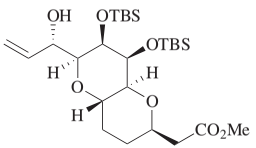


x	R^1	R^2	
2	H	H	(80)
4	H	BnO	(57)
4	BnO	H	(76)

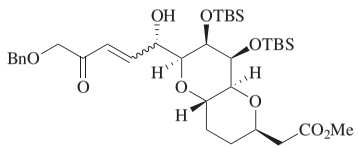
(*E*) only

717

10 eq



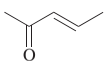
Hov II (0.05 eq),
toluene, 80°



(81)

989

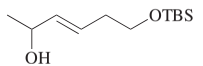
C_5



3 eq



1. Gr II (0.1 eq),
DCM, reflux, 3 h
2. DIBAL-H (3.75 eq)
DCM, –78°, 2 h

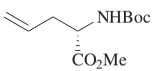


(72)

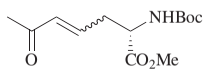
(*E*)/(*Z*) > 95:5

940

5 eq



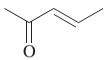
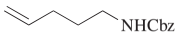
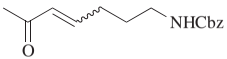
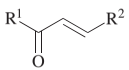
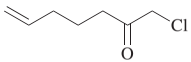
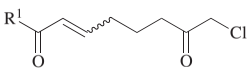
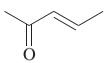
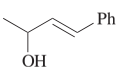
Gr II (0.05 eq),
DCM, reflux, 16 h



(—)

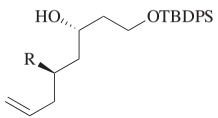
943

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

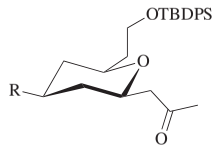
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5  5 eq		Gr II (0.05 eq), DCM, 45°, 48 h	 (67)	944
$C_{5–11}$  1.5 eq		Gr II (0.025 eq), DCM, 45°, 12 h		945
C_5  3 eq		1. Gr II (0.1 eq), DCM, reflux, 3 h 2. DIBAL-H (3.75 eq) DCM, –78°, 2 h	 (70) (*E*)/(*Z*) = 95:5	940

R^1	R^2	
Me	Me	(82)
$Ph(CH_2)_2$	H	(83)

3–10 eq



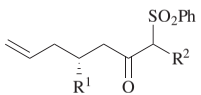
Hov II (0.1 eq), additive (0.03–0.1 eq), solvent



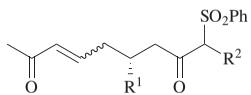
947

R	Additive	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)
H	—	toluene	80–100	11– 24	(73)	75:15
H	CSA	DCM	25–35	—	(19)	>95:5
TIPSO	—	DCM	100 (MW)	0.5	(73)	83:17
TIPSO	—	toluene	80–100	11–24	(80)	71:29
TIPSO	CSA	DCM	25–35	—	(73)	>95:5

x eq



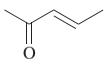
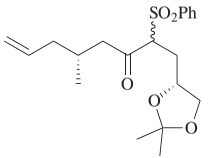
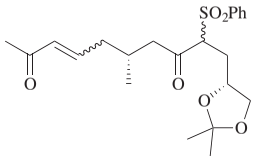
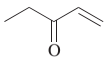
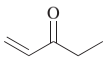
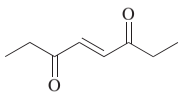
Hov II (*y* eq), DCM, rt



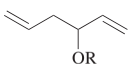
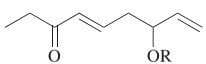
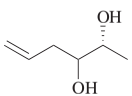
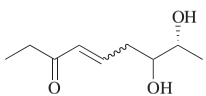
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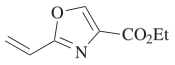
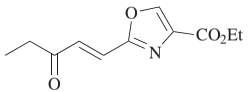
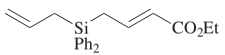
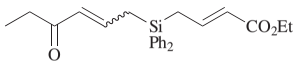
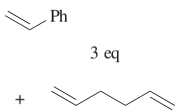
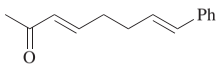
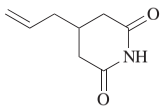
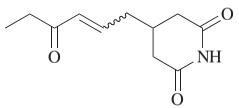
x	R^1	R^2	*y*	Time (h)	
3	H	Me	0.1	24	(70)
5	H	$TBSO(CH_2)_2$	0.05	24	(57)
1.5	H	$N_3(CH_2)_3$	0.05	3.5	(63)
3	H	$PhCH_2$	0.05	24	(65)
1.5	Me	$N_3(CH_2)_3$	0.05	2	(63)

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
 1.5 eq		Hov II (0.05 eq), DCM, rt, 36 h	 (88)	991
		Catalyst (0.05 eq), DCM		

Catalyst	Temp (°)	Time (h)		(*E*)/(*Z*)	
Gr II	40	3	(94)	(*E*) only	170
Hov II	100 (MW)	0.25	(>99)	—	165

3 eq		Hov II (0.05 eq), DCM, 40°	 (*E*)/(*Z*) = 95:5	R: TBDPS (76); TBS (80)	169
— eq		Hov II (0.025 eq), DCM, rt, 6 h		(60)	967

1.5 eq		Catalyst (0.1 eq), DCM, 40°, 24 h	 (*E*)/(*Z*) = 91:9	Catalyst Gr II (46) Hov II (65)	650
3 eq		Hov II (0.025 eq), DCM, rt, 12 h		(91)	992
3 eq +		Gr II (0.07 eq), DCM, 23°, 12 h		(47) (*E*) only	36
3 eq		Hov II (0.05 eq), DCM, rt		(60)	993

$C_{5–10}$

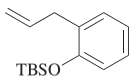
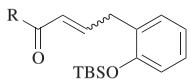
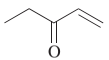
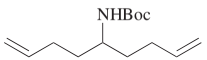
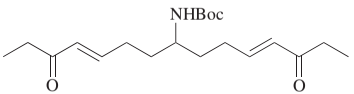
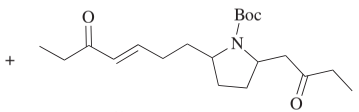
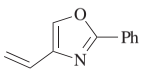
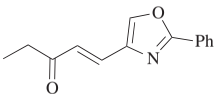
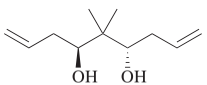
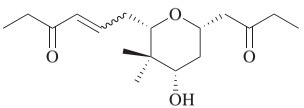
 3 eq		Gr II (0.02 eq), $KHSO_4$ (0.04 eq), 2.5 % aq. PTS, 22°, 4 h		R Et (88) $Ph(CH_2)_2$ (81)	931

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
 6 eq		Hov II (0.074 eq), DCM, rt, 144 h	 (34) (*E*) only +  (62) (*E*) only	994
1.5 eq		Hov II (0.1 eq), DCM, 40°, 36 h	 (72) (*E*)/(*Z*) > 95:5	650
2000 eq		Hov II (0.1 eq), DCE, 80°	 (76) dr 91:9	369

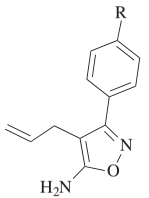
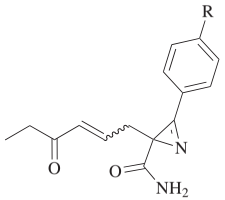
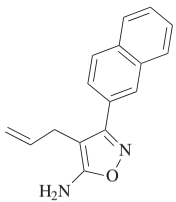
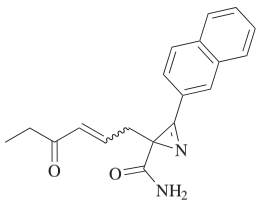
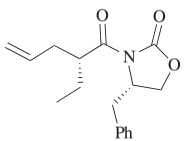
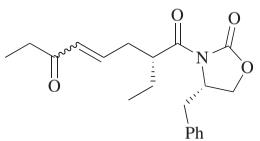
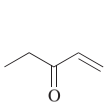
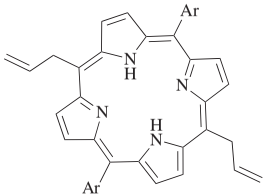
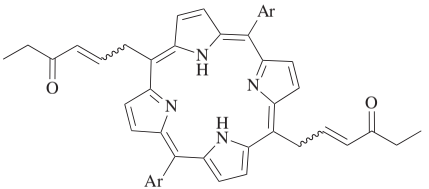
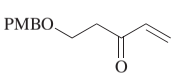
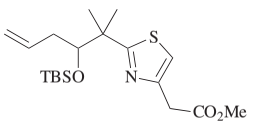
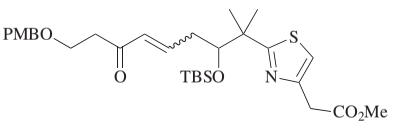
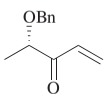
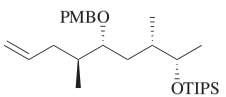
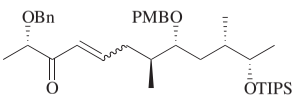
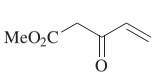
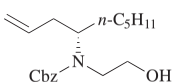
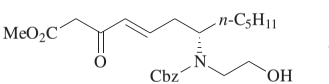
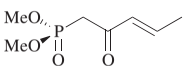
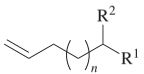
10 eq		Hov II (2 x 0.05 eq), DCM, rt, 48 h, green LED (36 W)		R H (72) Cl (65) Br (33) MeO (49) Me (51)	995
10 eq		Hov II (2 x 0.05 eq), DCM, rt, 48 h, green LED (36 W)		(62)	995
4 eq		Hov II (0.05 eq), DCM, rt, 3 h		(98)	996

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

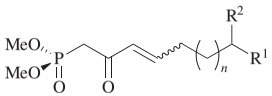
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5  2 eq		Gr II (0.1 eq), DCM, reflux	 Ar: Ph (94); 3-MeOC$_6$H$_4$ (94)	697
 1.5 eq		Gr II (5 x 0.005 eq) DCM, 50° (MW), 5 x 0.25 h	 (50)	997
 1.5 eq		Hov II (0.1 eq), DCM, 40°, overnight	 (70)	998
 2 eq		Hov II (0.075 eq), DCM, reflux, 20 h	 (70) (*E*) only	999



x eq



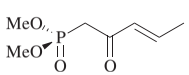
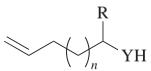
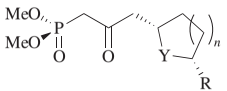
Catalyst (*y* eq),
DCM



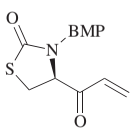
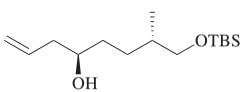
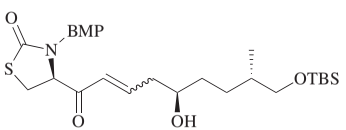
1000

x	R^1	R^2	*n*	Catalyst	*y*	Temp (°)	Time (h)	
3	HO	H	0	Gr II	0.05	rt	16	(10)
3	HO	H	0	Gr II	0.1	40	4	(70)
1	HO	H	0	Hov II	0.05	rt	16	(0)
3	HO	H	0	Hov II	0.05	rt	16	(75)
3	HO	Me	0	Hov II	0.05	rt	16	(14)
3	HO	Ph	0	Hov II	0.05	rt	16	(0)
3	HO	H	1	Hov II	0.05	rt	16	(15)
3	HO	H	2	Hov II	0.05	rt	16	(20)
3	TsHN	H	2	Hov II	2 x 0.05	100 (MW)	2 x 0.25	(72)
3	TsHN	*i*-Pr	2	Hov II	2 x 0.05	100 (MW)	2 x 0.25	(80)
3	TsHN	Ph	2	Hov II	2 x 0.05	100 (MW)	2 x 0.25	(88)

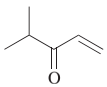
TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
 3 eq		Hov II (2 x 0.05 eq.), DCM, 100° (MW), 2 x 0.25 h		1000

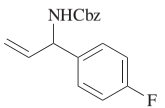
R	Y	*n*		dr
H	TsN	1	(55)	—
H	BocN	1	(80)	—
H	O	1	(54)	—
H	O	2	(46)	—
n-Bu	BocN	1	(43)	70:30
n-Bu	O	1	(77)	50:50
n-Bu	O	2	(80)	>98:2
Ph	BocN	1	(65)	70:30
Ph	TsN	1	(60)	80:20
Ph	O	1	(>99)	60:40
Ph	O	2	(90)	>98:2

 3 eq		Hov II (0.1 eq), DCE, 50°, 5 h		(70)	1001

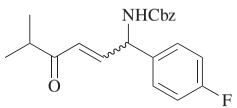
C_6



5 eq



Hov II (0.1 eq),
DCM, 40°, 96 h



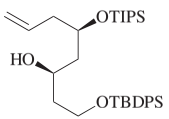
(50)

934

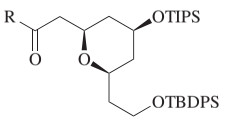
C_{6-9}



1.5 eq



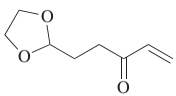
Hov II (0.1 eq),
DCM,
100° (MW), 0.5 h



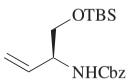
970

R		(*E*)/(*Z*)
$PMBO(CH_2)_3$	(84)	91:9
Ph	(79)	93:7

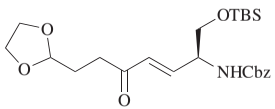
C_6



2 eq



Hov II (0.1 eq),
DCM, 40°, 72 h



(73) (*E*) only

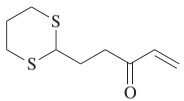
1002

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

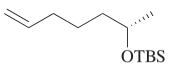
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

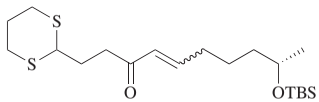
C_6



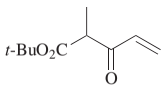
1.5 eq



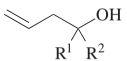
Gr II (0.05 eq), DCM, 45°, 2 h



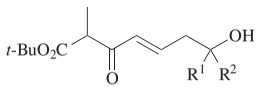
(76) 861



x eq



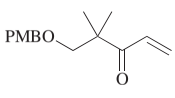
Catalyst (*y* eq), DCM, 40°



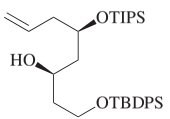
(*E*) only 738

x	R^1	R^2	Catalyst	*y*	Time (h)	
1.5	H	H	Hov II	0.1	36	(61)
1.5	*i*-Pr	H	Hov II	0.1	36	(81)
1.5	*c*-C_6H_{11}	H	Hov II	0.1	36	(78)
1.5	Ph	H	Hov II	0.1	36	(80)
3	*n*-C_7H_{15}	H	Gr II	0.025	14	(82)
3	Ph	Ph	Gr II	0.025	14	(78)

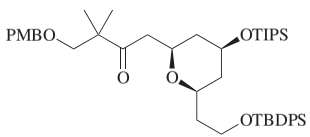
C_7



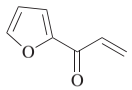
1.5 eq



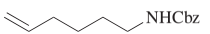
Hov II (0.1 eq), DCM, 100° (MW), 0.5 h



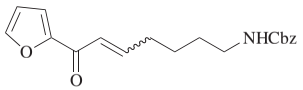
(70) *cis*/*trans* = 91:9 970



3 eq



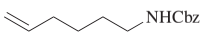
Hov II (0.05 eq),
DCM, rt, 12 h



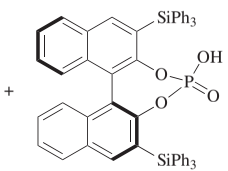
(62)

964

3 eq

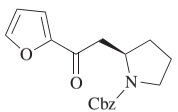


+



0.1 eq

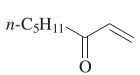
Hov II (0.05 eq),
DCM, 0°, 15 h



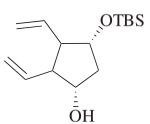
(52) er 92.0:8.0

964

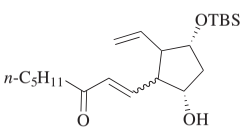
C_8



1.5 eq



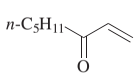
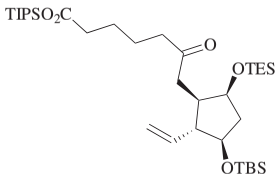
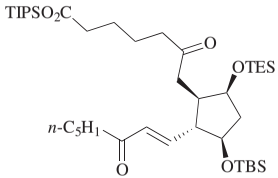
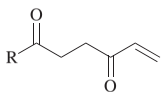
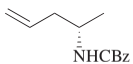
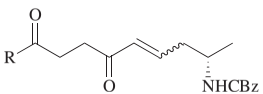
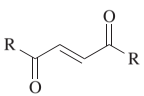
Hov II (0.05 eq),
DCM, 40°, 5 h

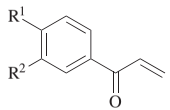


(74)

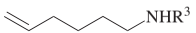
1003

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

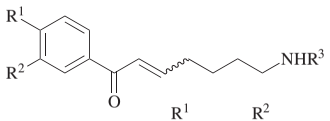
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
 3 eq		Ru cat **89** (0.05 eq), DCM, reflux, 11 h	 (65) (*E*)/(*Z*) > 95:5	817
C_{8-10}				
 1 eq		Hov II (0.05 eq) DCM, reflux, 4 h	 R: *n*-Bu (89); Et (87)	175
C_9				
		Gr II (0.05 eq), DCM, 40°, 3 h	 (*E*) only R: *c*-C_6H_{11} (95); *n*-C_6H_{13} (77)	170



3 eq

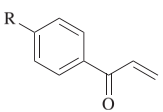


Hov II (0.05 eq),
DCM, rt, 12 h

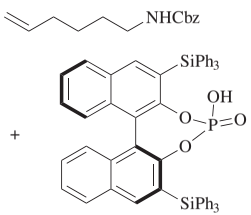


964

R^1	R^2	R^3	
H	H	Cbz	(75)
MeO	H	Cbz	(68)
O_2N	H	Cbz	(75)
Cl	H	Cbz	(64)
MeO	MeO	Boc	(79)
MeO	MeO	Cbz	(78)



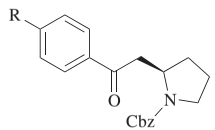
3 eq



+

0.1 eq

Hov II (0.05 eq),
DCM, 0°



964

R	Time (h)		er
H	11	(76)	97.0:3.0
MeO	18	(59)	98.5:1.5
O_2N	36	(52)	93.5:6.5
Cl	24	(60)	97.0:3.0

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

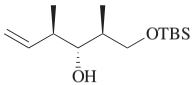
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

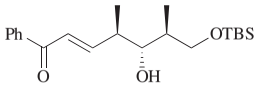
C_9



5 eq



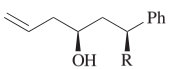
Catalyst (0.05–0.1 eq) DCM, 48 h



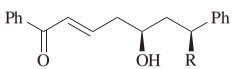
1004

Catalyst	Temp (°)		(*E*)/(*Z*)
Hov II	50	(21)	—
Hov II	40	(43)	—
Hov II	40 (MW)	(40)	—
Ru cat **89**	40	(65)	(*E*) only

x eq

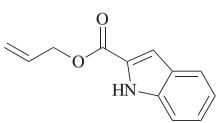


Gr II (*y* eq), DCM

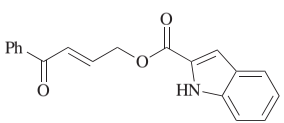


x	R	*y*	Temp (°)	Time (h)		(*E*)/(*Z*)	
3.3	BocHN	0.2	rt	1	(70)	—	1005
5	TBSO	0.05	reflux	—	(75)	95:5	1006
3	TBSO	0.05	reflux	3	(94)	(*E*) only	1007

1.5 eq



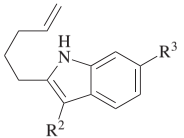
Ru cat **89** (0.05 eq), DCM, 45°

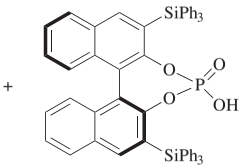


(20) (*E*)/(*Z*) > 98:2 982



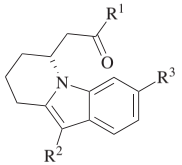
1.5 eq





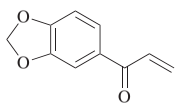
0.1 eq

Ru cat **89** (0.03 eq),
4 Å MS,
toluene, 50°

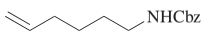


R^1	R^2	R^3		er
Ph	Me	H	(89)	95.0:5.0
4-BrC_6H_4	Me	H	(80)	94.0:6.0
Ph	Me	Me	(81)	97.0:3.0
Ph	$HO(CH_2)_2$	H	(45)	94.0:6.0
Ph	$Ac(CH_2)_2$	H	(92)	95.0:5.0
Ph	Bn	H	(88)	95.0:5.0
Ph	$Bz(CH_2)_2$	H	(94)	95.0:5.0
4-BrC_6H_4	$PhthN(CH_2)_2$	H	(96)	95.0:5.0

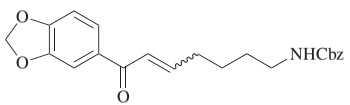
982



3 eq



Hov II (0.05 eq),
DCM, rt, 12 h

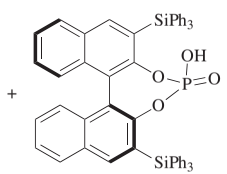


(78)

964

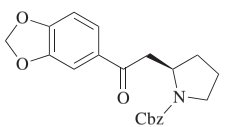
3 eq





0.1 eq

Hov II (0.05 eq),
DCM, 0°, 12 h



(62) er 97.0:3.0

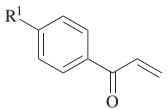
964

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

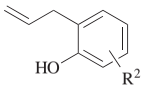
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

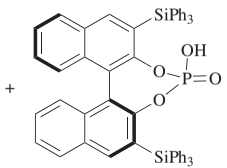
Please refer to the charts preceding the tables for the catalyst structures.

C_9



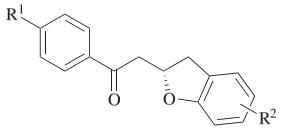
1.5 eq





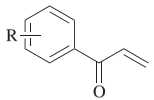
+ 0.05 eq

Hov II (0.05 eq),
DCM, 40°

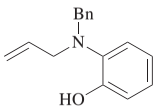


964

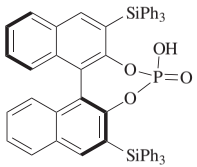
R^1	R^2	Time (h)		er
H	H	48	(56)	89.0:11.0
H	4-MeO	12	(52)	87.0:13.0
H	5-MeO	24	(46)	90.0:10.0
H	6-MeO	12	(59)	83.0:17.0
H	4-Br	24	(40)	89.5:10.5
H	4-Me	12	(49)	89.5:10.5
H	4-*i*-Pr	12	(72)	89.0:11.0
H	4-*t*-Bu	23	(64)	88.0:12.0
H	4-Ph	12	(53)	88.0:12.0
Me	H	12	(49)	90.5:9.5
MeO	H	12	(38)	88.0:12.0
Cl	H	12	(51)	89.5:10.5
Br	H	12	(61)	88.5:11.5
O_2N	H	12	(75)	75.0:25.0



1.5 eq

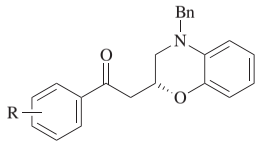


\+



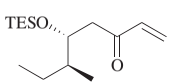
0.05 eq

Hov II (0.05 eq),
DCM, 40°

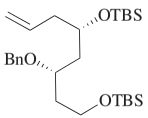


973

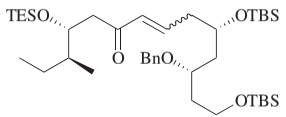
R	Time (h)		er
H	24	(65)	88.5:11.5
2-Br	11	(44)	84.5:15.5
4-Br	11	(52)	88.0:12.0
4-Cl	8	(48)	86.5:13.5
4-O_2N	5	(52)	88.0:12.0
4-MeO	24	(64)	83.5:16.5
4-Me	10	(54)	87.0:13.0



2 eq



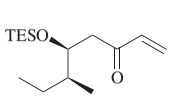
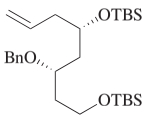
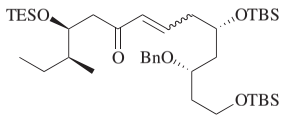
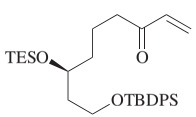
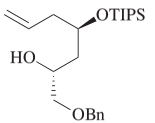
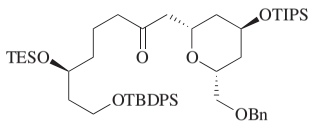
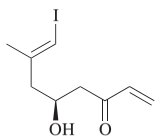
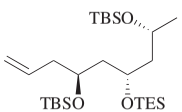
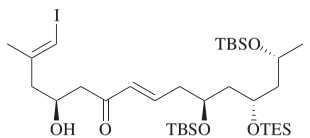
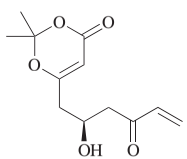
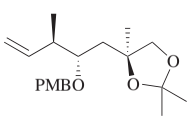
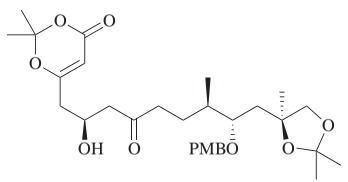
Hov II (0.1 eq),
DCM, 40°, 24 h

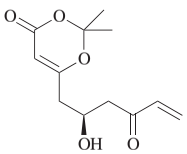


(75)

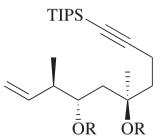
1008

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

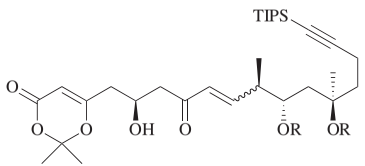
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
 2 eq		Hov II (0.1 eq), DCM, 40°, 24 h	 (77)	1008
 1.5 eq		Hov II (0.1 eq), DCM, 100° (MW), 0.5 h	 (90)	970
 1 eq		Hov II (0.1 eq), DCM, 30°, 15 h	 (66) (*E*) only	1009, 1010
 1.2 eq		1. Hov II (0.2 eq), DCM, 40°, 15 h 2. H_2, Pd/C, AcOEt, rt	 (79)	1011



1.4 eq



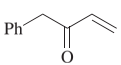
Hov II (*x* eq)
DCM, reflux, 72 h



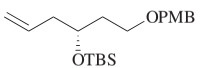
R	*x*	
TES	0.14	(81)
$PMPCH_2$	0.2	(78)

1012

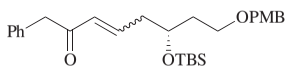
C_{10}



3 eq



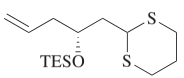
Gr II (0.05 eq),
DCM, 40°, 12 h



(72)

1013

3 eq

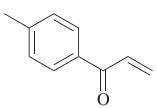


Gr II (0.05 eq),
DCM, 40°, 12 h

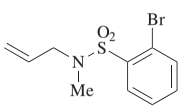


(72)

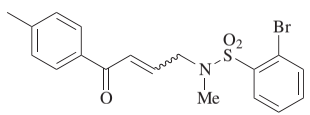
1013



3 eq



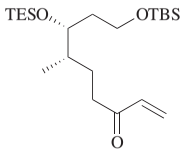
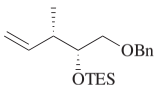
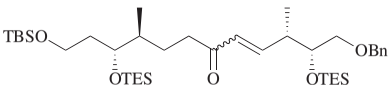
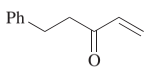
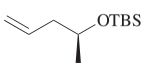
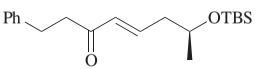
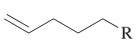
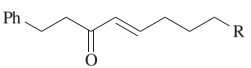
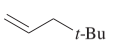
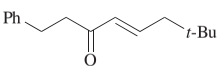
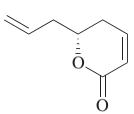
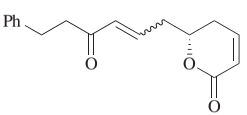
Gr II (0.05 eq),
DCM, 40°, 3 h



(21)

634

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{10}				
	 1.2 eq	Gr II (0.025 eq), DCM, reflux, 12 h	 (86)	1014
C_{11}				
 0.83 eq		Gr II (0.04 eq) DCM, reflux, 22 h	 (89) (*E*) only	1015
x eq		Gr II (0.02 eq), DCM, reflux, 22 h	 (*E*) only R *x* Me 0.5 (75) NC– 0.57 (53)	1015
	 2 eq	Gr II (0.04 eq), DCM, reflux, 22 h	 (58) (*E*) only	1015
		Gr II (0.05 eq) DCM, 40°, 12 h	 (74)	1016

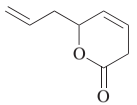
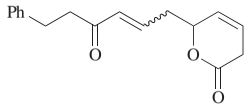
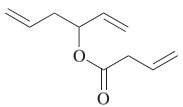
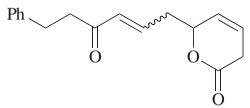
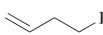
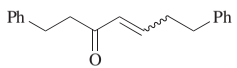
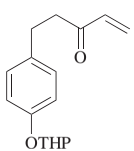
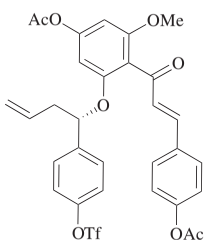
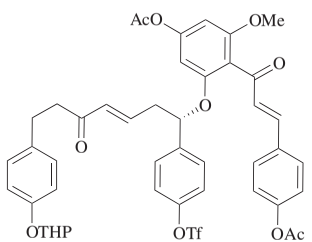
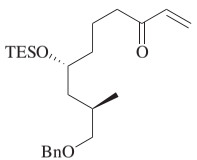
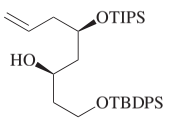
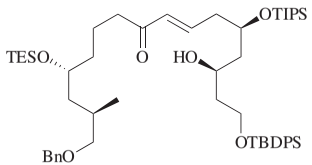
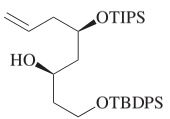
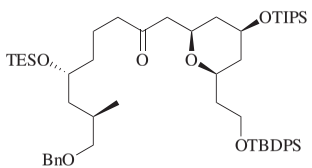
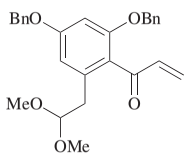
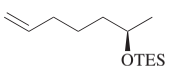
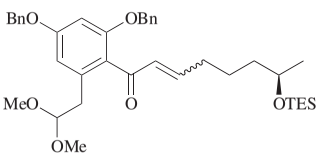
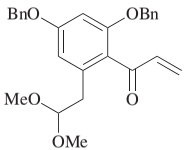
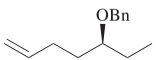
3 eq		Gr II (0.03 + 0.01 eq) DCM, MW, 0.33 + 0.17 h		(56)	394
3 eq		Gr II (0.05 + 0.025 eq) DCM, reflux, 16 h		(57)	394
2 eq		Gr II (0.04 eq) DCM, reflux, 22 h		(47)	1015
3 eq	 	Gr II (0.2 eq), benzene, 50°, 24 h		(47) (*E*) only	1017

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

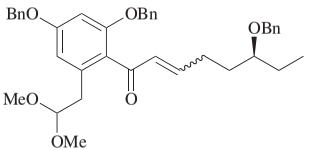
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{11}				
	 1.5 eq	Hov II (0.1 eq), DCM, 35°, 21 h	 (93) (*E*)/(*Z*) > 95:5	1018, 1019
	 1.5 eq	Hov II (0.1 eq), DCM, 100° (MW), 0.5 h	 (94) (*E*)/(*Z*) = 89:11	970
	 3 eq	Gr II (0.15 eq) DCM, 45°, 1.5 h	 (78)	260



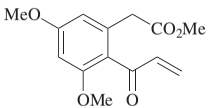


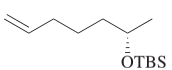
3 eq

Gr II (0.15 eq)
DCM, 45°, 1.5 h

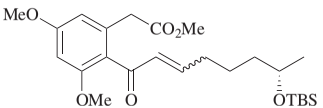


(84) 260

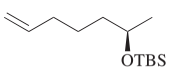




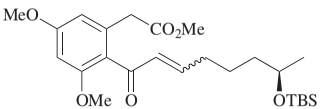
Gr II (0.2 eq),
DCM, reflux, 24 h



(80) 1020

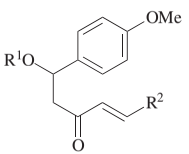


Gr II (0.2 eq),
DCM, reflux, 24 h



(85) 1020

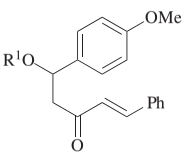
$C_{11–12}$





2 eq

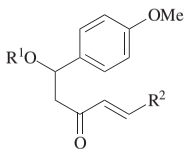
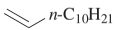
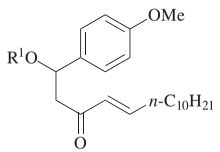
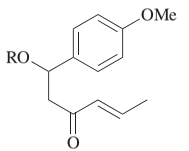
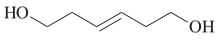
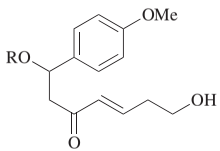
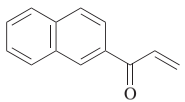
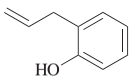
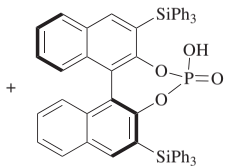
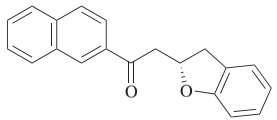
Hov II (0.05 eq),
DCM, 18–24 h



(*E*) only 1021

R^1	R^2	Temp	
H	Me	rt	(66)
H	H	rt	(70)
TBS	Me	reflux	(80)

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)		Refs.
Please refer to the charts preceding the tables for the catalyst structures.					
C_{11-12} 	 2 eq	Hov II (0.05 eq), DCM, 18–24 h		(*E*) only	1021
			R^1 R^2 Temp		
			H Me rt	(85)	
			H H rt	(76)	
			TBS Me reflux	(91)	
C_{12} 	 3 eq	Hov II (0.05 eq), DCM, reflux, 18–24 h	 (*E*) only	R H (24) TBS (50)	1021
C_{13}  1.5 eq	 +  0.05 eq	Hov II (0.05 eq), DCM, 40°, 12 h		(49) er 89.5:10.5	973

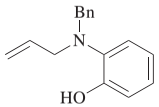
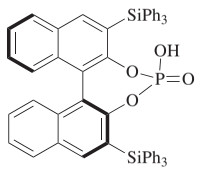
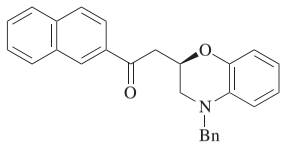
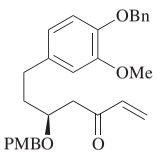
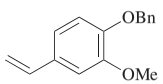
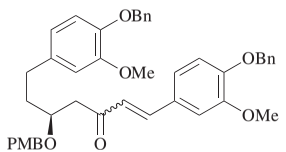
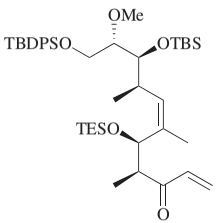
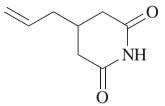
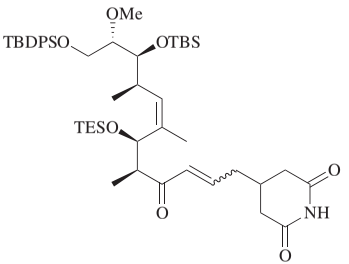
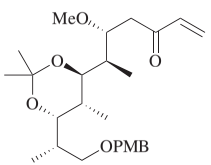
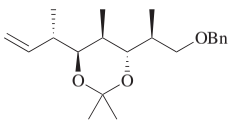
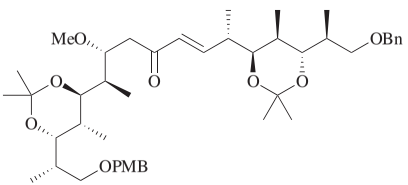
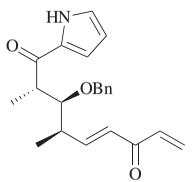
1.5 eq	 +  0.05 eq	Hov II (0.05 eq), DCM, 40°, 12 h		(51) er 88.0:12.0	973
	 1 eq	Gr II (0.1 eq), DCM, 50°, 48 h		(70)	1022

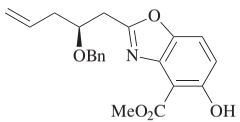
TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{14}				
 3 eq		Hov II (0.3 eq), DCM, rt, 72 h	 (32)	1023, 993
 1.5 eq		Ru cat **88** (0.12 eq), DCM, 50°, 24 h	 (80) (*E*) only	1024

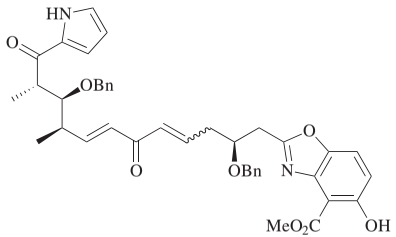
C_{15}



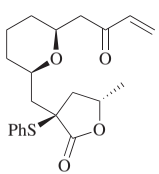
1.8 eq

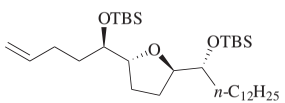


Gr II (0.15 eq), THF, rt, 6 h



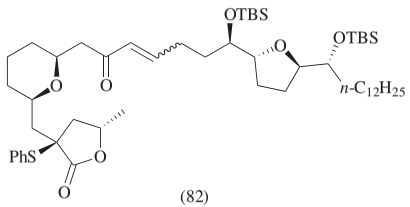
(59) 340



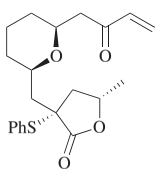


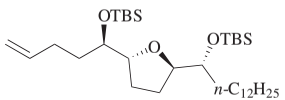
1.6 eq

Gr II (0.09 eq), DCM, 45°, 2 h



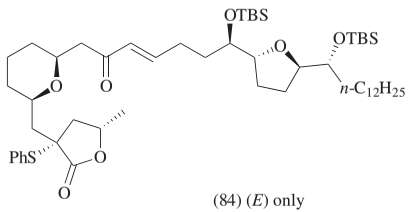
(82) 1025





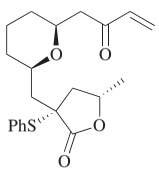
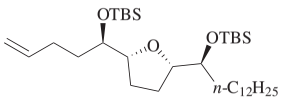
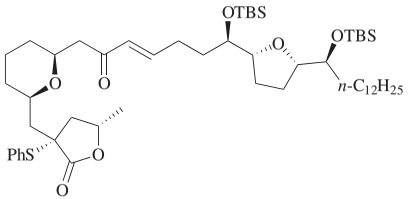
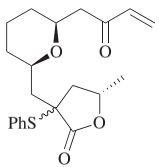
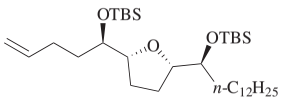
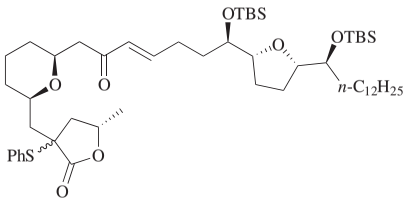
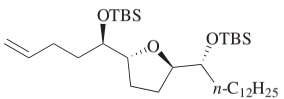
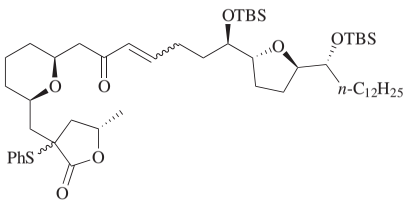
1.6 eq

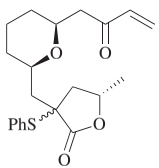
Gr II (0.14 eq), DCM, 45°, 2 h

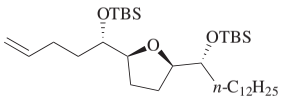


(84) (*E*) only 1025

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

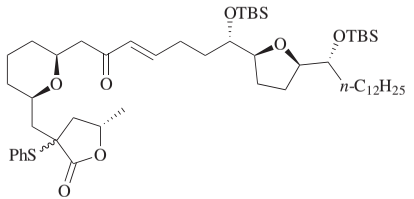
Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{15}				
	 1.6 eq	Gr II (0.18 eq), DCM, 45°, 2 h	 (83) (*E*) only	1026
	 1.6 eq	Gr II (0.18 eq), DCM, 45°, 2 h	 (84) (*E*) only	1026
	 1.6 eq	Gr II (0.13 eq), DCM, 45°, 2 h	 (76)	1025





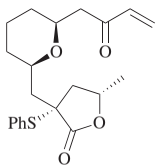
1.6 eq

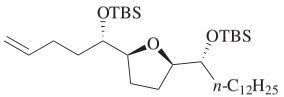
Gr II (0.18 eq),
DCM, 45°, 2 h



(81) (*E*) only

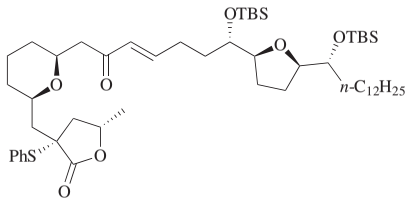
1026





1.6 eq

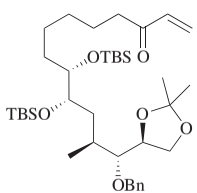
Gr II (0.18 eq),
DCM, 45°, 2 h

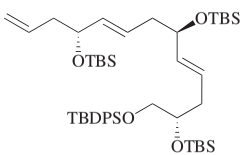


(85) (*E*) only

1026

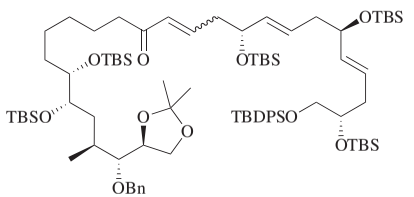
C_{16}





1 eq

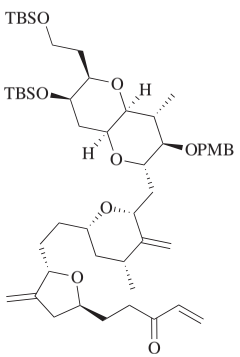
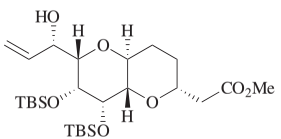
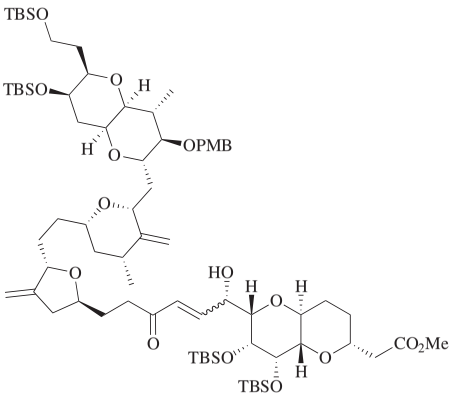
Hov II (0.1 eq),
DCM, rt, 47.5 h



(69)

1027

TABLE 17. CROSS-METATHESIS OF α,β-UNSATURATED KETONES (*Continued*)

Ketone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{31} 	 2 eq	Ru cat **271** (0.2 eq), toluene, 80°, 2 h	 (62)	1028

[a] The conversion was determined by GC analysis.

[b] The yield was determined by GC analysis.

[c] The yield was determined by ^{31}P NMR analysis.

TABLE 18. CROSS-METATHESIS OF α,β-UNSATURATED ACRYLIC ACIDS

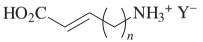
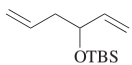
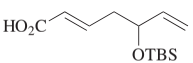
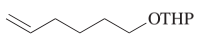
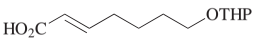
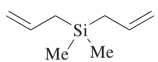
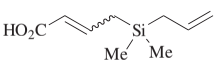
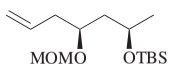
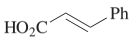
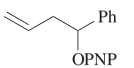
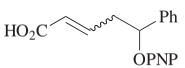
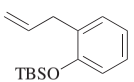
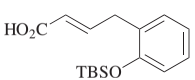
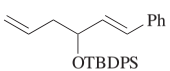
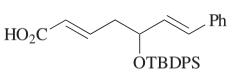
Acrylic Acid	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 20 eq		Hov II (0.01 eq), EtOAc, reflux, 1 h		548
			n R Y Conv. (%)[a] (—) (*E*)/(*Z*) 1 H TfO >95 (—) >75:25 2 H BF_4 >99 (—) 87:13 3 H BF_4 >99 (70) >95:5 3 H TfO >99 (95) >95:5 3 H TsO >99 (—) >95:5 8 Me TsO >99 (—) >95:5	
3 eq		Hov II (0.05 eq), DCM, 40°	 (81) (*E*)/(*Z*) = 95:5	169
3 eq		Gr II (0.05 eq), DCM, 40°, 15 h	 (100) (*E*) only	166
3 eq		Hov II (0.025 eq), DCM, rt, 2 h	 (44)	992
3 eq		Hov II (0.05 eq), DCM, 25°, 16 h	 (82) (*E*)/(*Z*) = 95:5	1029

TABLE 18. CROSS-METATHESIS OF α,β-UNSATURATED ACRYLIC ACIDS (*Continued*)

Acrylic Acid	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
	 *x* eq	Catalyst (0.05 eq), DCM	 (*E*) only	
		x = 2.5, Gr II, 100 (MW), 0.5 h	(99)	971
		x = 2.5, Hov II, 100 (MW), 0.5 h	(99)	971
		x = 2.5, Ru cat **86**, 100 (MW), 0.5 h	(99)	971
		x = 1.9, Gr II, 40, 15 h	(63)	166
3 eq		Hov II (0.02 eq), DCM, 40°, 15 h	 (75)	932
3 eq		Gr II (0.02 eq), additive (0.03 eq), Et_2O, 35°, 3 h		167
		Additive: NaI (64) (*E*)/(*Z*) —; CuI (82) (*E*)/(*Z*) >95:5		
3 eq		Hov II (0.05 eq), DCM, 40°	 (83) (*E*)/(*Z*) = 95:5	169

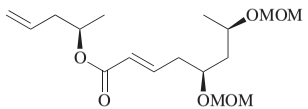
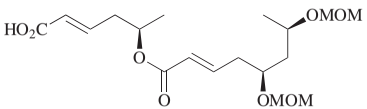
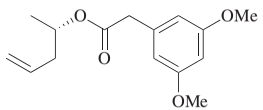
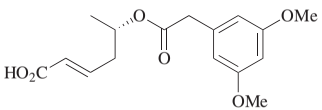
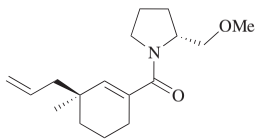
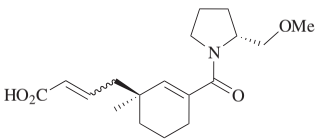
3 eq		Hov II (0.05 eq), DCM, 25°, 16 h	 (78) (*E*)/(*Z*) = 95:5		1029
3 eq		Hov II (0.05 eq), DCM, 25°, 16 h	 (82) (*E*)/(*Z*) = 95:5		1030
3–20 eq		Hov II (0.025 eq), DCM, reflux, 7 h		(86)	896

TABLE 18. CROSS-METATHESIS OF α,β-UNSATURATED ACRYLIC ACIDS (*Continued*)

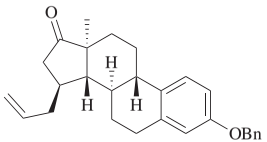
Acrylic Acid	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

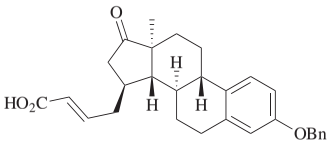
C_3



2 eq



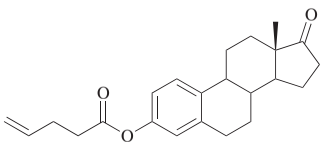
Catalyst (0.03–0.05 eq), solvent



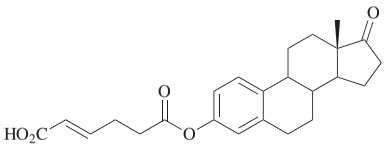
163

Catalyst	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)
Gr II	DCM	40	2.5	(88)	(*E*) only
Ru cat **68**	DCE	80	5.5	(0)	—
Ru cat **125**	DCM	40	5.5	(99)	(*E*) only

4 eq



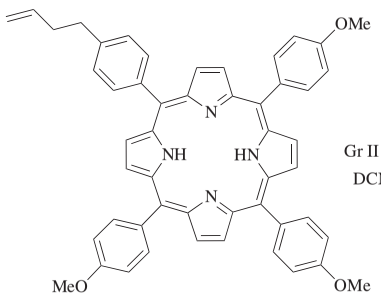
Catalyst (0.05 eq), toluene, 80°, 12 h



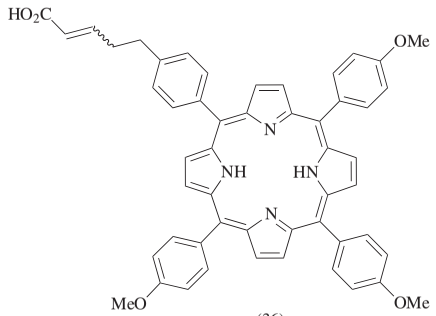
1031

Catalyst		(*E*)/(*Z*)
Ru cat **266**	(90)	78:22
Ru cat **267**	(93)	79:21

18 eq



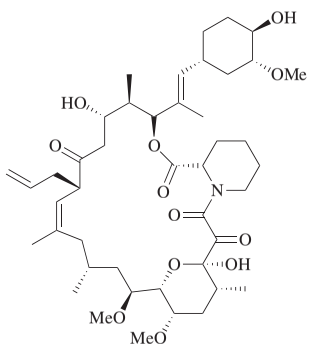
Gr II (0.1 eq),
DCM, rt, 48 h



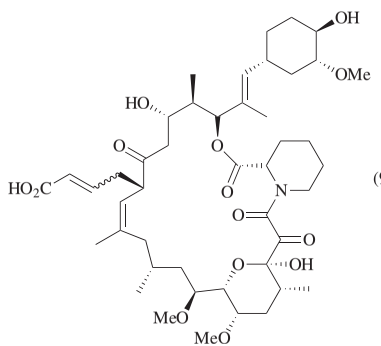
1032

(36)

20 eq



Gr II (0.1 eq),
DCB, MW (20 W)



(99)

432

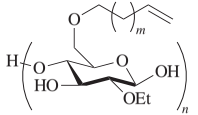
TABLE 18. CROSS-METATHESIS OF α,β-UNSATURATED ACRYLIC ACIDS (*Continued*)

Acrylic Acid	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

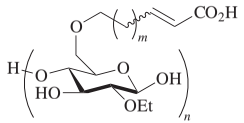
Please refer to the charts preceding the tables for the catalyst structures.

C_3

40 eq



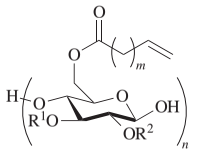
Hov II (*x* eq),
solvent, 37°



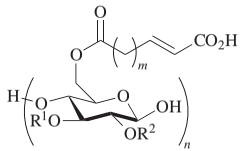
1033

m	*x*	Solvent	Time (h)	Conv. (%)[a]
0	0.05	THF	2	31
0	0.05	DCM	2	40
0	0.05	acetic acid	2	23
2	0.05	THF	2	60
2	0.05	DCM	2	45
2	0.05	acetic acid	2	72
2	0.05	THF	2	87
2	0.1	DCM	2	100
2	0.1	acetic acid	2	100
4	0.1	DCM	2	>95
8	0.05	DCM	2	44
8	0.05	acetic acid	2	38
8	0.1	acetic acid	2	59
8	0.05	DCM	12	83
8	0.1	DCM	12	100

20 eq

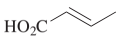


Catalyst (x eq),
BHT (y eq),
THF, 1 h

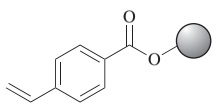


R^1	R^2	m	Catalyst	x	y	Temp (°)	Conv. (%)[a]		(E)/(Z)	
H	Ac	—	Hov II	0.03	0.12	30	100	(—)	—	1034
H	H	2	Gr II	0.05	0	rt	—	(94)	94:6	1035
Me	Me	8	Gr II	0.05	0	rt	—	(93)	94:6	1035
H	H	8	Hov II	0.03	0	30	—	(93)	—	1036
Ac	Ac	8	Hov II	0.03	0	30	—	(71)	—	1036
EtCO	EtCO	8	Hov II	0.03	0	30	—	(85)	—	1036
n-PrCO	*n*-PrCO	8	Hov II	0.03	0	30	—	(95)	—	1036

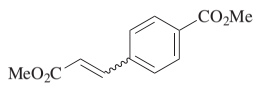
C_4



5 eq

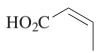
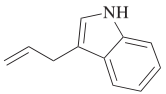
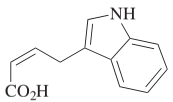
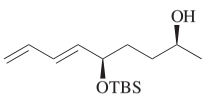
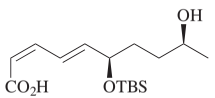


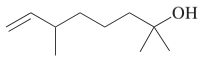
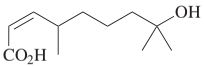
1. Gr II (0.05 eq),
DCM, reflux, 20 h
2. TFA (10%), DCM, 1 h
3. CH_2N_2, DCM, 0°, 0.5 h



(97) 677

TABLE 18. CROSS-METATHESIS OF α,β-UNSATURATED ACRYLIC ACIDS (*Continued*)

Acrylic Acid	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 **I**		1. Ru cat **364** (0.01 eq), (*Z*)-2-butene (5 eq), THF, 22°, 1 h 2. Ru cat **364** (0.04 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 7 h 3. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 11 h	 (52) (*Z*)/(*E*) = >98:2	1037
I		1. Ru cat **364** (0.02 eq), (*Z*)-2-butene (5 eq), THF, 22°, 1 h 2. Ru cat **364** (0.04 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 7 h 3. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 11 h	 (53) (*Z*)/(*E*) > 98:2	1037

5 eq		1. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 11 h 2. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 11 h		(63) (*Z*)/(*E*) = 98:2	1037
I		1. Ru cat **364** (0.01 eq), (*Z*)-2-butene (5 eq), THF, 22°, 1 h 2. Ru cat **364** (0.04 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 7 h 3. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 11 h	 (*Z*)/(*E*) > 98:2	R n Ph 2 (65) OHC 8 (49) FeC(O) 9 (52)	1037
I		1. Ru cat **364** (0.01 eq), (*Z*)-2-butene (5 eq), THF, 22°, 1 h 2. Ru cat **364** (0.05 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 7 h		(41) (*Z*)/(*E*) > 98:2	1037

[a] The conversion was determined by ^{1}H NMR analysis.

TABLE 19. CROSS-METATHESIS OF ACRYLOYL CHLORIDE

Acryloyl Chloride	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

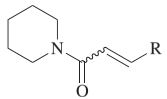
C_3



1.5 eq



1. Hov II (0.05 eq), DCM, 16 h
2. Piperidine (6 eq), 1 h

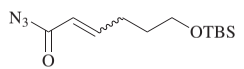


R		
$TMSCH_2$	(87)	174
$PhCH_2$	(86)	
n-C_6H_{13}	(86)	
Ph	(54)	

1.5 eq

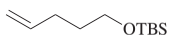


1. Hov II (0.05 eq), toluene, 16 h
2. NaN_3 (3 eq), MeCN, 2 h

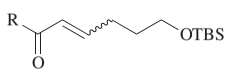


(63) 174

1.5 eq



1. Catalyst (0.05 eq), DCM, 16 h
2. RH (6 eq), 1 h



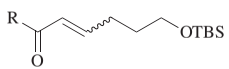
174

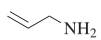
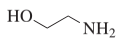
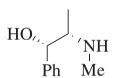
Catalyst	Temp	RH	
Gr I	rt	Me_2NH (33% in EtOH)	(tr)
Gr II	rt	Me_2NH (33% in EtOH)	(19)
Gr II	40°	Me_2NH (33% in EtOH)	(74)
Hov II	rt	Me_2NH (33% in EtOH)	(73)
Ru cat **88**	rt	Me_2NH (33% in EtOH)	(54)
Hov II	rt	$MeNH_2$ (33% in EtOH)	(80)
Hov II	rt	NH_3 (28% in H_2O)	(81)

769

1.5 eq 

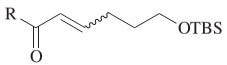
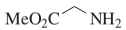
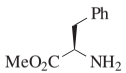
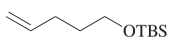
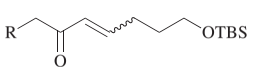
1. Hov II (0.05 eq), DCM, 16 h
2. RH (*x* eq), K_3PO_4 (*y* eq), 1 h



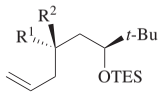
RH	*x*	*y*	
	1.6	3.8	(75)
	1.6	3.8	(65)
	6	—	(73)
	6	—	(76)
	1.6	3.8	(68)
	1.6	3.8	(70)

174

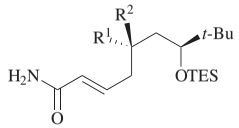
TABLE 19. CROSS-METATHESIS OF ACRYLOYL CHLORIDE (*Continued*)

Acryloyl Chloride	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 1.5 eq		1. Hov II (0.05 eq), DCM, 16 h 2. RH•HCl (1.6 eq), NMM (6 eq), 1 h	 RH:  (69);  (74);  (78)	174
1.5 eq		1. Hov II (0.05 eq), DCM, 16 h 2. RCH_2OH (3 eq), pyridine (3 eq), 0°, 1 h	 R: CH_2=CH (63); HC≡C (65)	174

1.5 eq



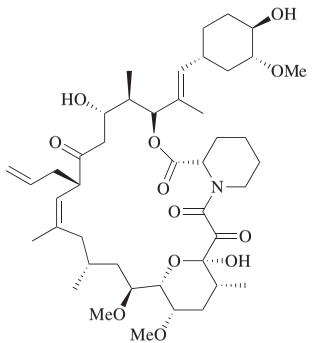
1. Hov II (0.05 eq), DCM, rt, overnight
2. NH_4OH, 1 h



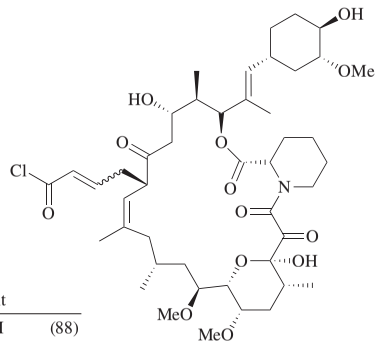
R^1	R^2		(*E*)/(*Z*)
H	Me	(82)	96:4
Me	H	(58)	—

1038

20 eq



Gr II (0.1 eq), solvent, MW (20 W)

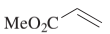
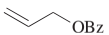
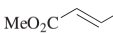
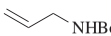
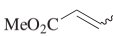
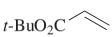
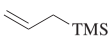
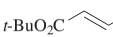


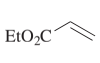
Solvent	
i-PrOH	(88)
DCB	(6)

432

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS

A. ESTERS

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)		Refs.
Please refer to the charts preceding the tables for the catalyst structures.					
C_3					
 2 eq		Ru cat **286** (*x* eq), DCM, 8 h	 (*E*)/(*Z*) > 95:5	*x* Temp (°) 0.02 25 (30) 0.02 40 (34) 0.05 40 (37)	161
1 eq		Hov II (0.05 eq), additive (0.1 eq), toluene, 80°, 12 h		Additive — (28) $Ti(Oi\text{-}Pr)_4$ (0) Me_2AlCl (20) ClBcat (50) $PhBCl_2$ (77) Cy_2BCl (84)	952
 2 eq		Gr II (0.02 eq), 2.5% aq. PTS, 22°, 12 h		(91) (*E*)/(*Z*) = 95:5	976



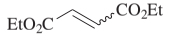
x eq



Hov II (0.1 eq),
DCM,
100° (MW), 0.25 h



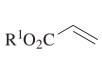
I **II**



III

x	R	**I**	**II**	**III**
—	*t*-BuO	(32)	(9)	(11)
—	H_2N	(0)	(37)	(35)
0.0025	Et	(45)	(8)	(20)
0.01	Et	(36)	(7)	(16)

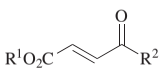
165



2 eq



Gr II (0.05 eq),
DCM, 3 h



(*E*) only

R^1	R^2	
Me	Me	(41)
t-Bu	Et	(41)

170

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

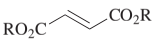
Please refer to the charts preceding the tables for the catalyst structures.

C_3

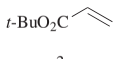




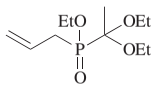
Catalyst (*x* eq), DCM



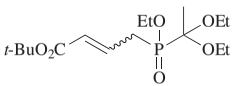
R	Catalyst	*x*	Temp (°)	Time (h)		(*E*)/(*Z*)	
n-Bu	Gr II	0.05	40	3	(87)	100:0	170
Cy	Gr II	0.05	40	3	(75)	100:0	170
t-Bu	Gr II	0.05	40	3	(94)	100:0	170
Ad	Gr II	0.05	40	3	(80)	100:0	170
t-Bu	Ru cat **108**	0.025	40	6	(88)	—	1039
n-Bu	Ru cat **108**	0.025	40	6	(91)	—	1039
t-Bu	Hov II	0.05	100 (MW)	0.25	(87)	—	165
Et	Hov II	0.05	100 (MW)	0.25	(66)	—	165
Et	Gr II	0.05	100 (MW)	0.25	(19)	—	165
Et	Gr II	0.05	rt	24	(20)	—	165
Et	Gr II	0.05	100 (MW)	1	(25)	—	165
Et	Hov II	0.05	rt	24	(18)	—	165
Et	Hov II	0.025	100 (MW)	0.25	(63)	—	165
Et	Hov II	0.005	100 (MW)	0.25	(23)	—	165
Et	Hov II	0.05	100 (MW)	0.17	(20)	—	165
2-hydroxyethyl	Ru cat **85**	0.025	40	48	(>99)	—	1040
2-hydroxyethyl	Hov II	0.025	40	2	(>99)	—	1040



3 eq

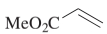


Gr II (0.05 eq),
DCM, 40°, 22 h

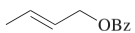


(73)

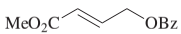
1041



2 eq



Ru cat **286** (x eq),
DCM, 40°, 8 h

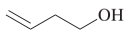


(E)/(Z) > 95:5

x	
0.02	(22)
0.05	(28)

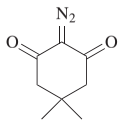
161

1 eq



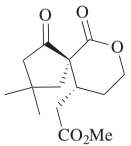
1 eq

+



1 eq

1. DCM, 300 W, 0.25 h
2. Hov II (0.04 eq),
100°, 0.5 h
3. IPr (0.2 eq), rt, 20 h



(55) (E)/(Z) > 95:5

955

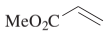
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

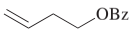
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

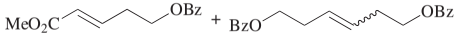
C_3



x eq



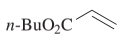
Catalyst (*y* eq), solvent



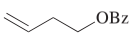
I **II**

x	Catalyst	*y*	Solvent	Temp (°)	Time (h)	**I**	(*E*)/(*Z*) **I**	**II**	
2	Hov II	0.01	DCM	20	24	(30)	—	(52)	1040
2	Ru cat **85**	0.01	DCM	20	24	(69)	—	(9)	1040
2	Ind II	0.01	DCM	rt	5	(26)	94:6	(3)	1042
2	Ru cat **294**	0.01	DCM	rt	5	(73)	>95:5	(7)	1042
2	Ru cat **320**	0.01	DCM	rt	5	(5)	88:12	(3)	1042
2	Ru cat **285**	0.01	DCM	rt	5	(57)	94:6	(13)	1042
2	Ru cat **297**	0.01	DCM	rt	5	(79)	94:6	(11)	1042
2	Ru cat **322**	0.01	DCM	rt	5	(31)	>95:5	(25)	1042
2	Ru cat **41**	0.01	DCM	rt	5	(79)	>95:5	—	562
2	Ru cat **44**	0.01	DCM	rt	5	(85)	>95:5	—	562
2	Ru cat **45**	0.01	DCM	rt	5	(91)	>95:5	—	562
2	Ru cat **248**	0.01	DCM	rt	5	(69)	>95:5	—	562

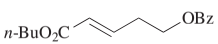
5	Ru cat **316**	0.002	MTBE	50	8	(72)	>95:5	—	1043
5	Gr II	0.002	MTBE	50	8	(72)	>95:5	—	1043
2	Ru cat **139**	0.02	DCM	30	18	(75)	>95:5	—	1044
2	Ru cat **324**	0.01	DCM	rt	5	(50)	94:6	(15)	1045
2	Ru cat **325**	0.01	DCM	rt	5	(47)	94:6	(18)	1045
2	Ru cat **298**	0.01	DCM	rt	5	(81)	>95:5	(5)	1045
2	Ru cat **323**	0.01	DCM	rt	5	(23)	93:7	(26)	1045
2	Ru cat **316**	0.02	toluene	80	2.5	(75)	>95:5	—	591
4	Ru cat **209**	0.025	toluene	80	1.5	(72)	90:10	(9)	1046
—	Ru cat **93**	0.01	DCM	rt	0.5	(76)	>95:5	—	550
2	Ru cat **93**	0.01	DCM	25	0.5	(76)	>95:5	—	957
2	Ru cat **169**	0.01	DCM	25	0.5	(74)	>95:5	—	957
2	Ru cat **170**	0.01	DCM	25	0.5	(64)	>95:5	(34)	957
2	Ru cat **171**	0.01	DCM	25	0.5	(62)	>95:5	(31)	957
5	Ru cat **170**	0.01	DCM	25	1	(92)	>95:5	—	957
2	Ru cat **286**	0.02	DCM	25	2	(>99)	>95:5	—	957



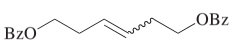
4 eq



Ru cat **208** (0.005 eq), DCM, 20°, 3.5 h



(70) (*E*)/(*Z*) > 95:5 1046

\+ 

(10)

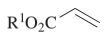
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

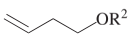
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

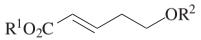
C_3



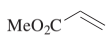
x eq



Catalyst (*y* eq), solvent



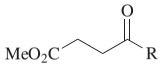
R^1	*x*	R^2	Catalyst	*y*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
Me	4	PMP	Ru cat **209**	0.025	toluene	80	1.5	(72)	90:10	1046
Me	2	PNP	Hov II	0.02	DCM	40	15	(89)	(*E*) only	932
t-Bu	2	PNP	Hov II	0.02	DCM	40	15	(96)	(*E*) only	932
2-ethylhexyl	2	PNP	Hov II	0.02	DCM	40	15	(95)	(*E*) only	932



10 eq



1.Catalyst (0.03 eq), DCM, rt, 350 nm
2. *t*-BuOH/DCM (1:4), rt, h*ν* (254 nm)



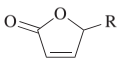
911

R	Catalyst	
Me	Ru cat **163**	(66)
$MeO_2C(CH_2)_2$	Ru cat **353**	(62)
4-BrC_6H_4	Ru cat **163**	(70)
3-BrC_6H_4	Ru cat **163**	(68)
4-ClC_6H_4	Ru cat **163**	(71)
4-$MeOC_6H_4$	Ru cat **163**	(76)
3-$MeOC_6H_4$	Ru cat **163**	(76)
n-C_9H_{19}	Ru cat **163**	(62)

10 eq



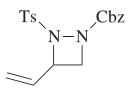
1. Catalyst (0.03 eq), DCM, rt, 350 nm
2. Phenanthrene (*x* eq), DCM, rt, hν (254 nm)



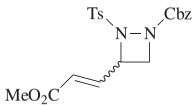
R	Catalyst	*x*	
Me	Ru cat **163**	0.3	(62)
$MeO_2C(CH_2)_2$	Ru cat **353**	0.3	(53)
4-BrC_6H_4	Ru cat **163**	2.1	(70)
3-BrC_6H_4	Ru cat **163**	2.1	(67)
4-ClC_6H_4	Ru cat **163**	2.1	(72)
4-$MeOC_6H_4$	Ru cat **163**	2.1	(0)
3-$MeOC_6H_4$	Ru cat **163**	2.1	(63)
n-C_9H_{19}	Ru cat **163**	0.3	(70)

911

3 + 3 eq



Gr II (0.05 + 0.05 eq)
DCM, reflux, 6 + 24 h

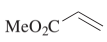
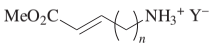


(83)

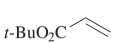
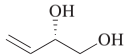
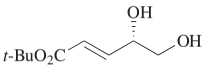
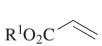
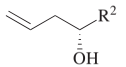
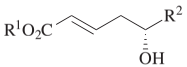
647

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

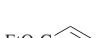
A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 20 eq		Hov II (*x* eq) EtOAc, reflux, 1 h		548

R	Y	*n*	*x*	Conv. (%)[a]	(*E*)/(*Z*)
H	TfO	2	0.05	>99	86:14
H	BF_4	2	0.01	>99	87:13
H	TfO	3	0.01	>95	87:13
H	BF_4	3	0.01	>99	91:9
H	TsO	3	0.01	>99	91:9
Me	BF_4	8	0.01	>99	91:9
Me	TsO	8	0.01	>99	95:5

 10 eq		Ru cat **353** (0.06 eq), DCM, rt, hν (350 nm)		(46) (*E*) only	911
 2 eq		Gr II (*x* eq), benzene, rt			336

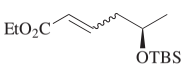
R^1	R^2	*x*	Time (h)		(*E*)/(*Z*)
Me	Ph	0.02	24	(83)	>91:9
Me	n-$C_{15}H_{31}$	0.02	16	(65)	95:5
Et	Me	0.05	24	(75)	>95:5
Et	n-$C_{15}H_{31}$	0.05	24	(55)	>95:5



2.5 eq

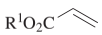


Gr II (0.02 eq),
benzene, rt, 20 h

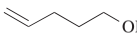


(80)

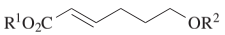
794



2 eq



Catalyst (*x* eq), solvent



R^1	R^2	Catalyst	*x*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
Me	TBS	Ru cat **324**	0.01	DCM	rt	0.5	(77)	>95:5	1045
Me	TBS	Ru cat **325**	0.01	DCM	rt	0.5	(78)	>95:5	1045
Me	TBS	Ru cat **286**	0.01	DCM	rt	2.5	(91)	>95:5	1045
Me	TBS	Ru cat **323**	0.01	DCM	rt	15	(50)	>95:5	1045
Me	TBS	Ru cat **326**	0.02	toluene	rt	18	(91)	—	1047
Me	Bz	Ru cat **106**	0.01	DCM	20	0.5	(99)	—	216
Me	Bz	Ru cat **112**	0.01	DCM	20	0.5	(99)	>97:3	216
Me	Bz	Ru cat **110**	0.01	DCM	rt	0.33	(95)	98:2	961
Me	Bz	Gr II	0.01	DCM	20	3	(86)	97:3	962
Me	Bz	Ru cat **112**	0.01	DCM	20	0.25	(93)	97:3	962
Me	Ac	Ru cat **109**	0.02	H_2O	22	12	(82)	>95:5	341
Me	Ac	Hov II	0.02	2.5 % aq. PTS	22	12	(83)	>95:5	976
t-Bu	Ac	Hov II	0.02	2.5 % aq. PTS	22	12	(87)	95:5	976

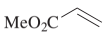
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

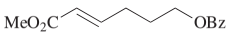
C_3



x eq



Catalyst (*y* eq), solvent



x	Catalyst	*y*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
2	Ru cat **98**	0.01	DCM	rt	0.5	(69)	95:5	965
2	Ru cat **99**	0.01	DCM	rt	0.5	(50)	95:5	965
2	Ru cat **100**	0.01	DCM	rt	0.5	(71)	95:5	965
2	Ru cat **101**	0.01	DCM	rt	0.5	(73)	95:5	965
2	Ru cat **102**	0.01	DCM	rt	0.5	(62)	95:5	965
2	Ru cat **316**	0.02	toluene	80	2.5	(85)	>95:5	591
2	Ru cat **316**	0.002	toluene	120	15	(81)	>95:5	591
2	Ru cat **191**	0.05	DCM	45	12	(97)	>95:5	923
2	Ru cat **243**	0.05	DCM	45	12	(96)	>95:5	923
2	Hov II	0.05	DCM	40	—	(87)	>95:5	922
—	Ru cat **185**	0.05	BMI•PF_6/toluene	rt	3	(80)	>95:5	924
2	Ru cat **286**	0.02	DCM	25	2	(>99)	>95:5	161
2	Ru cat **185**	0.05	BMI•PF_6/toluene	rt	3	(80)	>99:1	1048
2	Ru cat **186**	0.05	BMI•PF_6/toluene	rt	3	(79)	>99:1	1048
1	Ru cat **186**	0.05	BMI•PF_6/toluene	rt	3	(78)	>99:1	1048
5	Ru cat **186**	0.025	toluene	rt	24	(11)	—	1048
5	Ru cat **186**	0.025	MTBE	rt	24	(<5)	—	1048
5	Ru cat **186**	0.025	DCM	rt	2	(87)	—	1048
5	Ru cat **186**	0.05	BMI•PF_6/toluene	rt	3	(98)	>99:1	1048
5	Ru cat **186**	0.05	BMI•PF_6/benzene	rt	2.5	(93)	>99:1	1048
5	Ru cat **186**	0.05	BMI•PF_6/MTBE	rt	6	(56)	94:6	1048
5	Ru cat **186**	0.05	BMI•PF_6/toluene	rt	3	(98)	>99:1	1048
5	Ru cat **186**	0.05	BMI•PF_6/toluene	50	0.5	(97)	>99:1	1048
2	Ru cat **170**	0.01	DCM	25	1	(91)	>95:5	1048

2 eq



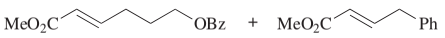
1 eq

+



1 eq

Catalyst (0.01 eq), [bdmim][PF_6]/toluene, rt, 4 h



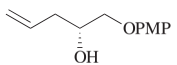
I + **II**

1050

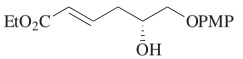
Catalyst	**I**	(*E*)/(*Z*) **I**	**II**	(*E*)/(*Z*) **II**
Ru cat **142**	(92)	95:5	(90)	95:5
Ru cat **141**	(90)	94:6	(89)	95:5



2 eq

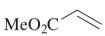


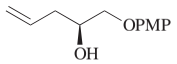
Hov II (0.025 eq), DCM, rt, 15 h



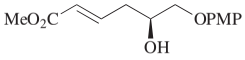
(70) (*E*)/(*Z*) = 98:2

626





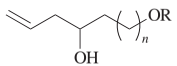
Gr II (0.01 eq), DCM, reflux, 3 h



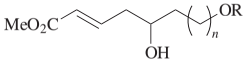
(87) (*E*)/(*Z*) = 99:1

566

3 eq



Gr II (0.01 eq), DCM, reflux, 3 h



1051

R	*n*		(*E*)/(*Z*)
Bn	0	(94)	>99:1
PMB	0	(84)	99:1
Bn	1	(92)	>99:1
Bn	2	(89)	>99:1
Bn	3	(96)	>99:1
TBS	3	(66)	99:1

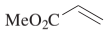
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

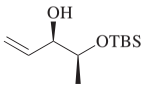
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

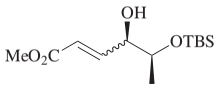
C_3



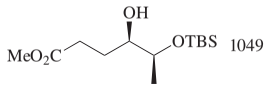
10 eq



Gr II (*x* eq),
phenol (*y* eq), toluene



I



II

1049

x	C/mol L	*y*	Temp (°)	Time (h)	**I**	**II**
0.05	1	—	110	12	(62)	(28)
0.05	0.5	—	110	2.5	(80)	(12)
0.05	0.5	—	110	0.5	(83)	(—)
0.05	0.5	—	80	0.5	(73)	(—)
0.05	1	—	110	0.5	(80)	(—)
0.05	neat	—	80	0.5	(83)	(—)
0.025	0.5	—	110	0.5	(75)	(—)
0.025	0.5	0.5	110	0.5	(86)	(—)
0.025	1	0.5	110	0.5	(98)	(—)
0.025	neat	0.5	80	0.5	(83)	(—)
0.05	0.5	0.5	110	2.5	(77)	(17)
0.025	1	0.5	110	12	(48)	(20)

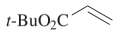
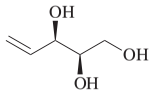
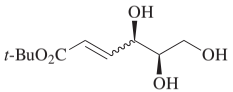
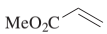
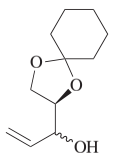
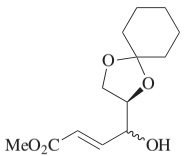
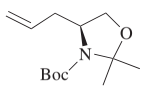
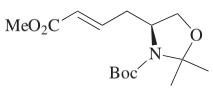
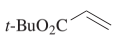
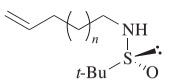
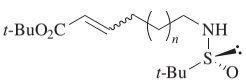
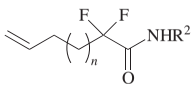
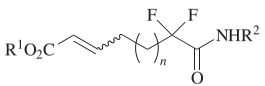
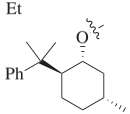
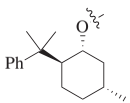
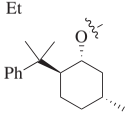
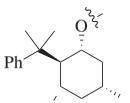
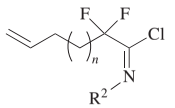
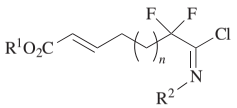
 10 eq		Ru cat **353** (0.06 eq), DCM, rt, hν (350 nm)		(10)	911
 10 eq		Gr II (0.025 eq), phenol (0.5 eq), toluene, 110°, 0.5 h		(91)	1049
2.5 eq		Gr II (0.08 eq), DCM, rt, 6 h		(80) (*E*) only	670
 5 eq		Ru cat **190** (0.1 eq), Ti(O*i*-Pr)$_4$ (0.1 eq), DCM, reflux, 2 h		*n* 1 (84) 2 (75)	959

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

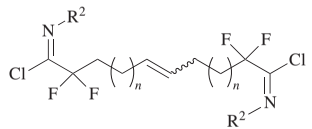
A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3 3 eq		Hov II (0.05 eq), additive (0.1 eq), DCM, reflux		960

R^1	R^2	*n*	Additive	Time (h)	
Et	PMP	0	Ti(O*i*-Pr)$_4$	5	(90)
Et	PMP	0	BF_3•OEt_2	5	(80)
Et	MeO	0	Ti(O*i*-Pr)$_4$	5	(71)
Et	MeO	0	BF_3•OEt_2	2	(76)
Et	SAMP	0	Ti(O*i*-Pr)$_4$	3	(75)
	PMP	0	Ti(O*i*-Pr)$_4$	5	(87)
	MeO	0	Ti(O*i*-Pr)$_4$	5	(46)
Et	PMP	1	Ti(O*i*-Pr)$_4$	5	(89)
Et	MeO	1	Ti(O*i*-Pr)$_4$	6	(75)
Et	SAMP	1	Ti(O*i*-Pr)$_4$	4	(64)
	PMP	1	Ti(O*i*-Pr)$_4$	5	(89)
	MeO	1	Ti(O*i*-Pr)$_4$	5	(38)

x eq  Gr II (*y* eq), solvent  1052, 392

I

+ 

II

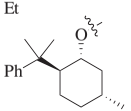
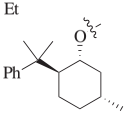
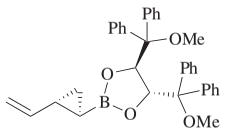
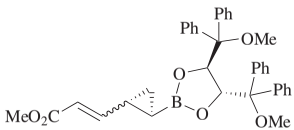
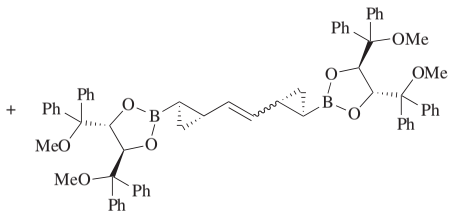
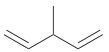
R^1	*x*	R^2	*n*	*y*	Solvent	Temp (°)	Time (h)	**I**	(*E*)/(*Z*) **I**	**II**
Et	5	PMP	0	0.05	toluene	95	15	(95)	96:4	(0)
	2	PMP	0	0.05	toluene	95	15	(76)	92:8	(0)
Et	2	PMP	0	0.1	DCM	40	5	(40)	>95:5	(16)
Et	2	PMP	0	0.1	DCM	40	15	(60)	>95:5	(8)
Et	3	PMP	0	0.1	DCM	40	48	(70)	>95:5	(6)
Et	5	PMP	0	0.1	toluene	95	15	(95)	>95:5	(0)
Et	2		0	0.05	toluene	95	15	(71)	90:10	(0)
Et	5	PMP	1	0.05	toluene	95	15	(94)	98:2	(0)
Et	3	PMP	1	0.1	toluene	95	15	(94)	>95:5	(0)
	2	PMP	1	0.1	toluene	95	15	(80)	95:5	(0)
Et	5	PMP	2	0.05	toluene	95	15	(93)	92:8	(0)

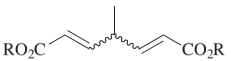
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
MeO_2C 2 eq		Gr I (0.15 eq), DCM, reflux	 (52) +  (14)	648
BnO_2C 2.5 eq	*n*-Pr	Gr II (0.025 eq), TPGS-750-M in H_2O (2 wt %) $KHSO_4$ (0.02 M), rt	BnO_2C *n*-Pr 100[b]	1053
RO_2C 3 eq		Ru cat **93** (0.025 eq), $CDCl_3$, 100° (MW), 1 h	RO_2C CO_2R R: Et (75); *t*-Bu (88)	926

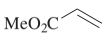
x eq 

Hov II (*y* eq),
4-methoxyphenol (*z* eq),
solvent

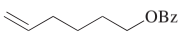


1054

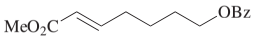
R	*x*	*y*	*z*	Solvent	Temp (°)	Time	
Me, *t*-Bu	—	0.1	—	DCM	reflux	—	(80–90)
t-Bu	2.5 + 4 x 1.25	0.005 + 7 x 0.0025	—	DCM	reflux	7 d	(80)
t-Bu	20	3 x 0.23	0.0047	—	50	5 h	(58)



5 eq



Catalyst (0.00025 eq),
DCM, 30°, 2 h

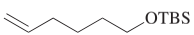


(*E*)/(*Z*) > 95:5

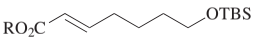
Catalyst		
Ru cat **321**	(92)	1055
Ru cat **322**	(82)	
Ru cat **285**	(100)	



x eq



Catalyst (*y* eq), solvent



R	*x*	Catalyst	*y*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
Me	5	Ru cat **316**	0.05	MTBE	50	8	(83)	>95:5	1043
Me	2	Ru cat **112**	0.025	DCM	20	0.33	(91)	97:3	609
Me	2	Ru cat **88**	0.01	DCM	25	1	(95)	97:3	609
Me	2	Ru cat **138**	0.01	DCM	25	2	(68)	97:3	609

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

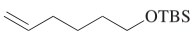
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

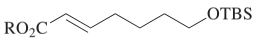
C_3



x eq

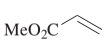


Catalyst (*y* eq), solvent

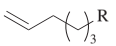


R	*x*	Catalyst	*y*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
Me	2	Ru cat **115**	0.01	DCM	25	0.33	(59)	97:3	609
Me	2	Ru cat **115**	0.01	DCM	25	5	(85)	97:3	609
Me	2	Ru cat **115**	0.01	DCM	25	11.5	(89)	97:3	609
Me	2	Ru cat **116**	0.01	DCM	25	0.33	(74)	97:3	609
Me	2	Ru cat **116**	0.01	DCM	25	5	(78)	97:3	609
Me	2	Ru cat **139**	0.01	DCM	30	18	(85)	95:5	1044
Me	2	Ru cat **158**	0.01	DCM	25	2	(92)	—	590
Me	2	Ru cat **157**	0.005	DCM	25	2	(90)	—	590
Me	2	Ru cat **316**	0.02	toluene	80	1.75	(97)	—	591
Me	2	Ru cat **316**	0.02	toluene	80	0.5	(90)	—	591
Me	2	Ru cat **314**	0.02	toluene	80	1.75	(38)	—	591
Me	2	Ru cat **314**	0.02	toluene	80	0.5	(6)	—	591
Me	2	Ru cat **315**	0.02	toluene	80	1.75	(67)	—	591
Me	2	Ru cat **315**	0.02	toluene	80	0.5	(13)	—	591
Me	2	Ru cat **317**	0.02	toluene	80	1.75	(94)	—	591
Me	2	Ru cat **317**	0.02	toluene	80	0.5	(60)	—	591
Me	2	Ru cat **316**	0.02	toluene	80	2	(81)	>95:5	591
Me	2	Ind I	0.02	DCM	25	8	(19)	>95:5	161
Me	2	Ind I	0.02	DCM	40	8	(55)	>95:5	161
Me	2	Ru cat 282	0.02	DCM	40	8	(26)	>95:5	161
Me	2	Ru cat **282**	0.02	DCM	25	8	(0)	—	161
Me	2	Ind II	0.02	DCM	25	8	(65)	>95:5	161
Me	2	Ind II	0.02	DCM	40	8	(81)	>95:5	161

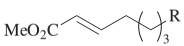
Me	2	Ru cat **286**	0.02	DCM	25	1	(60)	>95:5	161
Me	2	Ru cat **286**	0.02	DCM	25	3	(88)	>95:5	161
Me	2	Ru cat **286**	0.02	DCM	25	8	(98)	>95:5	161
Me	2	Ru cat **286**	0.02	DCM	40	1	(55)	>95:5	161
Me	2	Ru cat **286**	0.02	DCM	40	8	(98)	>95:5	161
Me	3	Ru cat **123**	0.05	DCM	rt	1	(97)	—	1207
Me	—	Ru cat **106**	0.01	DCM	25	0.42	(99)	78:22	216
Me	—	Ru cat **89**	0.01	DCM	25	0.5	(95)	95:5	216
Me	2	Ru cat **112**	0.025	DCM	25	0.3	(91)	—	1061
Me	2	Ru cat **88**	0.01	DCM	25	16	(95)	—	1061
Me	2	Ru cat **115**	0.01	DCM	25	2	(90)	—	1061
Me	2	Ru cat **115**	0.01	DCM	25	16	(89)	—	1061
Me	2	Ru cat **116**	0.01	DCM	25	1	(80)	—	1061
Me	2	Ru cat **88**	0.01	DCM	25	0.5	(95)	95:5	171
Me	2	Ru cat **88**	0.01	DCM	rt	0.5	(95)	95:5	160
Me	2	Ru cat **112**	0.025	DCM	rt	0.33	(91)	95:5	160
Me	2	Ru cat **112**	0.025	DCM	20	0.33	(91)	99:1	962
Me	—	Ru cat **268**	0.01	DCM	40	1.3	(97)	—	329
Me	—	Ru cat **269**	0.01	DCM	40	0.5	(98)	—	329
Me	—	Ru cat **270**	0.01	DCM	40	0.3	(90)	—	329
Me	3	Gr II	0.05	H_2O	40	5	(65)	—	1083
Me	3	Ru cat **282**	0.05	H_2O	40	5	(56)	—	1083
t-Bu	3	Gr II	0.05	H_2O	40	5	(81)	—	1083
t-Bu	4	Ru cat **143**	0.05	H_2O	30	12	(78)	100:0	588



4 eq



Ru cat **245** (0.25 eq),
toluene, 80°, 1 h



(*E*)/(Z) = 95:5

R	Conv. (%)[b]	
TBSO	91	1056
$MeO_2C(CH_2)_4$	98	

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

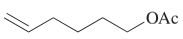
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

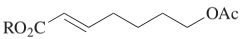
C_3



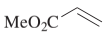
x eq



Catalyst (*y* eq), solvent



R	*x*	Catalyst	*y*	Solvent	Temp (°)	Time (h)	Conv. (%)	(*E*)/(*Z*)	
Me	2.6	Gr II + HCl	0.05	benzene, THF	45	14	98	>95:5	711
Me	1	Gr I	0.025	CD_2Cl_2	35	3	10	—	1208
Me	1	Hov I	0.025	CD_2Cl_2	35	3	6	—	1208
Me	1	Gr II	0.025	CD_2Cl_2	35	3	100	—	1208
Me	1	Hov II	0.025	CD_2Cl_2	35	3	92	—	1208
Me	1	Ru cat **35**	0.025	CD_2Cl_2	35	3	84	—	1208
Me	1	Ru cat **187**	0.025	CD_2Cl_2	35	3	90	—	1208
Me	1	Ru cat **15**	0.025	CD_2Cl_2	35	3	38	—	1208
Me	1	Gr II	0.025	DCM	35	2	85	—	1209
Me	1	Ru cat **277**	0.025	DCM	35	60	60	—	1209
Me	1	Ru cat **278**	0.025	DCM	35	60	18	—	1209
Me	2	Ru cat **244**	0.01	toluene	50	2	84	—	1210
Me	1	Hov I	0.025	DCE	80	24	62	—	1211
Me	1	Ru cat **299**	0.025	toluene	80	1	24	—	1211
Me	1	Ru cat **300**	0.025	DCE	40	3	32	—	1211
Me	1	Ru cat **301**	0.025	toluene	80	24	53	—	1211
Me	1	Ru cat **302**	0.025	toluene	60	24	71	—	1211
Me	1	Ru cat **303**	0.025	toluene	60	1	42	—	1211
Me	1	Ru cat **304**	0.025	toluene	80	24	26	—	1211
Me	2	Ru cat **31**	0.004	toluene	80	2	95	—	1212
Et	1	Gr II	0.02	DCM	40	12	98	—	902
n-Bu	4	Ru cat **208**	0.005	DCM	20	3.5	82	>95:5	1046



2 eq



Catalyst (0.02 eq), solvent



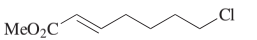
1057

Catalyst	Solvent	Temp (°)	Time (h)	Conv. (%)
Gr I	CD_2Cl_2	45	24	22
Ru cat **46**	CD_2Cl_2	45	24	7
Ru cat **46**	DMSO-d_6	80	24	0
Ru cat **47**	CD_2Cl_2	45	24	0
Ru cat **47**	DMSO-d_6	80	24	0
Ru cat **48**	CD_2Cl_2	45	24	15
Ru cat **48**	CD_2Cl_2	45	72	18
Ru cat **48**	DMSO-d_6	80	24	12
Ru cat **48**	DMSO-d_6	80	72	17

10 eq



Gr II (0.05 eq),
p-cresol (0.5 eq),
toluene, 120°, 3 h

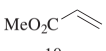
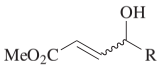
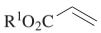
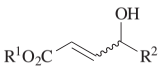
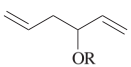
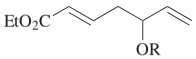


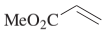
(80) (*E*) only

1058

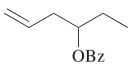
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

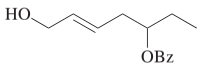
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 10 eq		Gr II (0.025 eq), phenol (0.5 eq), toluene, 110°, 0.5 h	 R: *n*-Pr (87); *n*-C_5H_{11} (93)	1058
 5 eq		Gr II (0.02–0.05 eq), CuI (0.03–0.06 eq), Et_2O, 40°, 12 h	 R^1 / R^2: Me / *i*-Pr (75); Me / Bn (87); Me / 4-BrC_6H_4 (91); *t*-Bu / 4-BrC_6H_4 (85); *t*-Bu / Bn (78); Bn / 4-BrC_6H_4 (86); Bn / Bn (80)	1059
 3 eq		Hov II (0.05 eq), DCM, 40°	 (*E*)/(*Z*) = 95:5 R: TBDPS (71); TBS (77)	169



3 eq



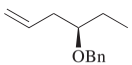
1. Hov II (0.1 eq), DCM, reflux, 3 h
2. DIBALH (3.75 eq) DCM, –78 to –45°, 2 h



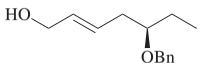
(59) (*E*)/(*Z*) > 95:5

940

3 eq

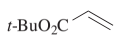


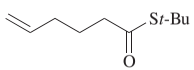
1. Hov II (0.1 eq), DCM, reflux, 3 h
2. DIBALH, DCM, –78 to –45°, 2 h



(59) (*E*)/(*Z*) > 95:5

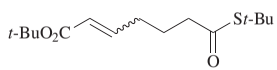
941





2 eq

Catalyst (0.05 eq), toluene, 80°

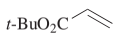
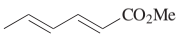
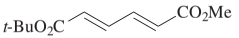
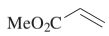
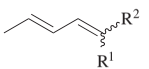
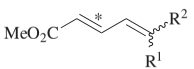
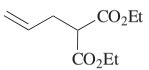
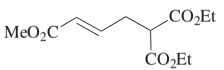
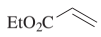
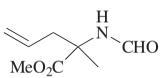
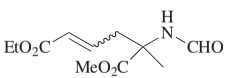
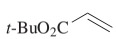
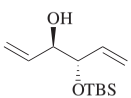
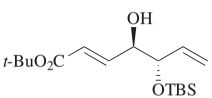


Catalyst	Time (h)	
Ru cat **166**	8	(84)
Ru cat **168**	6	(80)

1060

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 5 eq		Hov II (0.05 eq), DCM, rt, 48 h	 (30) (*E,E*)/(*Z,Z*) = 98:2	549
 1.9 eq		Gr II (2 x 0.05 eq), DCM, 40°, 24 h	 *(*E*)/(*Z*) > 99:1	649
		Gr II (0.071 eq), benzoic acid (0.075 eq), DCM, paraffin, rt, 22.5 h	 (77) (*E*)/(*Z*) = 95:5	511
 4 eq		Gr II (0.05 eq), toluene, rt, 17 h	 (70)	457
 10 eq		Gr II (0.05 eq), BHT (0.5 eq), toluene, reflux, 3 h	 (66) (*E*) only	750

R^1	R^2	
Br	NC–	(4)
NC–	Br	(18)

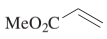
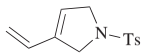
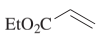
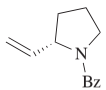
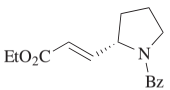
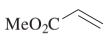
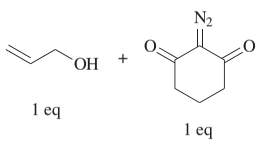
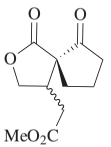
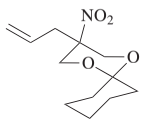
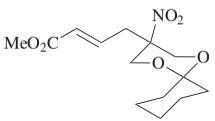
 3 eq		Hov II (0.05 eq), DCM, 45°, 3 h		(45)	939
 2 eq		Hov II (0.05 eq), DCM, reflux, 60 h		(82) (*E*) only	717
 1 eq	 1 eq 1 eq	1. DCM, 300 W, 0.25 h 2. Hov II (0.04 eq), 100°, 0.5 h 3. *n*-Bu_3P (0.2 eq), 100°, 0.25 h		(51) dr 61:39	955
2 eq		Ru cat **115** (0.02 eq), DCM, 26°, 5 h		(88) (*E*) only	609, 1061

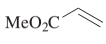
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

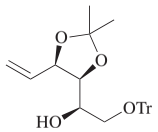
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

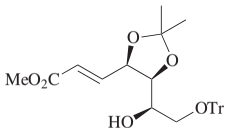
C_3



x eq



Gr II (*y* eq), Ti(O*i*-Pr)$_4$ (*z* eq), solvent, 13 h



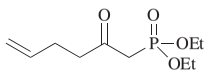
(*E*) only

406

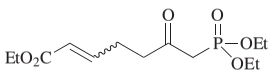
x	*y*	*z*	Solvent	Temp (°)	
2	0.05	—	DCM	rt	(20)
20	0.05	—	DCM	rt	(31)
2	0.1	—	DCM	reflux	(23)
10	0.1	—	DCM	reflux	(37)
2	0.1	0.3	toluene	80	(25)
10	0.1	0.3	toluene	reflux	(15)
10	0.1	0.3	toluene	75	(43)



x eq

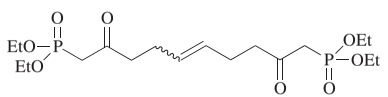


Catalyst (*y* eq), solvent



I

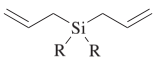
\+



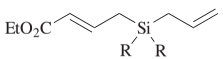
II

165

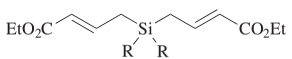
x	Catalyst	*y*	Solvent	Temp (°)	Time (h)	**I**	**II**
4	Gr II	0.1	DCM	100 (MW)	0.25	(70)	—
4	Gr II	0.1	DCM	rt	24	(46)	—
4	Gr II	0.1	DCM	40	2	(70)	—
4	Hov II	0.1	DCM	100 (MW)	0.25	(79)	—
4	Hov II	0.1	DCM	rt	24	(30)	—
4	Hov II	0.1	DCM	40	6	(80)	—
1.1	Gr II	0.1	DCM	100 (MW)	0.25	(30)	—
1.1	Hov II	0.1	DCM	100 (MW)	0.25	(65)	—
1.1	Gr II	0.1	DCM	100 (MW)	0.02	(30)	—
1.1	Hov II	0.1	DCM	100 (MW)	0.02	(66)	—
1.1	Hov II	0.1	DCM	100 (MW)	0.003	(62)	—
1.1	Hov II	0.05	DCM	100 (MW)	0.25	(81)	—
1.1	Hov II	0.01	DCM	100 (MW)	0.25	(50)	(10)
1.1	Hov II	0.1	DCE	100 (MW)	0.0003	(72)	—
1.1	Hov II	0.1	DCM	60 (MW)	0.25	(51)	(8)

x eq 

Hov II (0.025 eq),
DCM, rt, 4 h



I (*E*) only

\+ 

II

992

x	R	**I**	**II**	(*E*,*E*)/(*E*,*Z*) **II**
1.5	Me	(60)	(12)	83:17
3	Me	(53)	(16)	83:17
6	Me	(40)	(53)	88:12
3	Ph	(5)	(87)	98:2

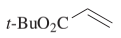
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

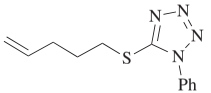
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

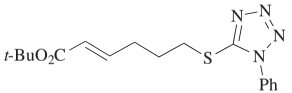
C_3



x eq



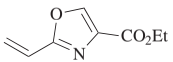
Gr II (0.02 eq),
additive (0.03 eq),
solvent



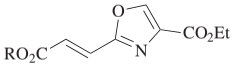
x	Additive	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
1	—	2.5 % aq. PTS	22	12	(55)	86:14	976
3	CuI	Et_2O	35	3	(84)	>95:5	167
2	—	2.5 % aq. TPGS-750-M	22	20	(55)	—	167
2	CuI	2.5 % aq. TPGS-750-M	22	20	(80)	—	931
2	—	2.5 % aq. PTS	22	20	(55)	—	931
2	CuI	2.5 % aq. PTS	22	20	(80)	—	931



1.5 eq



Hov II (0.1 eq),
DCM, 40°, 48 h

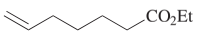


(*E*)/(*Z*) = 75:25

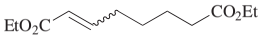
R			
Me	(52)		650
t-Bu	(24)		



4 eq



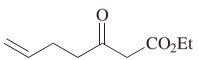
Hov II (0.1 eq), DCM, rt, 2 h



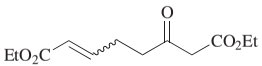
(83)

165

x eq

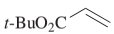


Hov II (*y* eq), DCM

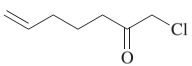


165

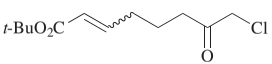
x	*y*	Temp (°)	Time (h)	
4	0.1	rt	24	(33)
4	0.1	40	2	(64)
1.1	0.1	100 (MW)	0.25	(75)
1.1	0.01	100 (MW)	0.25	(59)
1.1	0.1	100 (MW)	0.003	(71)



1.5 eq



Gr II (0.025 eq), DCM, 45°, 18 h



(85)

945

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

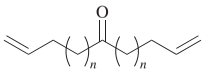
A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

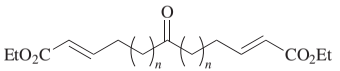
Please refer to the charts preceding the tables for the catalyst structures.

C_3

6 eq

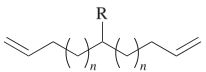


Hov II (*x* eq), DCM, rt

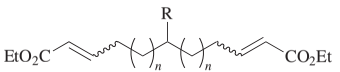


n	*x*	Time (h)		(*E*)/(*Z*)	Refs.
0	2 x 0.025	89	(8)	—	231
1	0.086	190	(66)	—	231
1	0.043	216	(66)	100:0	994

x eq



Hov II (*y* eq), DCM, rt



231

x	R	*n*	*y*	Time (h)	
12	HO	0	2 x 0.025	89	(44)
6	HO	1	0.05	120	(14)
6	TBSO	1	0.05	120	(57)
6	SESHN	1	0.05	48	(77)

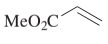
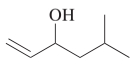
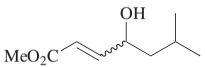
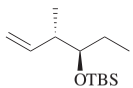
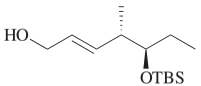
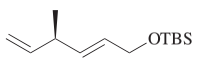
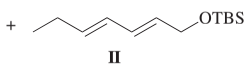
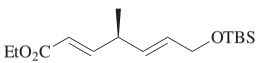
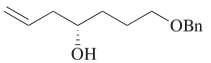
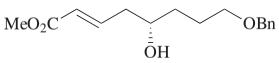
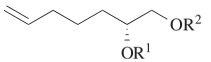
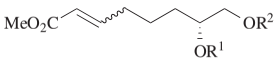
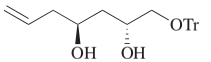
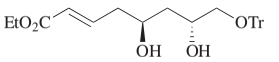
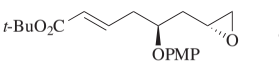
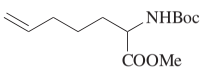
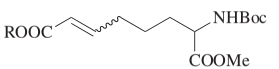
 10 eq		Gr II (0.025 eq), phenol (0.5 eq), toluene, 110°, 0.5 h		(94)	1049
3 eq		1. Hov II (0.1 eq), DCM, reflux, 3 h 2. DIBALH (3.75 eq) DCM, –78 to –45°, 2 h		(64) (*E*)/(*Z*) > 95:5	940, 914
 1.02 eq	 **I** +  **II** **I/II** = 91:9	Hov II (0.01 eq), DCM, rt, 2 d	 (57) (*E,E*)/(*Z,Z*) = 100:1 +  (traces)		1062

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

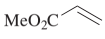
A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
MeO_2C		Gr II, DCM, reflux	 (94) $(E)/(Z) > 99:1$	1063
		Gr II, DCM, 40°		

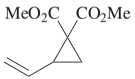
R^1	R^2	Time (h)		Refs.
H	TBDPS	—	(95)	1064
PMB	H	4	(81)	1065

EtO_2C 2 eq		Hov II (0.025 eq), DCM, rt, 36 h	 (80) $(E)/(Z) > 98:2$	626
$t\text{-}BuO_2C$ 3 eq		Gr II (0.1 eq), DCM, reflux, 8 h	 (91) $(E)/(Z) = 95:5$	1066
RO_2C 1.5 eq		Gr II (0.025 eq) DCM, reflux, 2 h		1067

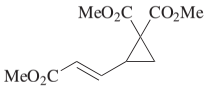
R		
n-Bu	(90)	
t-Bu	(83)	



1.4 eq



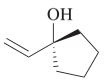
Gr II (0.01 eq),
DCM, reflux



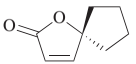
(92) (*E*)/(*Z*) = 89:11

407

10 eq

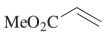


1. Ru cat **163** (0.03 eq),
DCM, rt, hν (350 nm)
2. Phenanthrene (0.3 eq),
DCM, rt, hν (254 nm)

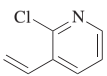


(52)

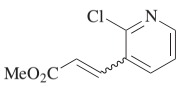
911



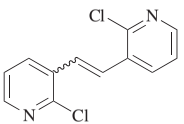
I 3 eq



Hov II (0.1 eq),
DCM, 50°, 24 h



+



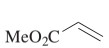
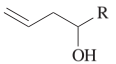
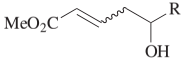
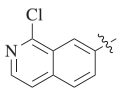
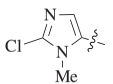
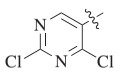
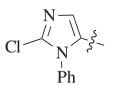
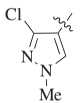
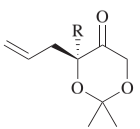
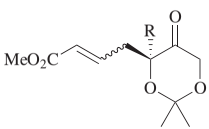
II **III**

(31) **I/II/III** = 40:40:20

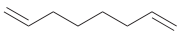
603

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

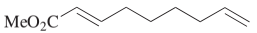
A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 3 eq		Hov II (0.1 eq), DCM, 50°, 24 h		603
			R:  (53)	R:  (21)
			 (70)	 (71)
			 (82)	 (82)
9.5 eq		Gr II (0.02 eq), DCM, 37°, 40 h		R: Me (83); Et (89); Bn (75) — 977

4 eq



Gr II (0.00025 eq),
p-cresol (*x* eq),
50°, 2 h



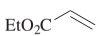
I



II

x	**I**	(*E*)/(*Z*) **I**	**II**
—	5	92:8	(29)
500	24	93:7	(66)

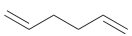
130



1 eq

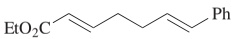


3 eq



1 eq

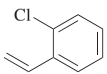
Gr II (0.052 eq),
DCM, 23°, 12 h



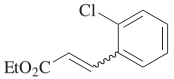
(34) (*E*) only

36

5 eq

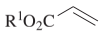


Ru cat **88** (5 x 0.024 eq),
$C_6F_5CF_3$, MW,
120°, 50 min

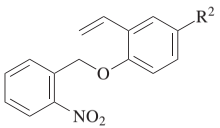


(65)

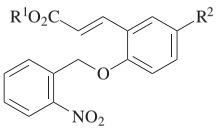
929



10 eq



Ru cat **353** (0.05 eq),
1-pyrenecarboxaldehyde
(7 eq),
DCM, hν (380 nm), 90 h



(*E*)/(*Z*) > 99:1

R^1	R^2	
Me	Me	(57)
t-Bu	Cl	(60)
t-Bu	O_2N	(65)

646

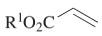
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

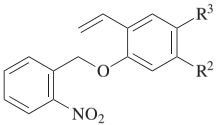
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

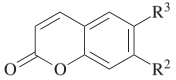
C_3



10 eq

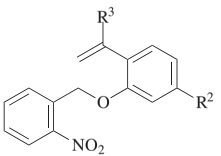


1. Ru cat **353** (0.05 eq), 1-pyrenecarboxaldehyde (7 eq), DCM, hν (380 nm), 80–100 h
2. hν (254 nm), lamp, 10–30 h

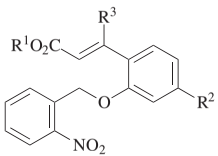


R^1	R^2	R^3		
Me	H	H	(65)	646
Me	Br	H	(51)	
Me	H	Me	(46)	
t-Bu	H	Cl	(56)	
t-Bu	H	O_2N	(55)	
t-Bu	Br	H	(57)	
t-Bu	Ph	H	(58)	

10 eq



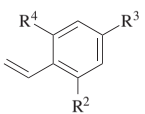
Ru cat **353** (0.05 eq), 1-pyrenecarboxaldehyde (7 eq), DCM, hν (380 nm), 90 h



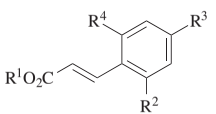
(*E*)/(*Z*) > 99:1 646

R^1	R^2	R^3	
Me	H	H	(75)
Me	H	Me	(0)
t-Bu	Br	H	(68)
t-Bu	Ph	H	(63)

x eq

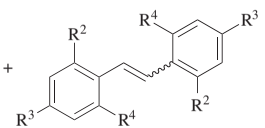


Catalyst (*y* eq), *p*-cresol (*z* eq), solvent



I

+

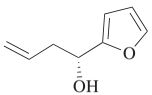
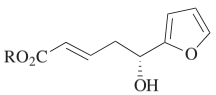
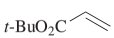
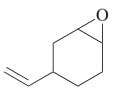
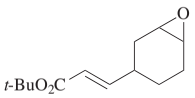
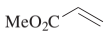
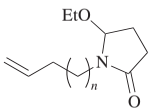
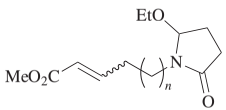
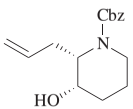
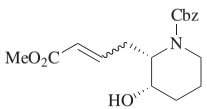


II

R^1	x	R^2	R^3	R^4	Catalyst	y	z	Solvent	Temp (°)	Time (h)	**I**	(*E*)/(*Z*) **I**	**II**	
Me	0.5	H	H	H	Gr II	0.00025	—	neat	50	2	(24)	>98:2	(0)	130
Me	0.5	H	H	H	Gr II	0.00025	500	neat	50	2	(66)	>98:2	(0)	130
Me	0.5	H	H	H	Gr II	0.0000625	—	neat	50	2	(16)	>98:2	(0)	130
Me	0.5	H	H	H	Gr II	0.0000625	500	neat	50	2	(57)	>98:2	(0)	130
Me	2	H	H	H	Gr II	0.00025	—	neat	50	2	(8)	>98:2	(0)	130
Me	2	H	H	H	Gr II	0.00025	500	neat	50	2	(40)	>98:2	(0)	130
Me	2	H	H	H	Gr II	0.05	—	DCM	40	12	(92)	(*E*) only	(0)	36
Me	2	H	O_2N	H	Gr II	0.05	—	DCM	40	12	(89)	(*E*) only	(0)	36
Et	2	F	H	H	Gr II	0.05	—	DCM	40	12	(72)	(*E*) only	(0)	36
Et	2	Cl	H	H	Gr II	0.05	—	DCM	40	12	(62)	(*E*) only	(0)	36
Et	2	Br	H	H	Gr II	0.05	—	DCM	40	12	(49)	(*E*) only	(0)	36
Et	2	F	H	F	Gr II	0.05	—	DCM	40	12	(15)	(*E*) only	(0)	36
Me	2	Cl	H	H	Ru cat **41**	0.01	—	DCM	rt	3	(72)	>95:5	(0)	562
Me	2	Cl	H	H	Ru cat **44**	0.01	—	DCM	rt	3	(83)	>95:5	(0)	562
Me	2	Cl	H	H	Ru cat **45**	0.01	—	DCM	rt	3	(77)	>95:5	(0)	562
Me	5	Cl	H	H	Ru cat **258**	0.00025	—	DCM	30	2	(28)	>95:5	(30)	1055
Me	5	Cl	H	H	Ru cat **321**	0.00025	—	DCM	30	2	(35)	>95:5	(33)	1055
Me	5	Cl	H	H	Ru cat **322**	0.00025	—	DCM	30	2	(38)	>95:5	(33)	1055
Me	3	Cl	H	H	Ru cat **316**	0.02	—	toluene	80	2	(81)	>95:5	(0)	591
Me	5	Cl	H	H	Ru cat **316**	0.001	—	toluene	80	15	(59)	>95:5	(0)	591
Me	2	Cl	H	H	Ru cat **286**	0.02	—	DCM	40	8	(78)	>95:5	(0)	161

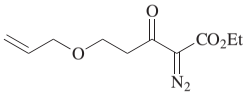
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

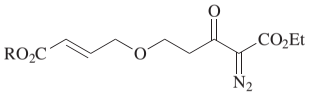
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 2 eq		Gr II (*x* eq), benzene, rt, 16 h	 R / *x* / (*E*)/(*Z*) Me 0.05 (90) >96:4 Et 0.02 (63) >95:5	336
 3.14 eq		Hov II (0.02 eq), 2.5% aq. PTS, 22°, 12 h	 (76) (*E*)/(*Z*) = 95:5	976
 10 eq		Gr II (0.02 eq), toluene, 70°	 *n* / Time (h) 1 3 (83) 2 2 (86) 3 2 (96)	1068
2 eq		Gr II (0.1 eq), DCM, reflux, overnight	 (62)	441



10 eq

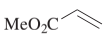


Gr II (0.05 eq), DCM, 40°, 18 h

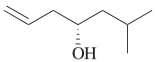


R		(*E*)/(*Z*)
Me	(86)	95:5
t-Bu	(78)	>99:1

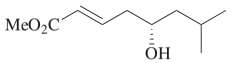
569



2 eq



Gr II (0.02 eq), benzene, rt, 16 h

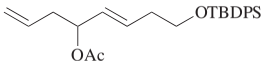


(70) (*E*)/(*Z*) = 95:5

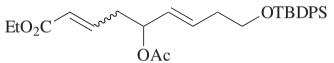
336



3 eq

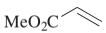


Hov II (0.05 eq) DCM, rt, 12 h

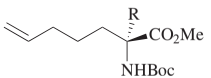


(69)

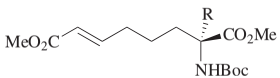
919



2 eq



Gr II (0.1 eq), DCM, reflux, 3 h

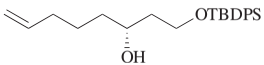


(*E*) only

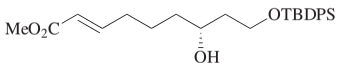
R		
Me	(93)	
i-Bu	(95)	

1069

x eq



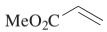
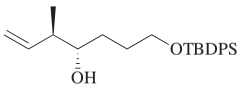
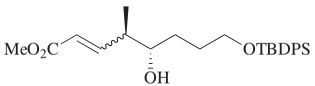
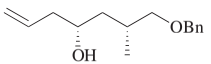
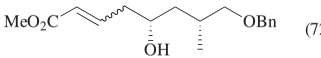
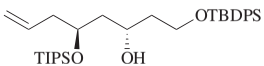
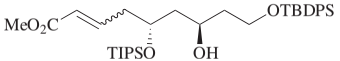
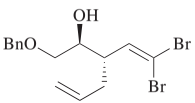
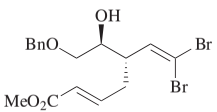
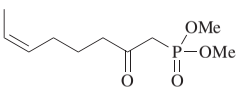
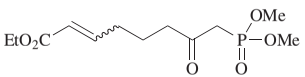
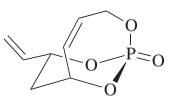
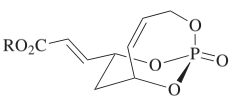
Gr II (*y* eq), DCM



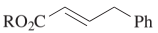
x	*y*	Temp (°)	Time (h)		(*E*)/(*Z*)	
—	0.005	—	—	(91)	—	1070
5	0.025	40	3	(99)	97:3	1071

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 15 eq		Gr II (0.075 eq), DCM, 80° (MW), 2 h	 (83)	885
12 eq		Gr II (0.02 eq), DCM, 35°, 2 h	 (72)	1018, 1019
3–10 eq		Hov II (0.1 eq), DCM, 100° (MW), 0.5 h	 (98)	947
		Gr II (0.1 eq), DCE, 60°	 (68) (*E*) only	1072
 3 eq		Gr II (0.03 + 0.01 eq), $Ti(O\textit{i}\text{-}Pr)_4$ (0.15 eq), DCM, 100°, 20 min	 (82)	1073
 3–5 eq		Gr II (0.01 eq), DCM, reflux		719

R		(*E*)/(*Z*)
Me	(78)	89:11
t-Bu	(60)	83:17

x eq  Catalyst (*y* eq), solvent, 12 h 

R	*x*	Catalyst	*y*	Solvent	Temp (°)		(*E*)/(Z)	
Me	0.4	Gr II	0.025	DCM	40	(99)	(*E*) only	971
Me	0.4	Hov II	0.025	DCM	40	(99)	(*E*) only	971
Me	0.4	Ru cat **86**	0.025	DCM	40	(99)	(*E*) only	971
2-ethylhexyl	2	Ru cat **109**	0.02	DCM	22	(94)	90:10	341
t-Bu	2	Gr II	0.02	2.5% aq. PTS	rt	(97)	—	976
t-Bu	1.3	Gr II	0.02	2.5% aq. PTS	rt	(93)	—	976
t-Bu	2	Gr II	0.02	2.5% aq. TPGS	rt	(67)	—	976
t-Bu	1.3	Gr II	0.02	2.3% aq. TPGS	rt	(61)	—	976
t-Bu	2	Gr II	0.02	2.5% aq. PSS	rt	(78)	—	976
t-Bu	1.3	Gr II	0.02	2.5% aq. PSS	rt	(70)	—	976
t-Bu	2	Gr II	0.02	2.5% aq. Triton X-100	rt	(69)	—	976
t-Bu	1.3	Gr II	0.02	2.5% aq. Triton X-100	rt	(63)	—	976
t-Bu	2	Gr II	0.02	2.5% aq. Brij 30	rt	(63)	—	976
t-Bu	1.3	Gr II	0.02	2.5% aq. Brij 30	rt	(55)	—	976
t-Bu	2	Gr II	0.02	2.5% aq. PEG 600	rt	(60)	—	976
t-Bu	1.3	Gr II	0.02	2.3% aq. PEG 600	rt	(47)	—	976
t-Bu	2	Gr II	0.02	2.5% aq. SDS	rt	(68)	>95:5	976
t-Bu	1.3	Gr II	0.02	2.5% aq. SDS	rt	(64)	(*E*) only	976
t-Bu	2	Gr II	0.02	H_2O	rt	(71)	(*E*) only	976
t-Bu	1.3	Gr II	0.02	H_2O	rt	(62)	—	976
t-Bu	2	Gr II	0.02	2.5% aq. PTS	22	(96)	>95:5	976
2-ethylhexyl	2	Gr II	0.02	2.5% aq. PTS	22	(92)	90:10	976

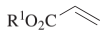
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

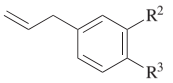
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

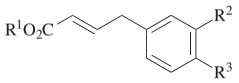
C_3



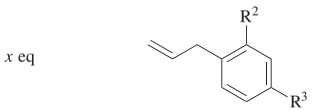
2 eq



Catalyst (*x* eq),
BQ (*y* eq), solvent



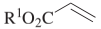
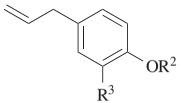
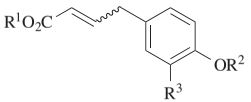
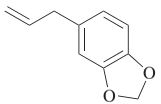
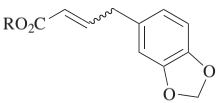
R^1	R^2	R^3	Catalyst	*x*	*y*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
Me	MeO	HO	Gr II	0.02	0	DMC	80	3	(0)	—	1074
Me	MeO	HO	Hov II	0.02	0	DMC	80	3	(65)	—	1074
Me	MeO	HO	Hov II	0.02	0	DMC	80	3	(50)	—	1074
Me	MeO	HO	Hov II	0.02	0	DMC	80	24	(62)	—	1074
Me	MeO	HO	Hov II	0.005	0	DMC	80	3	(0)	—	1074
Me	MeO	HO	Ru cat **89**	0.02	0	DMC	80	3	(0)	—	1074
Me	MeO	HO	Ru cat **139**	0.02	0	DMC	80	3	(80)	—	1074
Me	MeO	HO	Hov II	0.01	0.05	DMC	80	16	(0)	—	1074
Me	MeO	HO	Ru cat **139**	0.01	0.05	DMC	80	8	(73)	—	1074
Me	MeO	HO	Ru cat **139**	0.01	0.05	DMC	80	16	(78)	—	1074
Me	MeO	HO	Ru cat **139**	0.005	0.05	DMC	80	3	(0)	—	1074
Me	MeO	*i*-PrO	Hov II	0.02	0.05	DMC	80	3	(75)	—	1074
Me	MeO	*i*-PrO	Hov II	0.02	0.05	DMC	80	8	(85)	—	1074
Me	MeO	AcO	Hov II	0.02	0.05	DMC	80	8	(81)	—	1074
Et	MeO	HO	Ru cat **41**	0.01	0	DCM	rt	5	(68)	>95:5	562
Et	MeO	HO	Ru cat **44**	0.01	0	DCM	rt	5	(89)	>95:5	562
Et	MeO	HO	Ru cat **45**	0.01	0	DCM	rt	5	(92)	>95:5	562
Ad	H	MeO	Ru cat **109**	0.02	0	DCM	22	12	(73)	(*E*) only	341

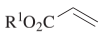


R^1	*x*	R^2	R^3	Catalyst	Additive	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
t-Bu	2	TBSO	H	Gr II	—	2.5% aq. PTS	22	12	(88)	—	972
t-Bu	2	TBSO	H	Gr II	—	2.5% aq. TPGS-750-W	22	12	(91)	—	972
Ad	2	H	MeO	Gr II	—	2.5% aq. PTS	22	12	(78)	—	972
Ad	2	H	MeO	Gr II	—	2.5% aq. TPGS-750-W	22	12	(82)	—	972
Me	3	TBSO	H	Gr II	NaI	Et_2O	35	3	(100)	—	167
Me	3	TBSO	H	Gr II	CuI	Et_2O	35	3	(100)	—	167
Me	3	TBSO	H	Gr II	NaI	DME	35	3	(67)	—	167
Me	3	TBSO	H	Gr II	CuI	DME	35	3	(48)	—	167
t-Bu	3	TBSO	H	Gr II	CuI	Et_2O	35	3	(93)	>95:5	167
Me	3	TBSO	H	Gr II	CuI	Et_2O	35	3	(93)	(*E*) only	167
Me	3	H	MeO	Gr II	CuI	Et_2O	35	3	(94)	(*E*) only	167
Ad	2	H	MeO	Gr II	—	2.5% aq. TPGS-750-W	22	12	(82)	—	167
Ad	2	H	MeO	Gr II	CuI	2.5% aq. TPGS-750-W	22	12	(89)	—	167
t-Bu	2	TBSO	H	Ru cat **290**	—	2.5% aq. PTS	22	12	(27)	—	931
t-Bu	2	TBSO	H	Ru cat **301**	—	2.5% aq. PTS	22	12	(0)	—	931
t-Bu	2	TBSO	H	Ru cat **299**	—	2.5% aq. PTS	22	12	(0)	—	931
t-Bu	2	TBSO	H	Ru cat **139**	—	2.5% aq. PTS	22	12	(80)	—	931
t-Bu	2	TBSO	H	Ind II	—	2.5% aq. PTS	22	12	(99)	—	931
t-Bu	2	TBSO	H	Gr II	NaI	2.5% aq. PTS	22	4	(99)	—	931
Me	2	H	MeO	Gr II	—	2.5% aq. PTS	22	12	(70)	(*E*) only	976
Ad	2	H	MeO	Gr II	—	2.5% aq. PTS	22	12	(78)	(*E*) only	976
t-Bu	2	H	MeO	Gr II	—	2.5% aq. PTS	22	12	(93)	>95:5	976
t-Bu	2	TBSO	H	Gr II	—	2.5% aq. PTS	22	12	(88)	(*E*) only	976

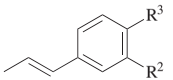
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

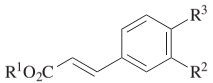
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 6 eq		1. Ru cat **352** (0.001 eq), toluene, rt, 0.5 h 2. Hov II (0.005 eq), toluene, 70°, 6 h	 R^1 / R^2 / R^3: Me / Me / H (100); Me / H / MeO (>99); 2-ethyhexyl / Me / H (>99); 2-ethyhexyl / H / MeO (>99)	1075
 6 eq		1. Ru cat **352** (0.001 eq), toluene, rt, 0.5 h 2. Hov II (0.005 eq), toluene, 70°, 6 h	 R: Me (>99); 2-ethyhexyl (>99)	1075



x eq



Hov II (*y* eq),
DCE, 70°, 6 h

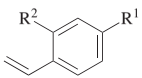


1076

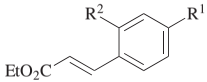
R^1	*x*	R^2	R^3	*y*		(*E*)/(*Z*)
Me	4	H	MeO	0.02	(99)	97:3
Me	4	H	MeO	0.001	(78)	>99:1
Me	4	H	MeO	0.005	(97)	99:1
Me	2	H	MeO	0.005	(90)	99:1
Me	10	H	MeO	0.005	(93)	98:2
Me	20	H	MeO	0.005	(89)	99:1
Me	6	H	MeO	0.005	(99)	99:1
Me	6	H	Me	0.005	(83)	99:1
Me	6	MeO	H	0.005	(90)	98:2
Et	6	H	Me	0.005	(85)	>99:1
Et	6	MeO	H	0.005	(95)	>99:1
2-ethylhexyl	6	H	Me	0.005	(89)	>99:1
2-ethylhexyl	6	MeO	H	0.005	(98)	>99:1



2 eq



Gr II (0.02–0.05 eq),
DCM, 40°, 12 h

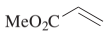
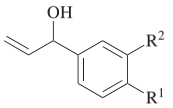
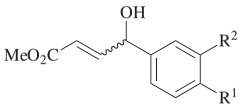
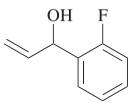
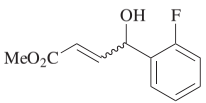
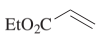
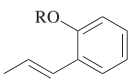
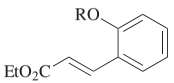


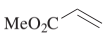
(*E*) only

R^1	R^2		
H	CF_3	(44)	36
OHC	H	(83)	

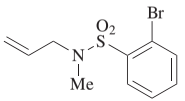
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

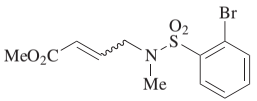
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 10 eq		Gr II (0.025 eq), phenol (0.5 eq), toluene, 110°, 0.5 h		1049
			R^1 / R^2: H / H (91); Br / H (94); MeO / H (91); TBSO / H (92); BnO / H (88); MOMO / MeO (85)	
10 eq		Gr II (0.025 eq), phenol (0.5 eq), toluene, 110°, 0.5 h	 (94)	1049
 2 eq		Gr II (0.05 eq), DCM, 40°, 12 h	 (*E*) only	R: TBS (30); Ac (87) — 36; 145



3 eq



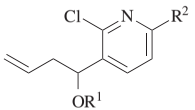
Gr II (0.05 eq),
DCM, 40°, 3 h



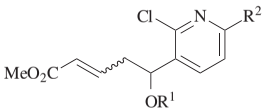
(96)

634

3 eq



Catalyst (0.1 eq),
solvent, 24 h

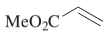
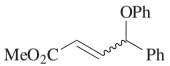
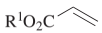
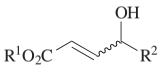


603

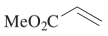
R^1	R^2	Catalyst	Solvent	Temp (°)	Concn (M)	
H	H	Hov II	DCM	50	0.1	(64)
H	H	Hov II	DCM	50	1	(84)
H	H	Hov II	toluene	80	1	(35)
H	H	Gr II	DCM	50	1	(65)
H	Br	Hov II	DCM	50	1	(73)
H	Cl	Hov II	DCM	50	1	(67)
H	F	Hov II	DCM	50	1	(68)
H	MeO	Hov II	DCM	50	1	(51)
H	CF_3	Hov II	DCM	50	1	(73)
H	*t*-Bu	Hov II	DCM	50	1	(52)
Ac	TfO	Hov II	DCM	50	1	(85)

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

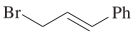
A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 2 eq		Hov II (0.05 eq), toluene, 80°, 6 h	 (65)	930
 10 eq		Catalyst (0.03 eq), DCM, rt, hν (350 nm)		911

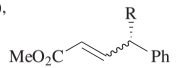
R^1	R^2	Catalyst	
Me	Ph	Ru cat **163**	(89)
t-Bu	Ph	Ru cat **163**	(94)
n-Bu	Ph	Ru cat **353**	(77)
Bn	Ph	Ru cat **353**	(82)
Bn	n-C_9H_{19}	Ru cat **353**	(78)
4-*t*-BuC_6H_4	Ph	Ru cat **353**	(74)
4-*t*-BuC_6H_4	n-C_9H_{19}	Ru cat **353**	(75)



I

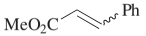


1. RMgBr (1.2 eq),
(*R*,*R*)-Taniaphos (0.012 eq),
$CuBr{\bullet}SMe_2$ (0.01 eq),
DCM, –75°
2. **I** (5 eq), catalyst (*x* eq),
DCM, rt



I

+

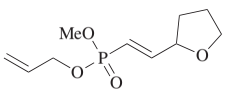


II

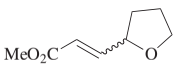
975

R	Catalyst	*x*	**I**	er **I**	**I/II**
Me	Hov II	0.02	(66)	—	>97:3
Et	Hov II	0.02	(67)	99:1	80:20
Et	Gr II	0.015	(49)	99:1	90:10

20 eq



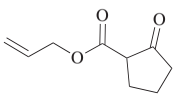
Gr II (0.1 eq),
CuI (0.13 eq),
DCM, reflux, 2 h



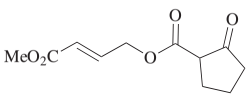
(78)

220

1 eq



Hov II (0.03 + 0.01 eq),
DCM, 100° (MW),
0.33 + 0.17 h

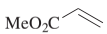
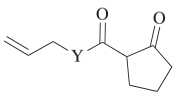
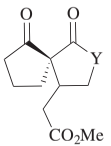
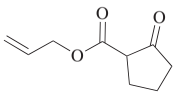
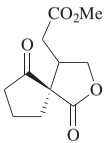
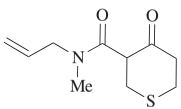
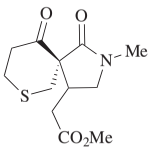


(53) (*E*)/(*Z*) > 91:9

955

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 1 eq		1. Hov II (0.04 eq), DCM, 100° (MW), 0.5 h 2. Alumina basic (0.8 g), MeOH, 50°, 24 h	 Y: O (65) dr 60:40; MeN (56) dr 57:43	955
1 eq		1. Hov II (0.03 + 0.01 eq), DCM, 100° (MW), 20 + 10 min 2. P(*n*-Bu)$_3$ (0.2 eq), 100° (MW), 20 min	 (53) dr = 62:38	979
1 eq		1. Hov II (0.04 eq), DCM, 100° (MW), 0.5 h 2. Alumina basic (0.8 g), MeOH, 50°, 24 h	 (43) dr = 56:44	955

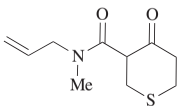
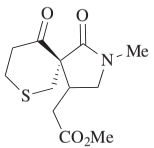
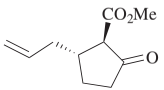
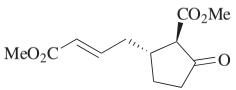
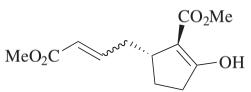
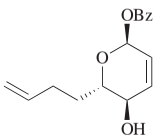
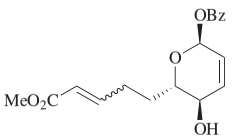
1 eq		1. Hov II (0.04 eq), DCM, 100° (MW), 0.5 h 2. *n*-BuP_3 (0.2 eq), 100° (MW), 20 min		(35) dr = 54:46	955
2.5 eq		Hov II (0.05 eq), DCM, 40°, 14 h	 +  **II**	**I** (79) (*E*) only **I/II** = 15:1	1077
		Hov II (0.05 eq), DCM		(82)	989

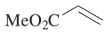
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

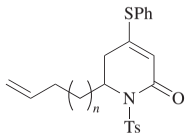
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

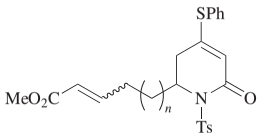
C_3



10 eq



Catalyst (0.05 eq),
p-cresol (*x* eq),
toluene

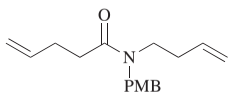


1078

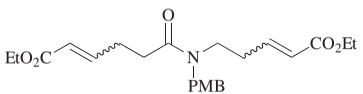
n	Catalyst	*x*	Temp (°)	Time (h)	
1	Gr II	0.5	150 (MW)	0.5	(91)
1	Gr II	0.5	80	3.5	(85)
2	Gr I	0.5	150 (MW)	3.5	(16)
2	Gr II	—	150 (MW)	0.5	(88)
2	Gr II	0.5	150 (MW)	0.5	(96)
2	Gr II	0.5	reflux	3.5	(91)
2	Gr I	—	150 (MW)	0.5	(0)
3	Gr II	0.5	150 (MW)	0.5	(94)
3	Gr II	0.5	80	3.5	(88)



6 eq



Hov II (2 x 0.025 eq),
DCM, rt, 144 h



(79)

231

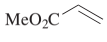
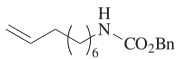
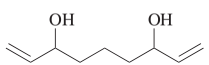
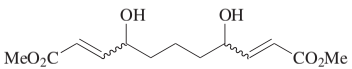
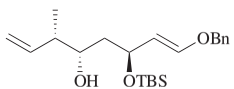
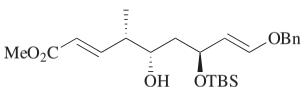
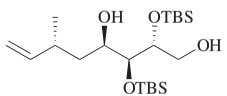
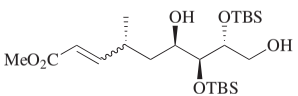
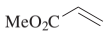
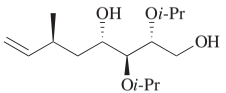
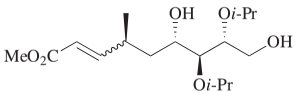
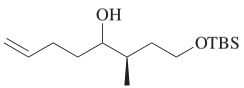
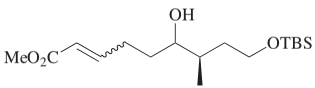
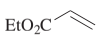
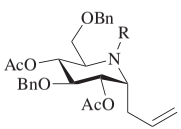
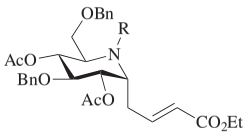
 10 eq		Hov II (0.005 eq), rt, 50°, 16.3 h		(90)	1079
20 eq		Gr II (0.1 eq), phenol (0.5 eq), toluene, 110°, 0.5 h		(82)	1049
3 eq		Hov II (0.27 + 0.27 eq), DCE, reflux, 12 + 16 h		(95) (*E*) only	974
2 eq		Gr II (0.07 eq), CuI (0.1 eq), DCM, 40°, 4 h		(60)	1080

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

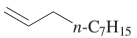
A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 2 eq		Gr II (0.07 eq), CuI (0.1 eq), DCM, 40°, 4 h	 (62)	1080
3 eq		Hov II (0.02 eq), DCM, 40°, 2 h	 (80)	342
 3 eq		Gr II (*x* eq), DCM, 40°, 16–24 h	 (*E*)/(*Z*) > 95:5	666

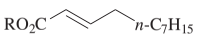
R	*x*	
Tr	0.05	(92)
OHC	0.1	(96)



2 eq

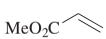


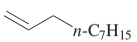
Gr II (*x* eq),
p-cresol (*y* eq), 50°, 2 h



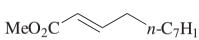
130

R	*x*	*y*		(*E*)/(*Z*)
Me	0.001	—	(24)	93:7
Me	0.001	500	(100)	97:3
Me	0.0005	—	(56)	94:6
Me	0.0005	500	(97)	96:4
Me	0.00025	—	(58)	93:7
Me	0.00025	500	(96)	96:4
Me	0.0000625	—	(47)	94:6
Me	0.0000625	500	(71)	94:6
Et	0.0005	—	(43)	93:7
Et	0.0005	500	(95)	96:4





Catalyst (0.025 eq),
solvent, 35°, 3 h



(*E*) only

384

Catalyst	Solvent	Conv. (%)[b]	
Gr II	DCM	94	(62)
Gr II	DMC	84	(56)
Hov II	DCM	95	(69)
Hov II	DMC	87	(58)

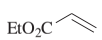
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

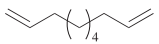
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

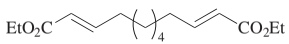
C_3



5 eq



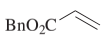
Catalyst (*x* eq)



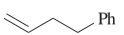
1081

Catalyst	*x*	Temp (°)	Time (h)		(*E*)/(*Z*)
Gr II	0.001	50	0.5	(76)	95:5
Gr II	0.001	50	4	(76)	95:5
Ind II	0.001	50	0.5	(75)	92:8
Ind II	0.001	50	4	(85)	94:6
Ind II	0.001	50	16	(88)	94:6
Hov II	0.001	50	0.5	(100)	93:7
Ru cat **84**	0.001	50	0.5	(84)	93:7
Ru cat **84**	0.001	50	4	(85)	92:8
Ru cat **85**	0.001	50	0.5	(45)	93:7
Ru cat **85**	0.001	50	16	(84)	93:7
Ru cat **139**	0.001	50	0.5	(92)	93:7
Ru cat **139**	0.001	50	4	(93)	92:8
Ru cat **131**	0.001	50	0.5	(55)	91:9
Ru cat **131**	0.001	50	16	(95)	92:8
Hov II	0.0005	50	0.5	(86)	94:6
Hov II	0.0005	50	16	(99)	93:7
Ru cat **131**	0.0005	50	16	(85)	91:9
Hov II	0.0003	50	16	(98)	94:6
Ru cat **131**	0.0003	50	16	(55)	91:9
Hov II	0.001	50	16	(54)	93:7
Hov II	0.0005	80	0.5	(99)	93:7
Hov II	0.0003	80	0.5	(99)	93:7
Hov II	0.0002	80	0.5	(98)	93:7
Gr II	0.0002	80	0.5	(50)	92:8

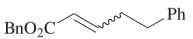
Ind II	0.0002	80	0.5	(47)	89:11
Ru cat **84**	0.0002	80	0.5	(82)	91:9
Ru cat **139**	0.0002	80	0.5	(82)	93:7
Ru cat **131**	0.0002	80	0.5	(93)	94:6
Ru cat **131**	0.0002	80	16	(100)	93:7
Hov II	0.00016	80	0.5	(92)	92:8
Hov II	0.00016	80	16	(95)	92:8
Ru cat **131**	0.00016	80	32	(99)	92:8
Hov II	0.0001	100	0.5	(96)	92:8
Ru cat **131**	0.0001	100	0.5	(89)	92:8
Ru cat **131**	0.0001	100	4	(98)	92:8



2 eq



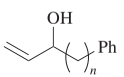
Catalyst (0.02 eq), DCM, 55°, 2 h



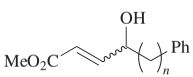
Catalyst	
Ru cat **81**	(82)
Ru cat **91**	(88)

1082

10 eq



Gr II (0.025 eq), phenol (0.5 eq), toluene, 110°, 0.5 h



n	
1	(88)
2	(90)

1049

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

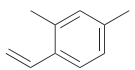
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

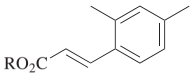
C_3



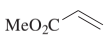
x eq



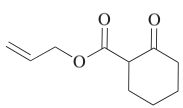
Gr II (0.02 eq),
additive (0.03 eq)



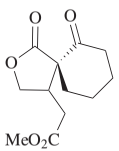
R	*x*	Additive	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
Et	2	—	DCM	40	12	(87)	(*E*) only	36
t-Bu	2	—	2.5% aq. PTS	22	12	(72)	—	972
t-Bu	2	—	2.5% aq. TPGS-750-W	22	12	(74)	—	972
t-Bu	2	—	2.5% aq. TPGS-750-W	22	15	(74)	—	167
t-Bu	2	CuI	2.5% aq. TPGS-750-W	22	15	(84)	—	167
t-Bu	2	—	2.5% aq. PTS	22	15	(72)	—	931
t-Bu	2	CuI	2.5% aq. PTS	22	15	(81)	—	931
t-Bu	1	—	2.5% aq. PTS	22	12	(72)	90:10	976



1 eq

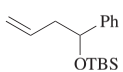


1. Hov II (0.04 eq),
DCM, 100° (MW), 0.5 h
2. Alumina basic (0.8 g),
MeOH, 50°, 24 h

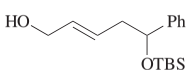


(52) dr 50:50 955

3 eq



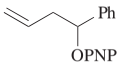
1. Hov II (0.1 eq),
DCM, reflux, 3 h
2. DIBALH (3.75 eq)
DCM, –78 to –45°, 2 h



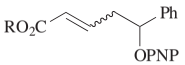
(56) (*E*)/(*Z*) > 95:5 940



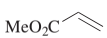
x eq



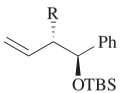
Hov II (0.02 eq),
DCM, 40°, 15 h



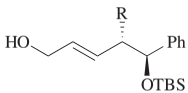
R	*x*		
Me	3	(93)	932
t-Bu	2	(93)	
2-ethylhexyl	2	(96)	



3 eq

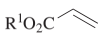


1. Hov II (0.1 eq),
DCM, reflux, 3 h
2. DIBALH (3.75 eq),
DCM, –78 to –45°, 2 h

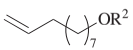


(*E*)/(*Z*) > 95:5

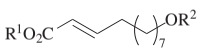
R		
H	(56)	940
Me	(57)	941



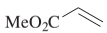
x eq



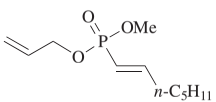
Catalyst (*y* eq), solvent



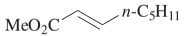
R^1	*x*	R^2	Catalyst	*y*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
Me	3	H	Gr II	0.05	H_2O	40	5	(99)	—	1083
Me	3	H	Ind II	0.05	H_2O	40	5	(90)	—	1083
t-Bu	2	TBS	Gr II	0.02	2.5% aq. PTS	22	12	(95)	—	972
t-Bu	2	TBS	Gr II	0.02	2.5% aq. TPGS-750-W	22	12	(95)	—	972
t-Bu	1	TBS	Gr II	0.02	2.5% aq. PTS	22	12	(95)	(*E*) only	976



2 eq



Gr II (0.1 eq),
CuI (0.1 eq),
DCM, reflux, 16 h



(78) (*E*) only 220

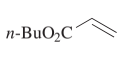
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

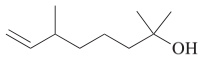
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

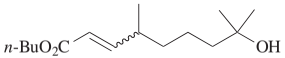
C_3



2 eq

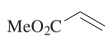


Catalyst (*x* eq), AcOEt, 60°

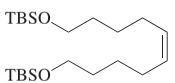


751

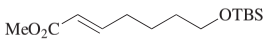
Catalyst	*x*	Time (h)	
Ru cat **170**	0.01	17	(71)
Ru cat **93**	0.01	17	(63)
Ru cat **170**	0.01	17	(73)
Ru cat **172**	0.01	17	(67)
Ru cat **94**	0.01	17	(68)
Ru cat **170**	0.01	18	(75)
Ru cat **170**	0.005	17	(47)
Ru cat **170**	0.002	17	(28)
Gr II	0.01	17	(25)



4 eq



Catalyst (0.04 eq), DCM, 40°, 8 h



161

Catalyst		(*E*)/(*Z*)
Ind I	(<2)	—
Ru cat **282**	(4)	80:20
Ind II	(35)	75:25
Ru cat **286**	(51)	75:25

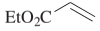
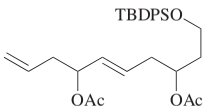
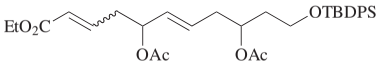
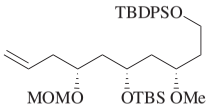
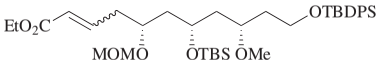
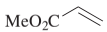
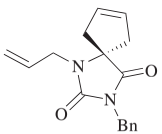
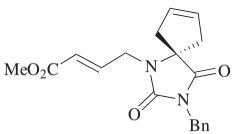
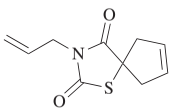
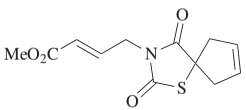
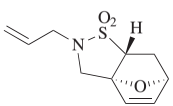
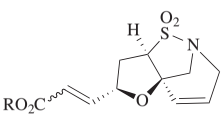
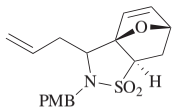
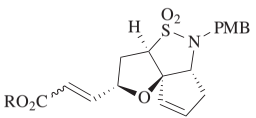
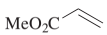
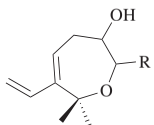
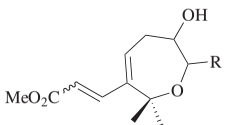
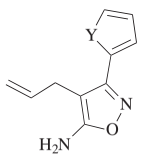
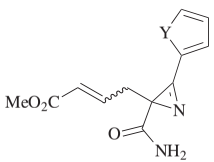
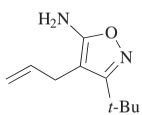
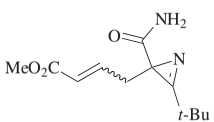
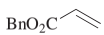
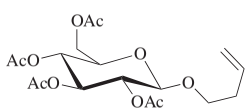
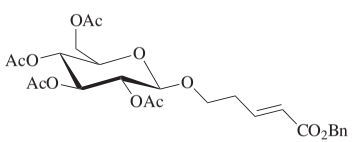
 3 eq		Hov II (0.05 eq), DCM, rt, 12 h		(72)	919
3 eq		Hov II (0.025 eq), DCM, rt, 24 h		(85)	1115
 5 eq		Hov II (0.03 eq), DCM, 45°, 12 h		(62) (*E*) only	1098
3 eq		Hov II (0.03 eq), DCM, 40°, 12 h		(60) (*E*) only	578
 10 eq	 (±)	Ru cat **35** (0.1 eq), DCM, 45°, 3 h	 (±)	R Me (56) Et (65) *t*-Bu (78)	359

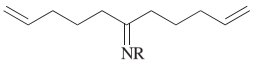
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

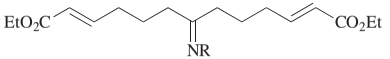
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)		Refs.
Please refer to the charts preceding the tables for the catalyst structures.					
C_3					
 100 eq	 (±)	Ru cat **35** (0.1 eq), DCM, 40°, 3 h	 (±)	R Et (52) *t*-Bu (49)	359
 1.5 eq		Gr II (0.15 eq), DCM, reflux, 18 h		R — Conv. (%)[d] H — 100 MeO_2C — 100	1084
10 eq		Hov II (2 x 0.05 eq), DCM, rt, 48 h, green LED (36 W)		Y O (61) S (58)	995
10 eq		Hov II (2 x 0.05 eq), DCM, rt, 48 h, green LED (36 W)		(82)	995
 1.9 eq		Gr II (0.043 eq), DCM, 45°, 8 h	 (82) (*E*)/(*Z*) = 93:7		1085



6 eq



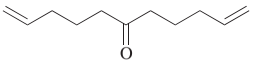
Hov II (0.05 eq),
DCM, rt



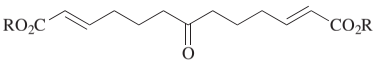
R	Time (h)		(*E*,*E*)/(*Z*,*Z*)	
Phth	144	(89)	—	231
HO	144	(0)	—	231
Phth	120	(88)	100:0	1086



6 eq

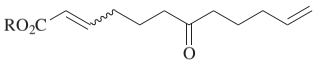


Catalyst (*x* eq), DCM



I

\+



II

R	Catalyst	*x*	Temp (°)	Time (h)	**I**	(*E*,*E*)/(*Z*,*Z*) **I**	**II**	
Et	Ru cat **35**	0.05	20	120	(31)	—	(44)	231
Et	Ru cat **190**	0.05	20	120	(90)	—	—	231
Et	Ru cat **190**	0.04	20	120	(83)	—	—	231
Et	Ru cat **190**	0.01	20	120	(67)	—	—	231
Et	Ru cat **190**	0.05	40	60	(79)	—	—	231
Me	Ru cat **190**	0.05	rt	120	(78)	—	—	231
Bn	Ru cat **190**	0.05	rt	120	(85)	—	—	231
t-Bu	Ru cat **190**	0.05	rt	120	(78)	—	—	231
Et	Hov II	0.05	rt	120	(90)	—	—	231
Et	Hov II	0.05	rt	72	(89)	100:0	—	1086

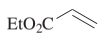
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

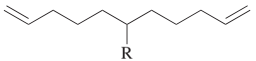
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

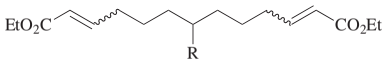
C_3



6 eq

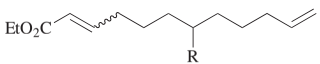


Hov II (0.05 eq), DCM, rt



I

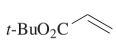
+



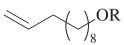
II

231

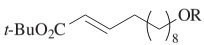
R	Time (h)	**I**	**II**
HO	96	(—)	(35)
TBSO	120	(67)	(—)
H_2N	144	(0)	(—)



x eq



Catalyst (0.02 eq), solvent, 12 h



R	*x*	Catalyst	Solvent	Temp (°)		(*E*)/(*Z*)	Refs.
H	1	Gr II	2.5% aq. PTS	22	(82)	>95:5	976
H	2	Ru cat **109**	H_2O	22	(85)	(*E*) only	341
TBS	2	Ru cat **109**	H_2O	22	(94)	(*E*) only	341
TBS	2	Gr II	H_2O	rt	(70)	—	341
TBS	2	Hov II	H_2O	rt	(56)	—	341



2 eq

1. Catalyst (x eq),
toluene, 1 h, temp
2. H_2 (20 bar),
t-BuOK (y eq), 80°, 40 h



I **II**

1087

Catalyst	x	Temp (°)	y	**I**	**II**
Gr II	0.01	100	0.3	(97)	(—)
Ru cat **139**	0.03	100	0.15	(43)	(50)
Ru cat **139**	0.03	100	0.3	(—)	(96)
Gr II	0.01	rt	0.3	(96)	(—)
Ru cat **139**	0.03	rt	0.2	(—)	(95)
Ru cat **139**	0.03	rt	0.3	(—)	(97)

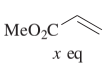
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

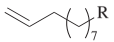
A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

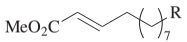
Please refer to the charts preceding the tables for the catalyst structures.

C_3

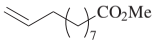
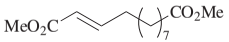




Catalyst (*y* eq), solvent



R	*x*	Catalyst	*y*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
OHC	2	Hov II	0.005	toluene	50	0.5	(98)	92:8	1088
OHC	2	Hov II	0.005	toluene	rt	0.5	(98)	92:8	1088
OHC	2	Ru cat **144**	0.005	toluene	50	0.5	(95)	7:93	1088
OHC	2	Ru cat **144**	0.005	toluene	rt	1.5	(85)	6:94	1088
NC–	2	Hov II	0.005	toluene	50	1	(98)	93:7	1088
NC–	2	Hov II	0.005	toluene	25	2	(99)	93:7	1088
NC–	2	Ru cat **79**	0.005	toluene	50	2	(98)	93:7	1088
NC–	2	Ru cat **79**	0.005	toluene	25	2	(95)	93:7	1088
NC–	2	Ru cat **89**	0.005	toluene	50	1	(99)	90:10	1087
NC–	2	Ru cat **89**	0.005	toluene	25	1	(96)	91:9	1087
NC–	2	Hov II	0.01	neat	50	22	(41)	93:7	1087
NC–	5	Hov II	0.01	neat	50	19	(63)	88:12	1087
NC–	10	Hov II	0.01	neat	50	23	(73)	90:10	1087
NC–	10	Hov II	0.01	neat	100	23	(74)	91:9	1087
NC–	20	Hov II	0.01	neat	50	20	(78)	92:8	1087
NC–	4	Hov II	0.0005	toluene	100	7.67	(98)	89:11	1087
NC–	4	Hov II	0.0005	toluene	50	7.67	(96)	94:6	1087
NC–	4	Hov II	0.0005	toluene	25	7.67	(36)	92:8	1087
NC–	4	Hov II	0.00025	toluene	100	7.67	(98)	90:10	1087
NC–	4	Hov II	0.0001	toluene	100	7.67	(92)	89:11	1087
NC–	4	Hov II	0.000075	toluene	100	7.67	(66)	88:12	1087
NC–	4	Hov II	0.000075	toluene	100	7.67	(80)	89:11	1087
NC–	4	Hov II	0.00005	toluene	100	7.67	(61)	87:13	1087
NC–	4	Hov II	0.00005	toluene	100	7.67	(63)	89:11	1087

2 eq  Catalyst (x eq), toluene 

Catalyst	x	Temp (°)	Time (h)		(E)/(Z)	
Hov II	0.005	50	0.5	(99)	92:8	1088
Hov II	0.005	rt	0.5	(98)	92:8	1088
Ru cat **144**	0.005	50	0.5	(92)	92:8	1088
Ru cat **144**	0.005	rt	1.5	(89)	92:8	1088
Hov II	0.001	100	3	(82)	92:8	1089
Hov II	0.001	50	3	(82)	93:7	1089
Hov II	0.005	50	3	(99)	92:8	1089
Hov II	0.001	50	3	(92)	93:7	1089
Hov II	0.001	rt	3	(85)	92:8	1089
Hov II	0.0005	100	5	(98)	93:7	1089
Hov II	0.00025	100	5	(95)	90:10	1089
Hov II	0.00025	100	5	(96)	90:10	1089
Hov II	0.000125	100	5	(93)	91:9	1089
Hov II	0.000125	50	5	(84)	91:9	1089
Hov II	0.000123	rt	5	(37)	93:7	1089

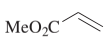
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

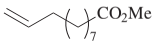
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

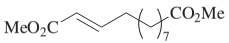
C_3



x eq

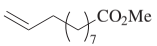


Catalyst (*y* eq), solvent



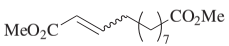
x	Catalyst	*y*	Solvent	Temp (°)	Time (h)	Conv. (%)[b]	(*E*)/(*Z*)	
2	Ru cat **88**	0.005	PC	80	3	97	89:11	1090
2	Ru cat **88**	0.0025	PC	80	2+1	93	90:10	1090
3	Ru cat **88**	0.0005	PC	50	3	9	88:12	1090
3	Ru cat **88**	0.0005	PC	80	3	46	86:14	1090
3	Hov II	0.001	PC	100	3	96	88:12	1090
3	Ru cat **88**	0.001	PC	100	3	97	87:13	1090
3	Hov II	0.005	PC	80	15	98	89:11	1090
8	Ru cat **246**	0.0005	toluene	60	0.5	84	93:7	606

5 eq



I

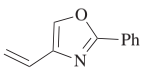
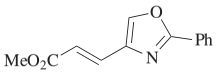
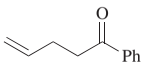
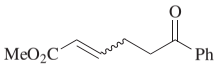
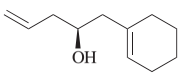
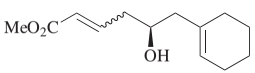
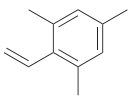
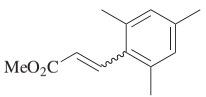
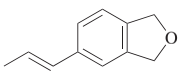
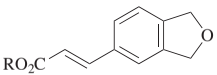
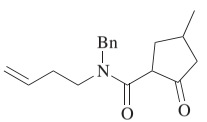
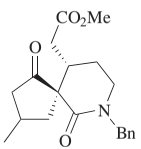
Ind II (0.005 eq), toluene, 80°, 0.5 h



II

1091

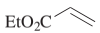
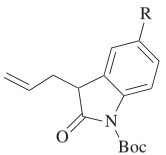
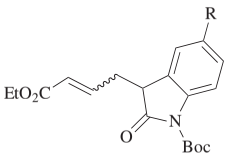
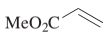
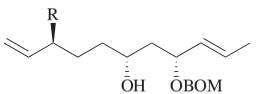
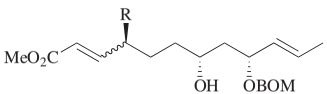
I/toluene (wt %)	Conv. **I** (%)[b]	
1:9	94	(87)
1:4	97	(97)
3:7	>99	(>99)
2:3	>99	(>99)
1:1	>99	(>99)

1.5 eq		Hov II (0.1 eq), DCM, 40°, 36 h		(60) $(E)/(Z) > 95:5$	650
2 eq		Ru cat **316** (0.004 eq), xylene, 140°, 0.25 h		(72)	1092
13 eq		Gr II (0.05 eq), neat, 19°, 50 min		(54) er 98.0:2.0	1093
2 eq		Gr II (0.05 eq), DCM, 40°, 12 h		(5)	36
 6 eq		Hov II (0.005 eq), DCE, 70°, 6 h			1076
1 eq		1. Hov II (0.03 + 0.01 eq), DCM, 100° (MW), 20 + 10 min 2. IPr (0.2 eq), 24°, 20 h		(54) *cis*/*trans* = 74:26	979

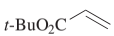
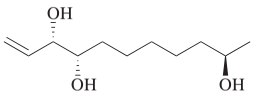
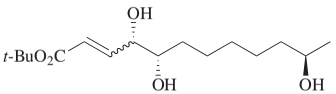
R		$(E)/(Z)$
Me	(85)	99:1
Et	(90)	99:1
2-ethylhexyl	(81)	>99:1

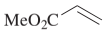
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

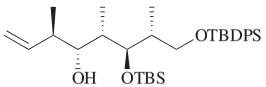
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 5 eq		Ru cat **89** (0.05 eq), DCM, reflux, 5 h	 R: H (71); MeO (80)	1094
 2.17 eq		Catalyst (0.067 eq), additive, solvent, rt		

R	Catalyst	Additive	Solvent	Time (h)		Ratio Epimer	
H	Gr II	none	DCM	7	(76)	—	1095
Me	Gr II	none	DCM	7	(81)	7:1	330
Me	Hov II	none	DCM	7	(76)	4:1	330
Me	Hov II	BQ	DCM	7	(60)	4:1	330
Me	Hov II	none	toluene	3	(71)	—	330
Me	Gr II	phenol (0.5 eq)	DCM	6	(67)	—	330
Me	Hov II	phenol (0.5 eq)	DCM	>6	(75)	—	330

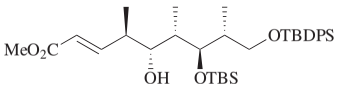
 10 eq		Ru cat **353** (0.05 eq), DCM, hν (350 nm), 30 h		(84)	911



2 eq



Hov II (0.025 eq),
DCM, rt, 15 h

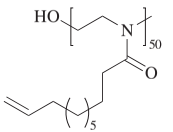


(75) (*E*)/(*Z*) > 98:2

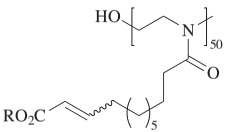
626



x eq



Gr II (*y* eq),
DCM, 40°, 2 h

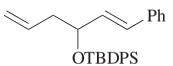


614

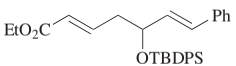
R	*x*	*y*	
Me	7	0.04	(92)
Et	7	0.04	(89)
Bu	7	0.04	(84)
n-C_6H_{13}	7	0.04	(72)
2-hydroxyethyl	12	0.04	(80)
PEG_{480}	7	0.05	(87)
n-$C_8F_{17}(CH_2)_2$	10	0.05	(60)
t-Bu	7	0.04	(87)



3 eq



Hov II (0.05 eq),
DCM, 40°

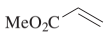
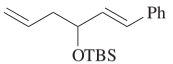
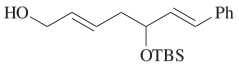
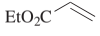
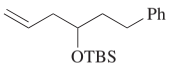
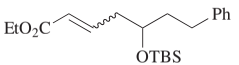
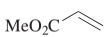
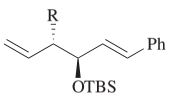
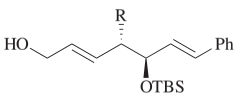
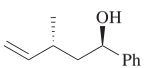
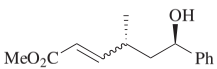
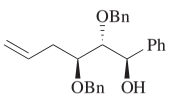
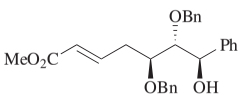


(78) (*E*)/(*Z*) = 95:5

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TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)		Refs.
Please refer to the charts preceding the tables for the catalyst structures.					
C_3					
 3 eq		1. Hov II (0.1 eq), DCM, reflux, 3 h 2. DIBALH (3.75 eq), DCM, –78 to –45°, 2 h		(56) (*E*)/(*Z*) > 95:5	940
 1.3 eq		Catalyst (0.1 eq), DCM, reflux		Catalyst Gr I (26) Gr II (86) Hov II (92)	941
 3 eq		1. Hov II (0.1 eq), DCM, reflux, 3 h 2. DIBALH (3.75 eq), DCM, –78 to –45°, 2 h	 (*E*)/(*Z*) > 95:5	R H (54) Me (74)	940 941
2 eq		Gr II (0.07 eq), CuI (0.1 eq), DCM, 40°, 4 h		(79)	1080
3 eq		Gr II (0.05 eq), DCM, 40°, 4 h		(91) (*E*) only	1096

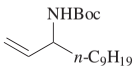
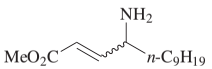
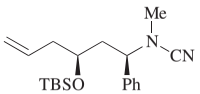
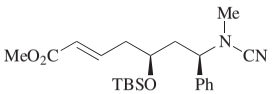
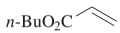
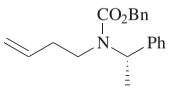
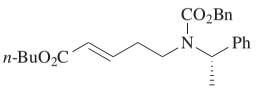
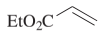
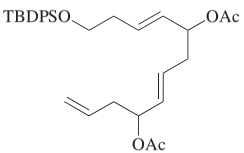
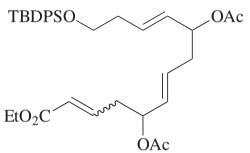
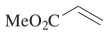
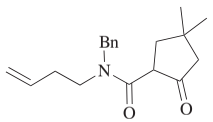
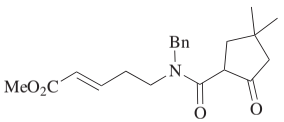
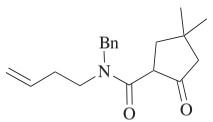
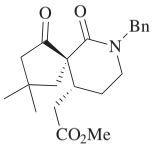
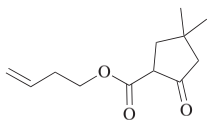
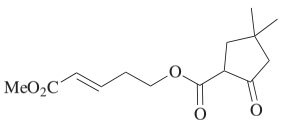
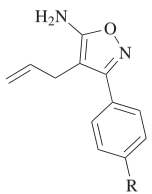
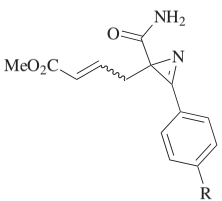
10 eq		1. Hov II (0.03 eq), toluene, reflux, overnight 2. 3N HCl, acetone, overnight		(67)	911
1 eq		Gr II (0.076 eq), DCM, 40°, 2 h		(70) (*E*) only	1097
 4 eq		Catalyst (0.05 eq), toluene, 80°, 12 h	 Catalyst (90) (*E*)/(*Z*) 71:29; Ru cat **267** (93) 73:27		1031
 3 eq		Hov II (0.05 eq), DCM, rt, 12 h		(69)	919

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 1 eq		Hov II (0.03 + 0.01 eq), DCM, 100° (MW), 0.33 + 0.17 h	 (73) (*E*)/(*Z*) = 91:9	955
1 eq		1. Hov II (0.04 eq), DCM, 100° (MW), 0.5 h 2. Dowex 550A, MeOH, 100° (MW), 0.33 h	 (68) dr > 95:5	955
1 eq		Hov II (0.03 + 0.01 eq), DCM, 100° (MW), 20 + 10 min	 (78) (*E*)/(*Z*) = 91:9	955
10 eq		Hov II (2 x 0.05 eq), DCM, rt, 48 h, green LED (36 W)	 R: H (82); F (52); Cl (70)	995

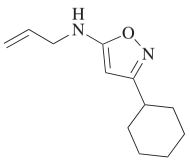
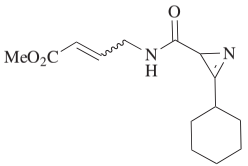
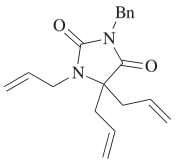
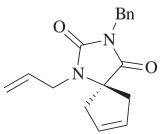
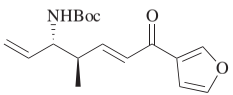
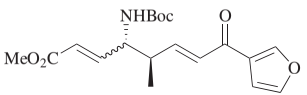
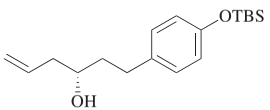
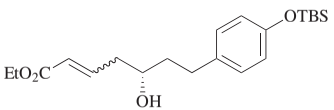
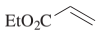
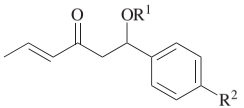
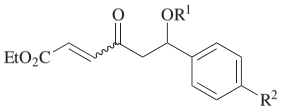
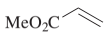
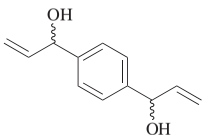
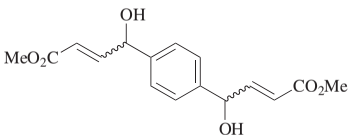
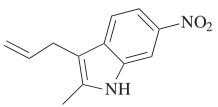
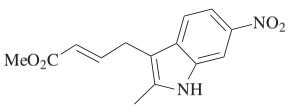
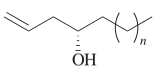
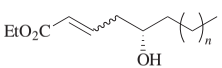
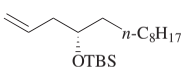
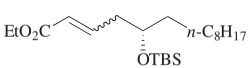
10 eq		Hov II (2 x 0.05 eq), DCM, rt, 48 h, green LED (36 W)		(59)	995
5 eq		Hov II (0.05), DCM, 45°, 24 h		(53)	1098
		Hov II (0.05 eq), toluene, 70°		(75)	1099
 3 eq		Hov II (0.05 eq) DCM, rt, 48 h		(80)	1100

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 3 eq		Hov II (0.05 eq), DCM, reflux, 18–24 h	 R^1 / R^2: H, MeO (24); H, O_2N (13); TBS, MeO (62)	1021
 20 eq		Gr II (0.1 eq), phenol (0.5 eq), toluene, 110°, 0.5 h	 (83)	1049
2 eq		Ru cat **88** (0.05 eq), DCM, 25°, 2 h	 (91) (*E*) only	171
		Gr II (0.05 eq), DCM, rt, 3 h	 *n*: 7 (94); 9 (94)	720
		Gr I (0.03 eq), DCM, rt, 1.5 h	 (92)	1101

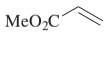
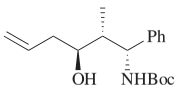
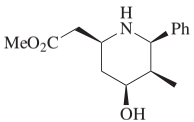
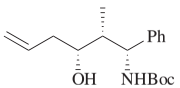
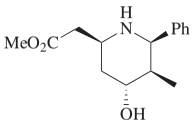
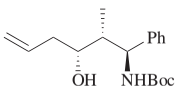
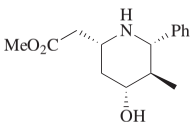
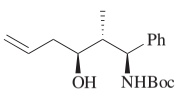
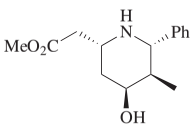
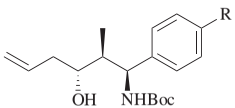
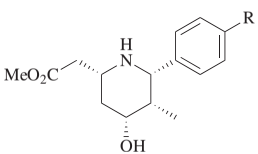
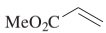
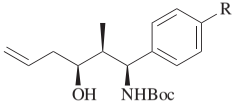
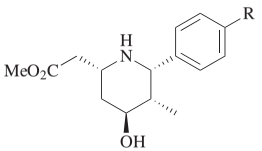
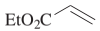
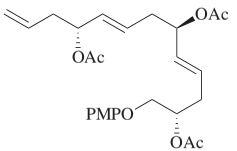
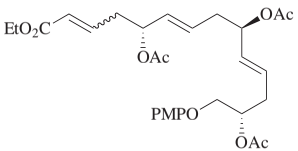
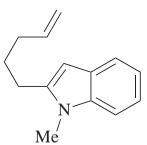
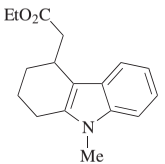
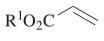
 3 eq		1. Gr II (0.05 eq), rt, 5 h 2. HCl, THF, rt, 6 h 3. aq NH_3, MeOH		(85) dr > 99:1	1102
3 eq		1. Gr II (0.05 eq), rt, 5 h 2. HCl, THF, rt, 6 h 3. aq NH_3, MeOH		(83) dr > 99:1	1102
3 eq		1. Gr II (0.05 eq), rt, 5 h 2. HCl, THF, rt, 6 h 3. aq NH_3, MeOH		(80) dr > 99:1	1102
3 eq		1. Gr II (0.05 eq), rt, 5 h 2. HCl, THF, rt, 6 h 3. aq NH_3, MeOH		(83) dr > 99:1	1102
3 eq		1. Gr II (0.05 eq), rt, 5 h 2. HCl, THF, rt, 6 h 3. aq NH_3, MeOH	 dr > 99:1	R F (75) Me (80)	1102

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

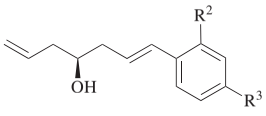
A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 3 eq		1. Gr II (0.05 eq), rt, 5 h 2. HCl, THF, rt, 6 h 3. aq NH_3, MeOH	 dr > 99:1	1102
 3 eq		Hov II (0.05 eq), DCM, 25°, 24 h	 (61) (*E*)/(*Z*) > 95:5	157
5 eq		Hov II (0.03 eq), BF_3•Et_2O (0.1 eq), DCE, reflux, 1.5 h	 (95)	950

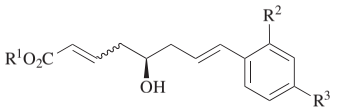
R		
F	(72)	
Me	(81)	



13 eq

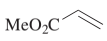


Gr II (0.05 eq)
neat, 19°, 50 min

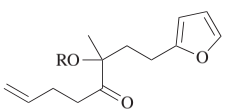


1093

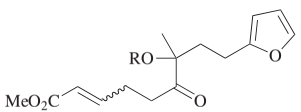
R^1	R^2	R^3		er
Me	H	H	(73)	—
Me	H	MeO	(43)	97.0:3.0
Me	O_2N	H	(73)	98.0:2.0
Me	MeO	H	(35)	—
t-Bu	H	H	(64)	—



3 eq



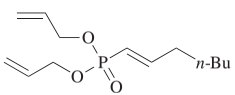
Gr II (0.05 eq),
DCM, 40°



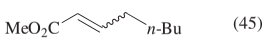
1103

R	Time (h)	
H	0.5	(87)
TMS	1	(57)

2 eq



Gr II (0.1 eq),
CuI (0.1 eq),
DCM, reflux, 16 h

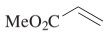
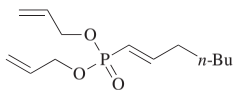
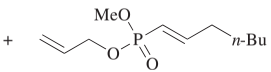
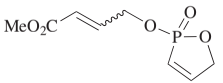
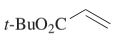
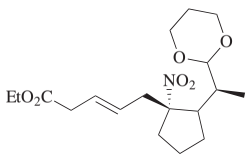
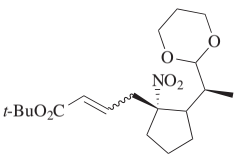
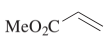
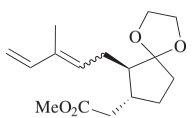
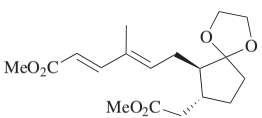


(45)

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TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 7 eq	 1 eq +  2.5 eq	Gr II (0.35 eq), CuI (0.35 eq), DCM, reflux, 16 h	 **I** +  **II**	**I** + **II** (86)	220
		Hov II (0.05 eq), DCE, reflux, 16 h		(68)	1104
 3 eq	 (*E*)/(*Z*) = 80:20	Hov II (0.05 eq), DCM, 45°, 3 h		(37) (*E*)/(*Z*) = 80:20	939

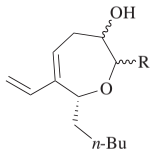
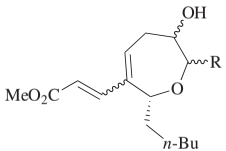
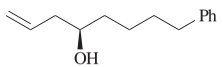
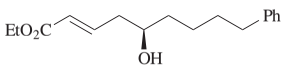
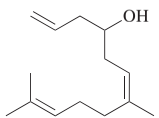
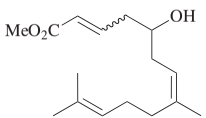
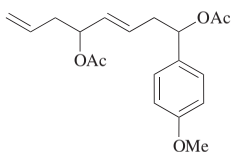
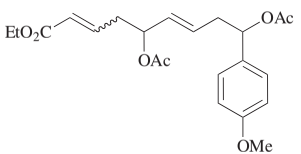
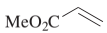
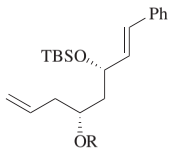
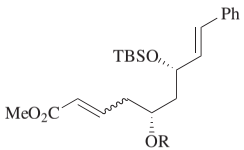
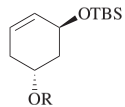
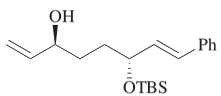
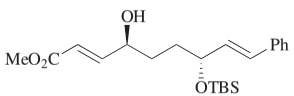
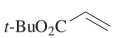
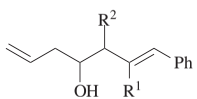
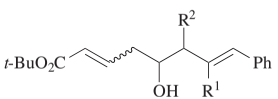
1.5 eq		Gr II (0.15 eq), DCM, reflux, 18 h		R: H, Conv. (%)[d] 100; R: MeO_2C, Conv. (%)[d] 100 — 1084
EtO_2C 1 eq		Gr II (0.05 eq), DCM, reflux, 12 h		(85) (*E*) only — 1105
MeO_2C 13 eq		Gr II (0.05 eq) neat, 19°, 50 min		(68) — 1093
EtO_2C 3 eq		Hov II (0.05 eq), DCM, rt, 16 h		(79) — 919

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

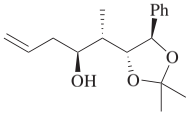
A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 *x* eq		Gr II (0.05 eq), solvent, rt, 4.5 h	 +  **I** **II**	1106
71 eq		Gr II (0.5 eq), toluene, rt, 2 h	 (90) (*E*)/(*Z*) = 95:5	1107, 1108
 13 eq		Gr II (0.05 eq), neat, 19°		1093

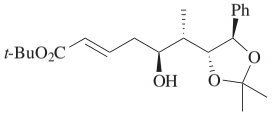
x	R	Solvent	**I**	**II**
excess	H	DCM	(77)	(7)
30	H	DCM	(82)	(7)
20	BOM	DCM	(25)	(71)
excess	BOM	toluene	(51)	(46)

R^1	R^2	Time (min)		dr
H	Me	50	(60)	~55:45
Me	H	60	(80)	96:4

5.6 eq

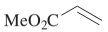


Gr II (0.04 eq),
DCM, rt, 19 h

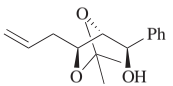


(71) (*E*) only

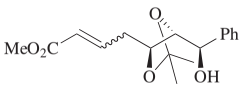
1109



8 eq



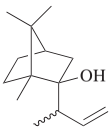
Gr II (0.05 eq),
DCM, rt, 3 h



(97)

1110

3 eq

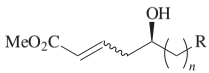


+



3 eq

1. CSA (0.1 eq), DCM, 25°
2. Gr II (0.2 eq), DCM, 4 h

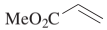
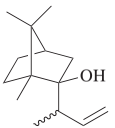
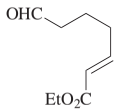
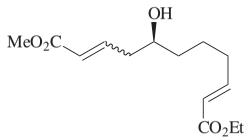
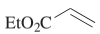
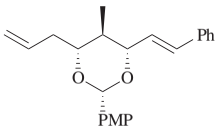
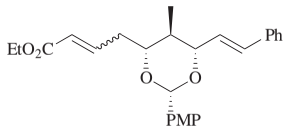


936

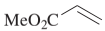
R	*n*	Time (h)		er
H	1	144	(62)	96.0:4.0
BnO	2	144	(46)	96.0:4.0
BnO	3	150	(52)	97.0:3.0
BnO	4	126	(50)	97.0:3.0
Me	7	126	(58)	97.0:3.0
Ph	2	122	(54)	97.0:3.0

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

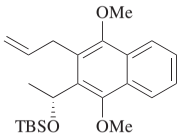
A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 3 eq	 3 eq +		1. CSA (0.1 eq), DCM, 25°, 126 h 2. Gr II (0.2 eq), DCM, 4 h	 (46) er = 98:2	936
 *x* eq		Catalyst (*y* eq), DCM		1111

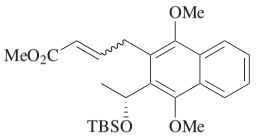
x	Catalyst	*y*	Temp (°)	Time (h)	
2	Gr II	0.05	rt	14	(61)
2	Gr II	0.05	40	3	(37)
2	Gr II	0.075	rt	14	(53)
5	Gr I	0.1	40	4	(20)
4	Gr I	0.05	40	14	(0)
10	Gr II	0.05	rt	14	(71)
20	Gr II	0.05	rt	14	(95)



5 eq



Hov II (2 x 0.05 eq),
DCM, rt,
8 h + overnight

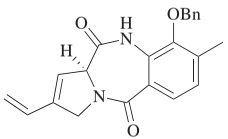


(80)

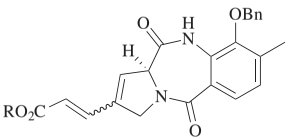
1112



x eq



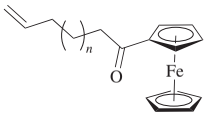
Catalyst (0.1 eq), DCM



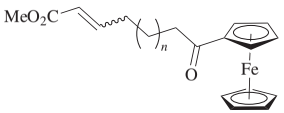
608

R	*x*	Catalyst	Temp (°)	Time (h)	
Me	10	Gr II	reflux	24	(41)
Me	10	Ru cat **112**	rt	17	(63)
Et	10,000	Ru cat **112**	rt	17	(60)

10 eq



Gr II (0.2 eq),
DCM, reflux

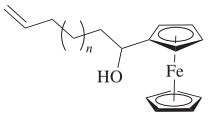


n	
1	(38)
2	(37)

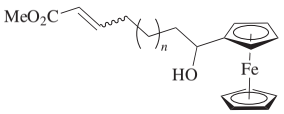
(*E*) only

587

10 eq



Gr II (0.2 eq),
DCM, reflux

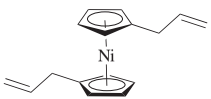


n	
1	(26)
2	(42)

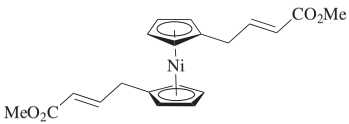
(*E*) only

587

6 eq



Gr II (0.06 eq),
DCM, reflux, 3 h

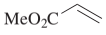
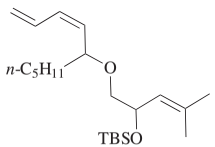
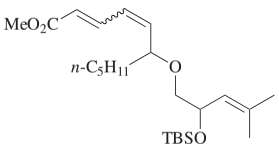
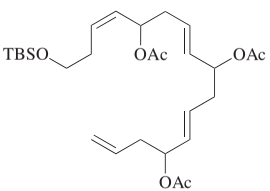
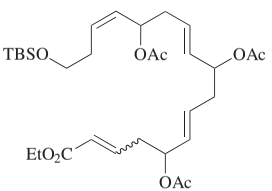
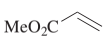
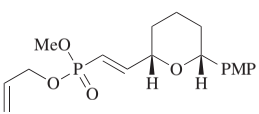
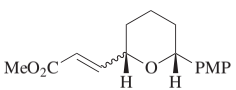
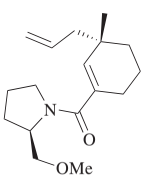
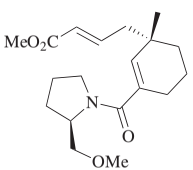


(84) (*E*) only

984

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 1.5 eq		Gr II (0.1 eq), DCM, reflux, 18 h	 (60)	1113
 3 eq		Hov II (0.05 eq), DCM, rt, 12 h	 (60)	919
 2 eq		Gr II (0.1 eq), CuI (0.1 eq), DCM, reflux, 2 h	 (73)	220
20 eq		Hov II (0.025 eq), DCM, reflux, 7 h	 (82) (*E*)/(*Z*) = 97:3	896

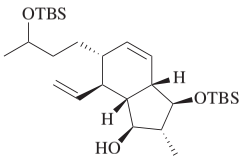
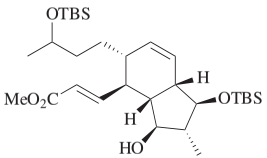
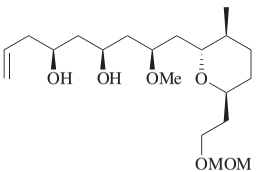
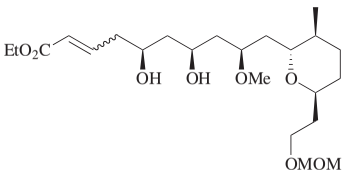
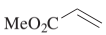
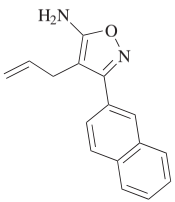
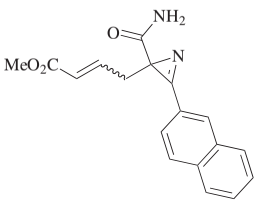
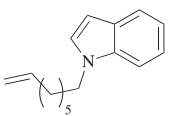
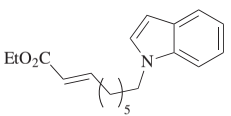
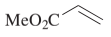
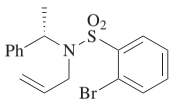
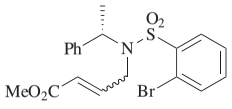
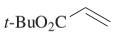
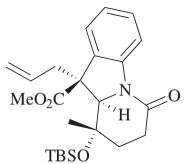
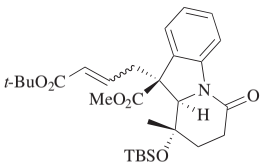
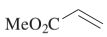
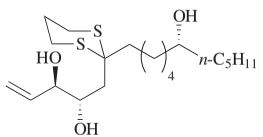
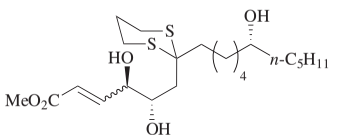
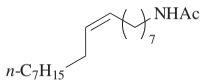
4 eq		Hov II (0.05 eq), DCM, reflux, 18 h		(80) (*E*)/(*Z*) = 84:16	1114
 6 eq		Hov II (0.05 eq), DCM, rt, 1.5 h		(89)	1115
 10 eq		Hov II (2 x 0.05 eq), DCM, rt, 48 h, green LED (36 W)		(70)	995
 3 eq		Ru cat **360** (0.01 eq), toluene, 80°, 8 h		(89) (*E*)/(*Z*) = 90:10	491

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 3 eq		Gr II (0.05 eq), DCM, 40°, 3 h	 (60)	634
 15 eq		Gr II (0.15 eq), DCM, 40°, overnight	 (89)	1116
 10 eq		Gr II (0.15 eq), DCM, reflux, 48 h	 (74)	1117

10 eq



Catalyst (x eq), solvent



I

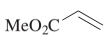
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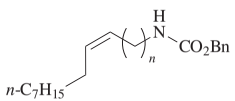
II

1118

Catalyst	x	Solvent	Temp (°)	Time (h)	**I** + **II**
Hov II	0.001	—	80	16	(12)
Hov II	0.005	—	80	16	(36)
Hov II	0.01	—	80	16	(58)
Ru cat **139**	0.005	—	80	16	(33)
Ru cat **139**	0.01	—	80	16	(48)
Hov II	0.01	DCM	40	16	(33)
Hov II	0.01	toluene	80	4	(88)
Ru cat **131**	0.01	toluene	80	4	(96)



10 eq



Hov II (0.005 eq),
50°, 16 h



n	
7	(91)
13	(90)

1079

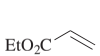
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

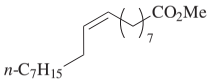
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

C_3



10 eq

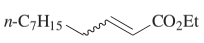


Catalyst (*x* eq),
toluene, 100°



I

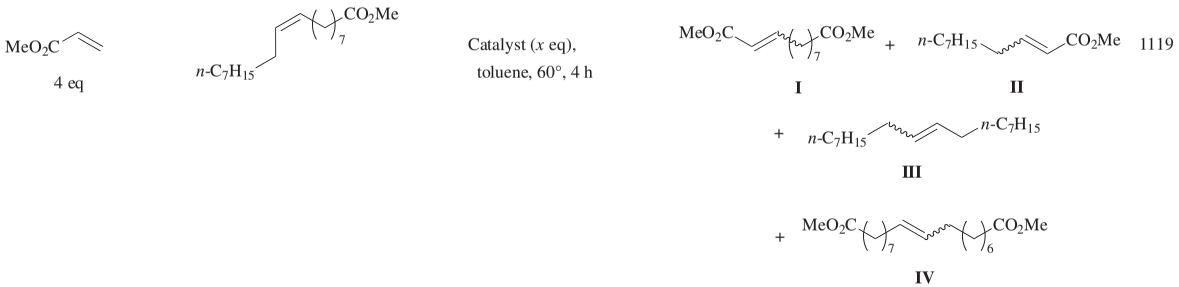
+



II

1118

Catalyst	*x*	Time (h)	**I** + **II**
Hov II	0.001	4	(55)
Hov II	0.001	16	(—)
Ru cat **139**	0.001	4	(22)
Ru cat **139**	0.001	16	(—)
Ru cat **131**	0.001	16	(58)
Hov II	0.003	0.5	(90)
Hov II	0.003	4	(92)
Ru cat **139**	0.003	4	(88)
Ru cat **131**	0.003	4	(35)
Ru cat **131**	0.003	16	(>97)



1119

Catalyst	*x*	(**I** + **II**)[d]	Selectivity (**I** + **II**)[d]	(**III** + **IV**)[d]	TON	Productive TON
Ru cat **139**	0.26	(99)	96	(4)	380	365
Ru cat **139**	0.026	(96)	92	(8)	3690	3400
Ru cat **139**	0.0026	(69)	52	(48)	26,500	13,800
Ru cat **139**	0.0003	(33)	15	(85)	127,000	19,000
Ru cat **320**	0.0029	(74)	63	(37)	260	160
Ru cat **320**	0.029	(63)	40	(60)	21,170	870
Ru cat **320**	0.0029	(58)	30	(70)	20,000	6000
Ru cat **320**	0.0003	(11)	13	(87)	36,600	4770

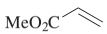
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

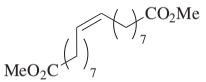
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

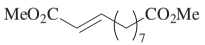
C_3



4 eq



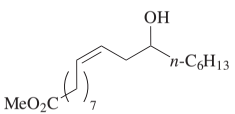
Hov II (*x* eq), toluene, 100°



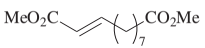
1089

x	Concn (mol/L)	Time (h)		(*E*)/(*Z*)
0.005	0.05	2	(93)	93:7
0.00025	0.05	6	(87)	90:10
0.00025	0.1	6	(90)	—
0.00025	0.5	6	(30)	90:10

4 eq

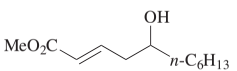


Hov II (*x* eq), toluene, 100°



I

+



II

1089

x	Time (h)	**I**	(*E*)/(*Z*) **I**	**II**	(*E*)/(*Z*) **II**
0.005	8	(89)	88:12	(85)	96:4
0.001	6	(45)	82:18	(78)	92:8

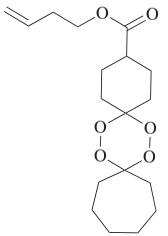
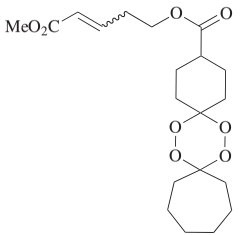
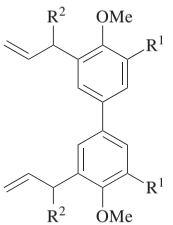
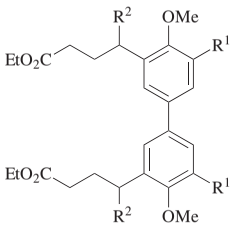
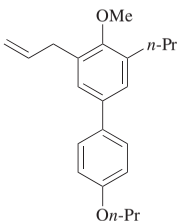
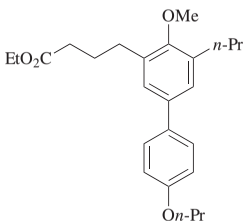
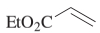
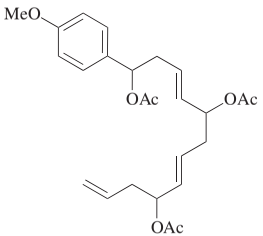
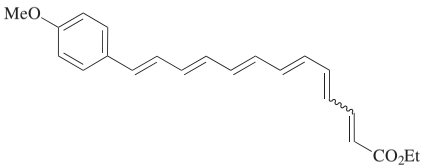
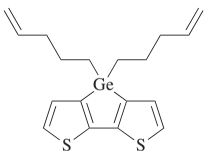
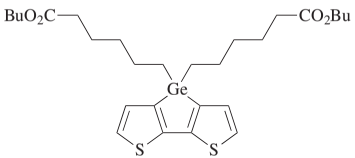
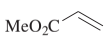
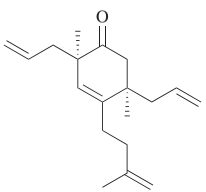
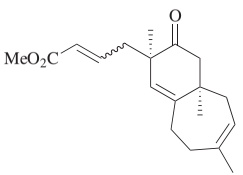
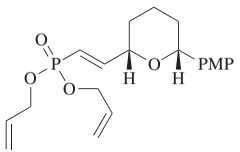
3 eq		Ru cat **88** (0.03 eq), DCM, 45°, 2 h		(89) (*E*) only	193
 4 eq		1. Gr II (0.028 eq), DCE, reflux, 10 h 2. 10 % Pd/C, H_2, AcOEt, rt, 10 h		R^1 R^2 H H (70) H Me (72) *n*-Pr H (75) *n*-Pr Me (66)	1120
4 eq		1. Gr II (0.028 eq), DCE, reflux, 10 h 2. 10 % Pd/C, H_2, AcOEt, rt, 10 h		(79)	1120

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

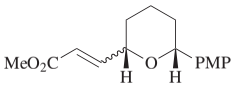
A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 3 eq		1. Hov II (0.05 eq), DCM, rt, 16 h 2. TBAF, THF, rt, 24 h	 (55)	919
 16 eq		1. Gr II (0.06 eq), DCM, reflux, 24 h 2. Wilkinson's catalyst (0.1 eq), H_2 (200 psi), toluene, 50 °, 2 d	 (81)	472
 15 eq		Ru cat **271** (0.05 eq), DCM, 30°, 4 h	 (47)	695

2 eq



Gr II (0.1 eq), CuI (0.1 eq), DCM, reflux, 2 h

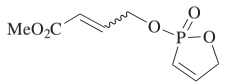


I + **II** (58)

220

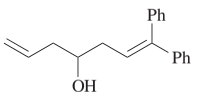
I

+

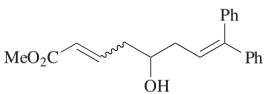


II

13 eq



Gr II (0.05 eq), neat, 19°, 50 min

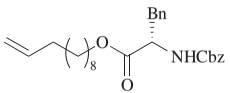


(84)

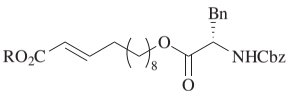
1093



x eq



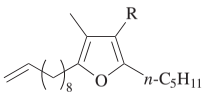
Catalyst (0.02 eq), solvent, 22°, 12 h



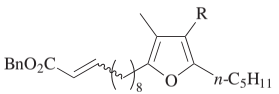
(*E*) only

R	*x*	Catalyst	Solvent		
t-Bu	2	Ru cat **109**	H_2O	(97)	341
t-Bu	1	Gr II	2.5 % aq. PTS	(96)	976
Ad	1	Gr II	2.5 % aq. PTS	(94)	976

1.3 eq



Hov II (0.02 eq), DCM, reflux, 2 h



R		
H	(89)	1121
Me	(89)	
CD_3	(87)	

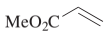
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

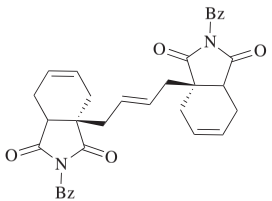
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

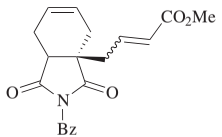
C_3



10 eq

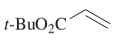


Hov II (0.05 eq), DCM, 45°, 72 h

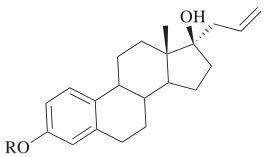


(79)

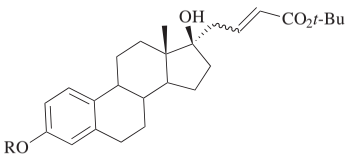
1098



3 eq

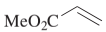


Gr II (0.01 eq), solvent, 6 h

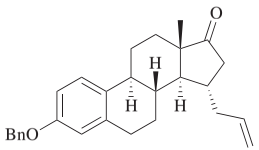


R	Solvent	Temp (°)	
H	DCM	40	(32)
n-$C_8F_{17}(CH_2)_2(i$-Pr$)_2$Si	$C_6F_5CF_3$	70	(93)

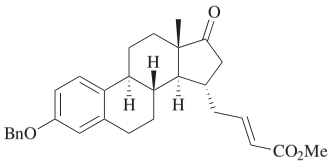
140



2 eq



Catalyst (*x* eq), solvent

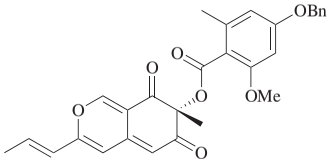
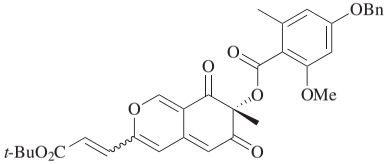


(*E*) only 163

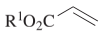
Catalyst	*x*	Solvent	Temp (°)	Time (h)	
Gr II	0.05	DCM	40	2.5	(97)
Ru cat **68**	0.05	DCE	80	5.5	(95)
Ru cat **125**	0.05	DCM	40	5.5	(95)
Hov II	0.05	DCM	40	4	(90)
Ru cat **67**	0.05	DCM	40	5.5	(34)
Gr II	0.02	DCM	40	2.5	(97)
Gr II	0.01	DCM	40	2.5	(9)
Gr II	0.005	DCM	40	2.5	(<2)
Gr II	0.0008	DCM	40	2.5	(0)
Ru cat **125**	0.02	DCM	40	8	(>99)
Ru cat **125**	0.01	DCM	40	8	(>99)
Ru cat **125**	0.005	DCM	40	8	(>99)
Ru cat **125**	0.0034	DCM	40	8	(95)
Ru cat **125**	0.0025	DCM	40	8	(72)
Ru cat **125**	0.0017	DCM	40	8	(11)
Ru cat **125**	0.0008	DCM	40	8	(3)

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

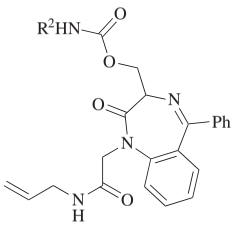
A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)		Refs.
Please refer to the charts preceding the tables for the catalyst structures.					
C_3					
t-BuO$_2$C 4 eq		Hov II (2 x 0.1 eq), DCM, reflux, 2 x 12 h		(90)	937
3 eq	HO$_2$C$_{11}$ *n*-C$_7$H$_{15}$	Catalyst (*x* eq), DCM, 40°	HO$_2$C$_{11}$ CO$_2$*t*-Bu **I** + *t*-BuO$_2$C *n*-C$_7$H$_{15}$ **II**		1040

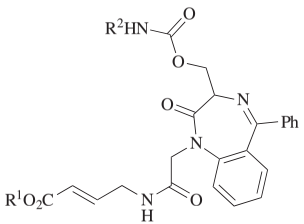
Catalyst	*x*	Time (h)	**I** + **II**
Ru cat **85**	0.025	22	(>99)
Hov II	0.025	22	(>99)
Ru cat **85**	0.005	17	(75)
Hov II	0.005	17	(81)



10 eq



Hov II (0.2 eq),
DCM, 100° (MW), 1 h



(*E*) only

987, 1122

R^1	R^2	
Me	4-Cl-2-$CF_3C_6H_3$	(99)
Et	4-Cl-2-$CF_3C_6H_3$	(99)
i-Bu	4-Cl-2-$CF_3C_6H_3$	(99)
Bn	4-Cl-2-$CF_3C_6H_3$	(99)
Et	4-$MeOC_6H_4$	(77)
i-Bu	4-$MeOC_6H_4$	(67)
Et	1-Naph	(74)
i-Bu	1-Naph	(73)
Et	*n*-Bu	(69)
i-Bu	*n*-Bu	(63)
Et	*n*-C_6H_{13}	(70)
i-Bu	*n*-C_6H_{13}	(62)

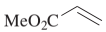
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

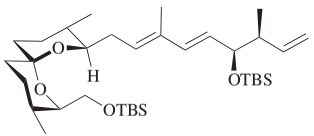
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

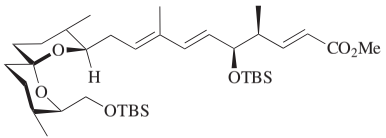
C_3



5 eq



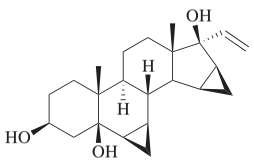
Gr II (0.1 eq), neat, 90°, 5 h



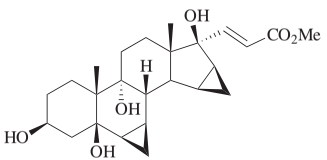
(65) (*E*) only

1123

5 eq



Catalyst (*x* eq), DCM, reflux

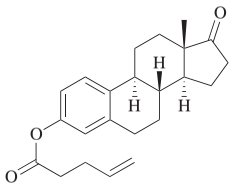


Catalyst	*x*	Time (h)		(*E*)/(*Z*)
Gr I	0.12	24	(0)	—
Gr II	0.12	24	(55)	>95:5
Hov II	0.12	3	(82)	>95:5
Hov II	0.06	3	(80)	>95:5

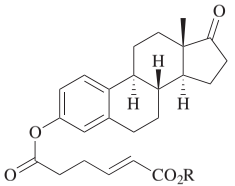
1124



x eq



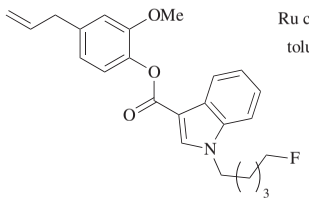
Catalyst (*y* eq), solvent



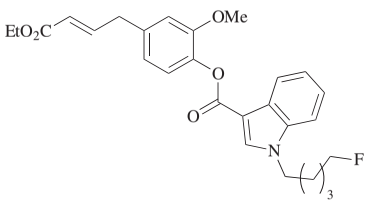
R	*x*	Catalyst	*y*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
Me	4	Ru cat **245**	0.25	toluene	80	1	(95)	95:5	1056
Me	—	Ru cat **269**	0.01	DCM	40	1	(88)	—	329
Me	—	Ru cat **270**	0.01	DCM	40	1	(84)	—	329
t-Bu	4	Ru cat **143**	0.05	H_2O	30	12	(74)	(*E*) only	588
t-Bu	3	Ru cat **139**	0.01	DCM	40	3	(95)	—	1044
t-Bu	3	Ru cat **137**	0.02	DCM	40	3	(52)	—	1044
t-Bu	2	Ru cat **107**	0.01	toluene	80	24	(91)	90:10	596



3 eq



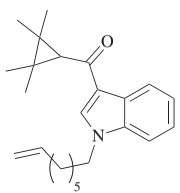
Ru cat **360** (0.01 eq), toluene, 80°, 8 h



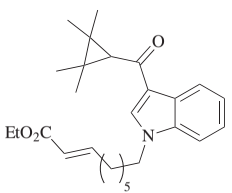
(91) (*E*)/(*Z*) = 67:33

491

3 eq



Ru cat **360** (0.01 eq), toluene, 80°, 8 h

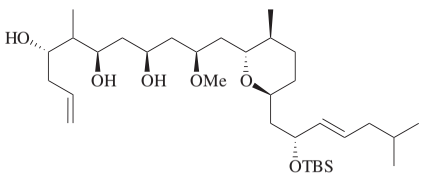
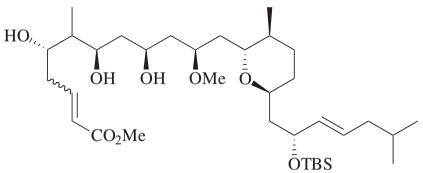
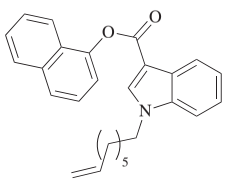
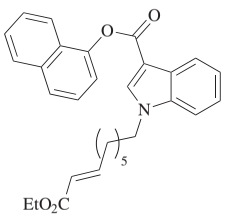
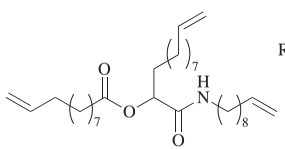
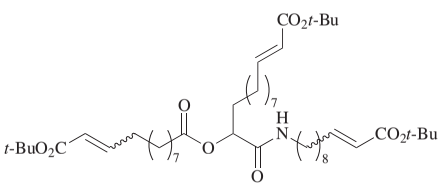


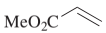
(83) (*E*)/(*Z*) = 91:9

491

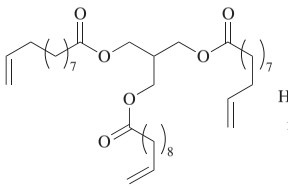
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

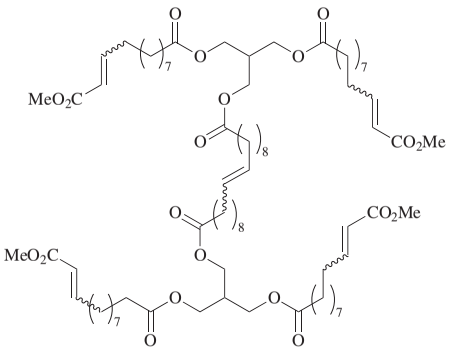
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
MeO_2C  10 eq		Hov II (0.15 eq), DCM, rt, 18 h	 (84)	1115
EtO_2C  3 eq		Ru cat **360** (0.01 eq), toluene, 80°, 8 h	 (87) (*E*)/(*Z*) = 91:9	491
t-BuO_2C 40 eq		Ru cat **89** (0.02 eq), BQ (0.06 eq), DCM, 40°, 1 h	 (88)	1125



3 eq

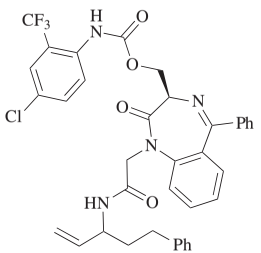


Hov II (0.015 eq), neat, 75°, 5 h



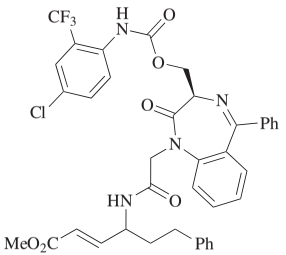
(4)

515



10 eq

Hov II (0.2 eq), DCM, 100° (MW), 1 h

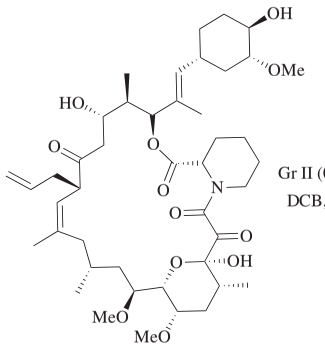
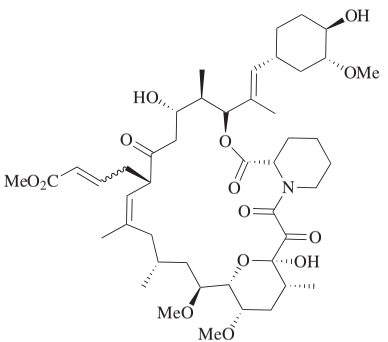
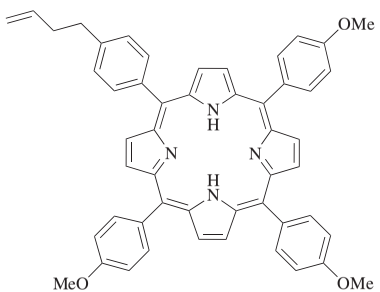
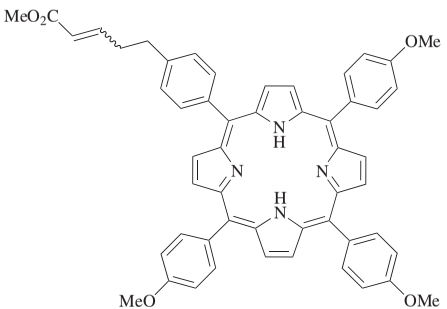


(99) (*E*) only

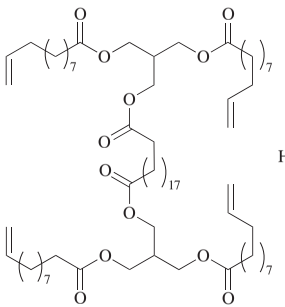
987

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

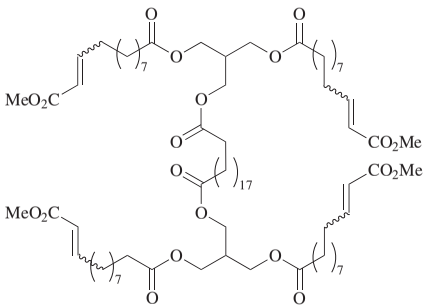
A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3		Gr II (0.1 eq), DCB, MW	 (97)	432
MeO_2C 20 eq				
4.6 eq		Gr II (0.1 eq), DCM, rt, 24 h	 (54)	1032

38 eq



Hov II (0.04 eq),
neat, 60°, 24 h



515

(51)

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

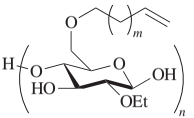
Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

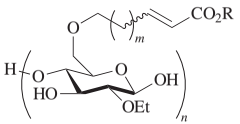
C_3



40 eq



Hov II (*x* eq), solvent

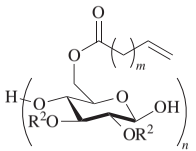


1033

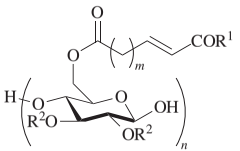
R	*m*	*x*	Solvent	Temp (°)	Time (h)	Conv. (%)[a]
Me	0	0.05	THF	37	2	47
Me	0	0.05	DCM	37	2	49
Me	0	0.1	DCM	37	2	70
Me	2	0.05	THF	37	2	35
Me	2	0.05	DMI	70	2	38
Me	2	0.05	DCM	37	2	1
Me	2	0.1	THF	37	2	51
Me	2	0.1	DCM	37	2	100
Me	4	0.1	DCM	37	2	>90
Me	8	0.05	DCM	37	2	33
Me	8	0.05	THF	37	2	29
Me	8	0.05	DMI	70	2	46
Me	8	0.05	DCM	37	12	95
Me	8	0.1	DCM	37	12	100
$HO(CH_2)_2$	2	0.1	DCM	37	2	100



20 eq

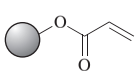


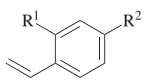
Gr II (0.05 eq),
THF, rt, 1 h



1035

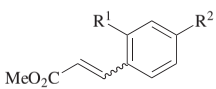
R^1	R^2	m		$(E)/(Z)$
MeO	Me	8	(94)	94:6
$MeO(CH_2CH_2O)_x$	H	2	(88)	89:11
$MeO(CH_2CH_2O)_x$	Me	8	(84)	97:3



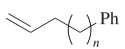


5 eq

1. Catalyst (0.05 eq),
DCM, reflux, 20 h
2. TFA (10%), DCM, 1 h
3. CH_2N_2, DCM, 0°, 0.5 h



R^1	R^2	Catalyst		
H	$ClCH_2$	Hov II	(23)	418
H	$ClCH_2$	Gr II	(11)	418
Br	H	Hov II	(16)	418, 677
Br	H	Gr II	(10)	418, 677



5 eq

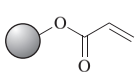
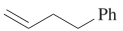
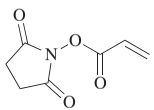
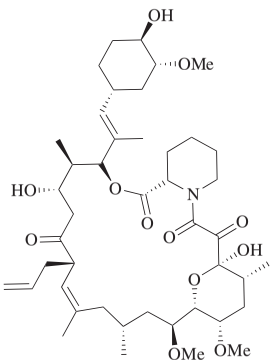
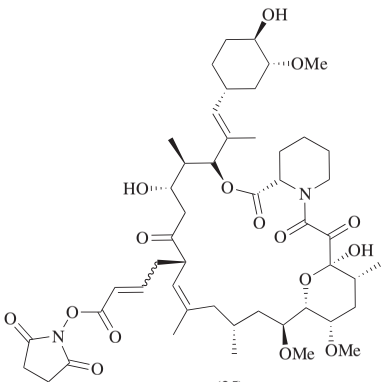
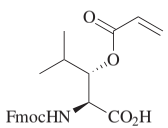
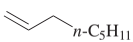
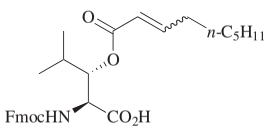
1. Catalyst (0.05 eq),
DCM, reflux, 20 h
2. TFA (10%), DCM, 1 h
3. CH_2N_2, DCM, 0°, 0.5 h

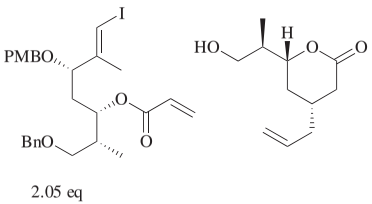


n	Catalyst		
0	Hov II	(59)	418
1	Hov II	(68)	418
0	Gr II	(35)	418, 677
1	Gr II	(26)	418, 677

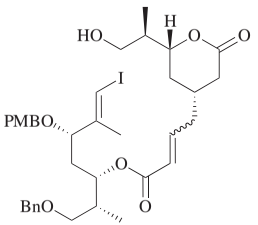
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3 	 5 eq	1. Gr II (0.05 eq), DCM, 50°, 20 h 2. Gr II (0.05 eq), Et_3SiH (5.0 eq), DCM, 150° (MW), 0.5 h 3. TFA (10%), DCM, 1 h 4. CH_2N_2, DCM, 0°, 0.5 h	 (62)	1126
 20 eq		Gr II (0.1 eq), DCB, MW (20 W)	 (25)	432
	 2.3 eq	Gr II (0.1 eq), DCM, reflux, 48 h	 (63)	372

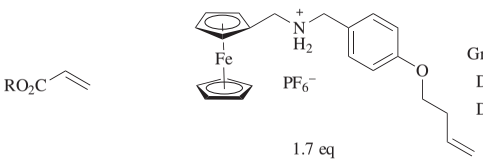


Gr II (0.1 eq),
DCE, 85°, 24 h

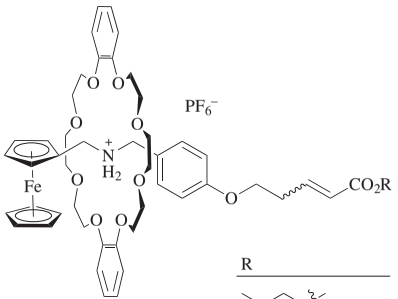


(80)

1127



Gr II (0.05 eq),
DB24C8 (1.7 eq)
DCM, reflux, 15 h

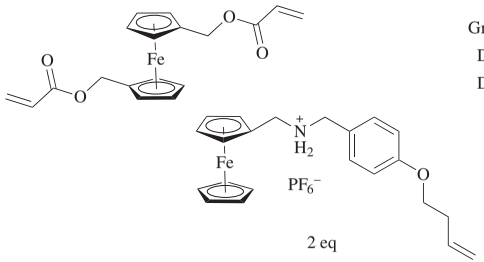
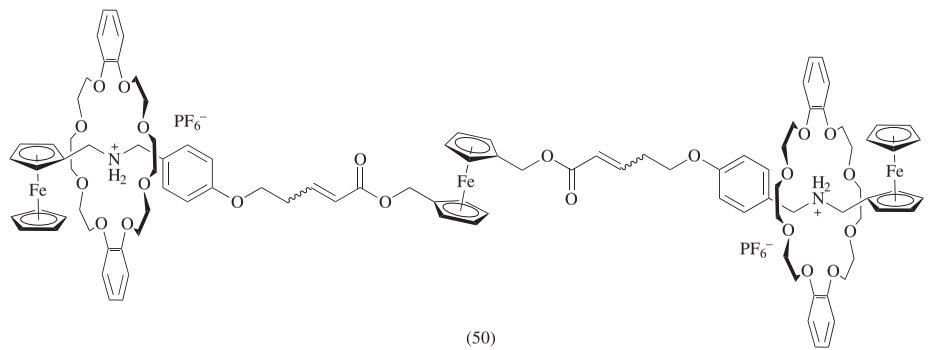


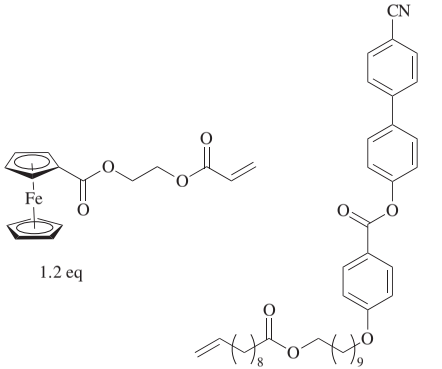
R	
	(72)
	(35)

1128,
1129

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

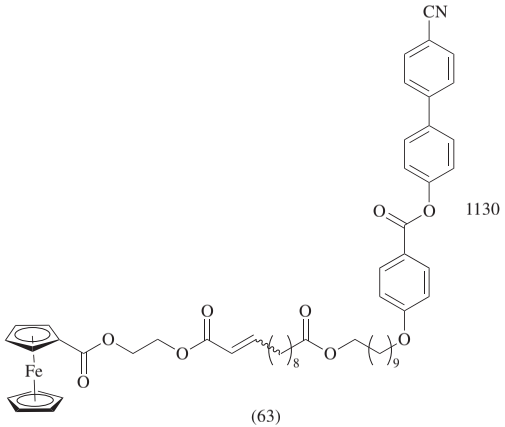
A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3		Gr II (0.1 eq), DB24C8 (2.7 eq) DCM, reflux, 15 h	 (50)	1129



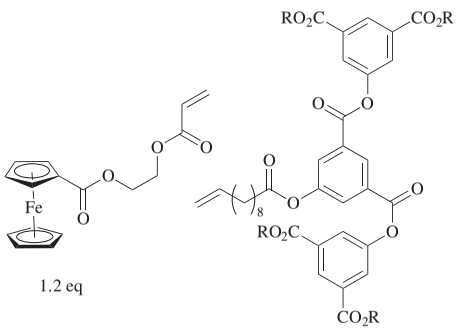
1.2 eq

Gr II (0.05 eq),
DCM, reflux, 16 h



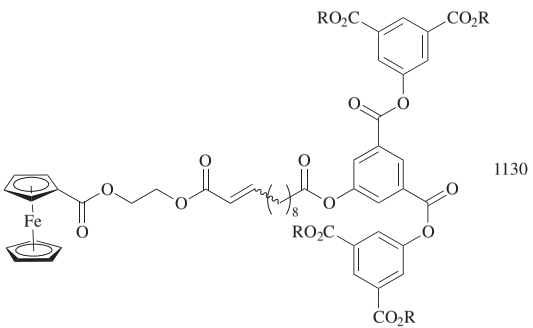
1130

(63)



1.2 eq

Gr II (0.05 eq),
DCM, reflux, 16 h



1130

(46)

R =

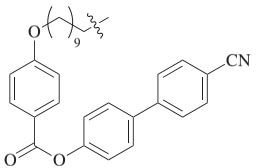
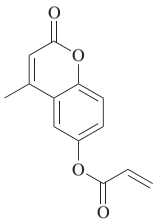
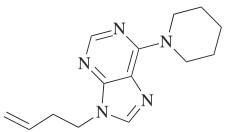
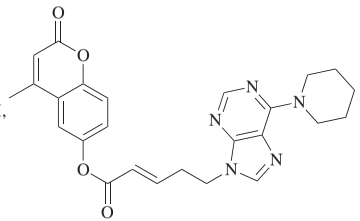
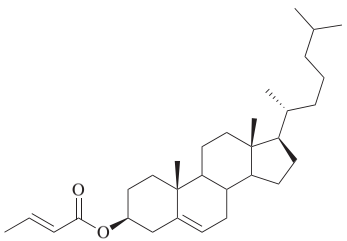
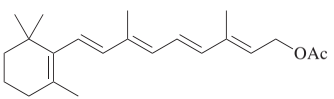
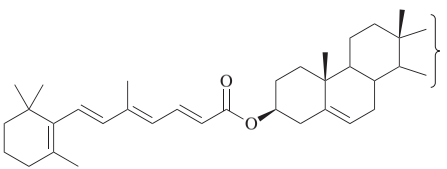
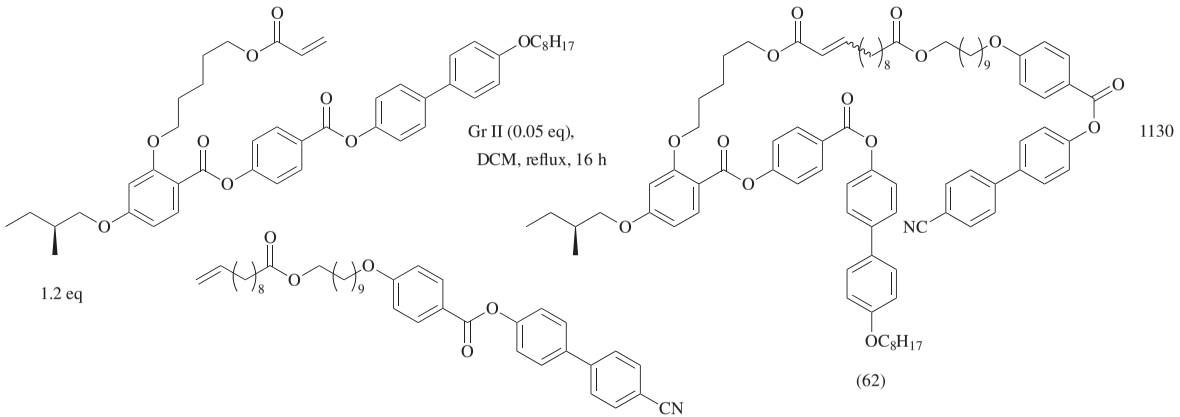


TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3		 3 eq	Gr II (0.1 + 0.04 eq), DCM, 100° (MW), 2 + 1 h	 (50) (*E*) only	499
	 4 eq		Hov II (0.15 eq), toluene, rt, 96 h	 (31) (*E*)/(*Z*) = 64:36	539


Gr II (0.05 eq),
DCM, reflux, 16 h
1.2 eq
(62)
1130

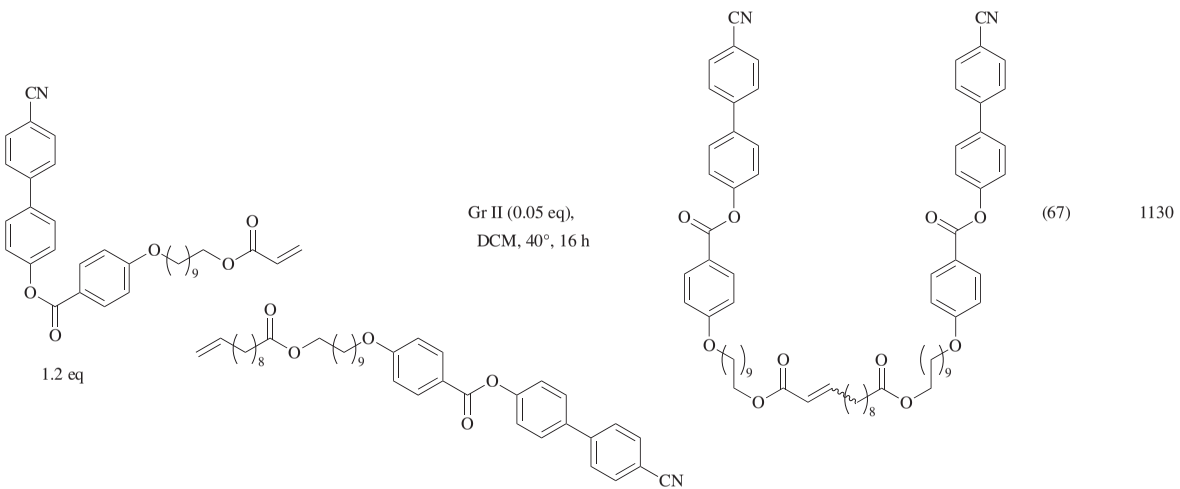

Gr II (0.05 eq),
DCM, 40°, 16 h
1.2 eq
(67)
1130

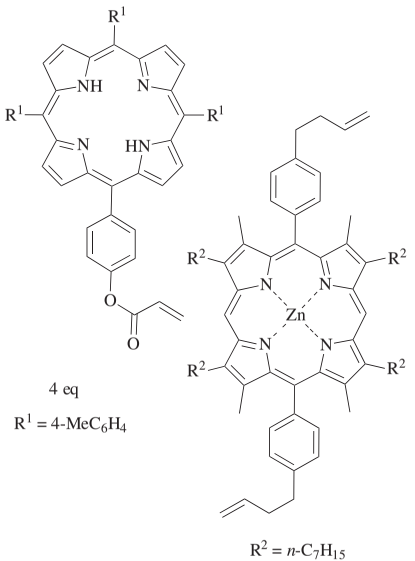
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

C_3

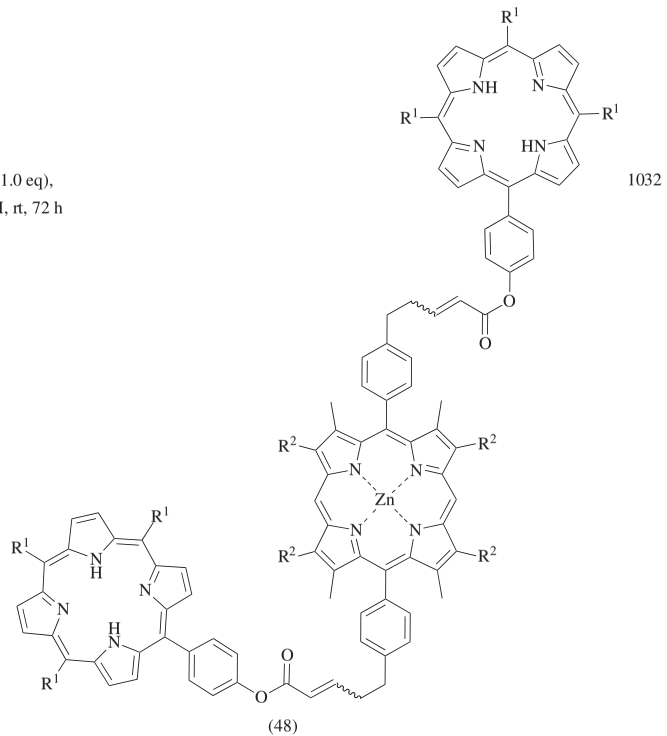


4 eq

R^1 = 4-MeC_6H_4

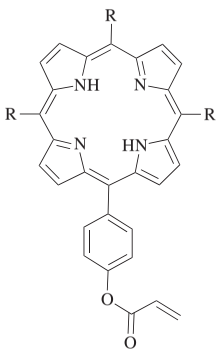
R^2 = *n*-C_7H_{15}

Gr II (1.0 eq),
DCM, rt, 72 h



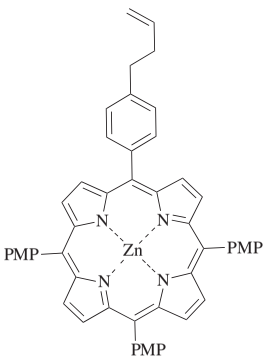
(48)

1032

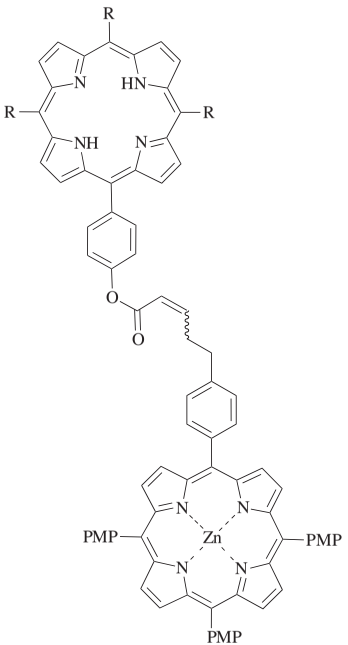


2 eq

R = 4-MeC$_6$H$_4$



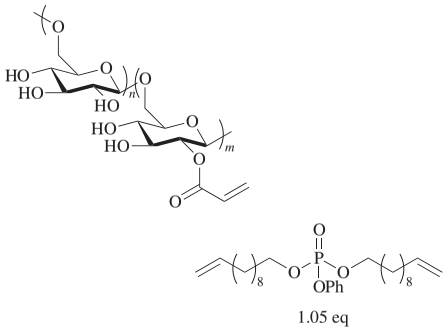
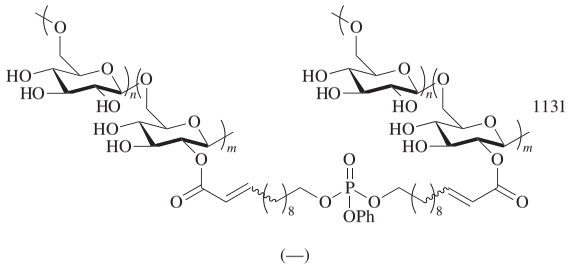
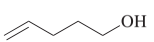
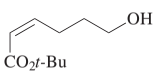
Gr II (0.2 eq),
DCM, rt, 24 h



(43) 1032

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3	 1.05 eq	Hov II (0.1 eq), toluene, 40°, 16 h	 (—)	1131
C_4				
 **I**		1. Ru cat **364** (0.01 eq), (*Z*)-2-butene (5 eq), THF, 22°, 1 h 2. Ru cat **364** (0.04 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 7 h 3. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 11 h	 (55) (*Z*)/(*E*) > 98:2	1037

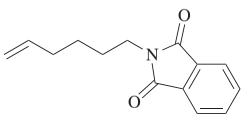
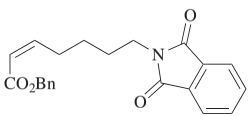
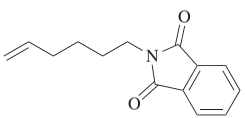
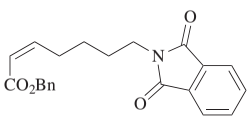
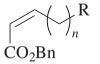
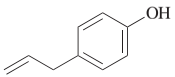
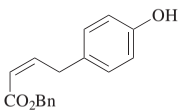
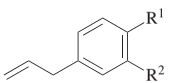
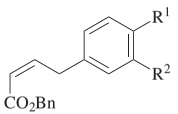
 **I**		1. Ru cat **364** (0.01 eq), (*Z*)-2-butene (5 eq), THF, 22°, 1 h 2. Ru cat **364** (0.04 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 7 h 3. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 11 h		R: HO$_2$C, Br, HO, Ph, OHC *n*: 2, 6, 7, 2, 8 (57), (63), (64), (66), (69) (*Z*)/(*E*): >98:2, 98:2, >98:2, 98:2, >98:2	1037
I		1. Ru cat **364** (0.01 eq), (*Z*)-2-butene (5 eq), THF, 22°, 1 h 2. Ru cat **364** (0.04 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 7 h 3. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 11 h		(52) (*Z*)/(*E*) = 96:4	1037
I		1. Ru cat **364** (0.01 eq), (*Z*)-2-butene (5 eq), THF, 22°, 1 h 2. Ru cat **364** (0.05 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 7 h		(45) (*Z*)/(*E*) = 98:2	1037

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 **I**		1. Ru cat **364** (0.01 eq), (*Z*)-2-butene (5 eq), THF, 22°, 1 h 2. Ru cat **364** (0.05 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 7 h	 (*Z*)/(*E*) = 98:2 R n Ph 2 (53) Br 6 (55)	1037
I		1. Ru cat **364** (0.01 eq), (*Z*)-2-butene (5 eq), THF, 22°, 1 h 2. Ru cat **364** (0.05 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 7 h	 (46) (*Z*)/(*E*) = 98:2	1037
I		1. Ru cat **364** (0.01 eq), (*Z*)-2-butene (5 eq), THF, 22°, 1 h 2. Ru cat **364** (0.04 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 7 h 3. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 11 h	 R^1 R^2 (*Z*)/(*E*) HO H (59) 98:2 MeO MeO (67) >98:2	1037

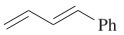
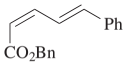
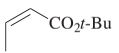
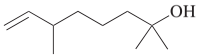
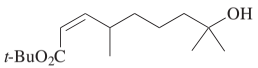
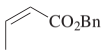
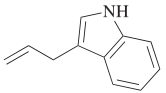
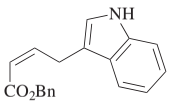
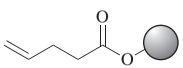
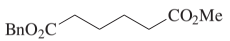
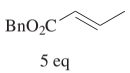
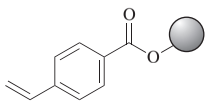
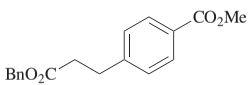
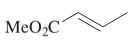
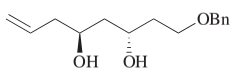
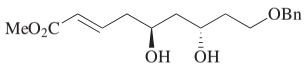
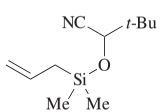
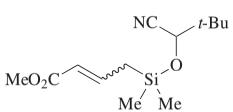
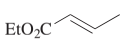
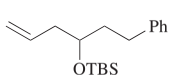
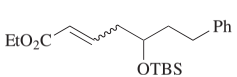
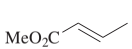
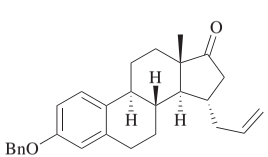
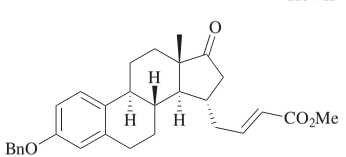
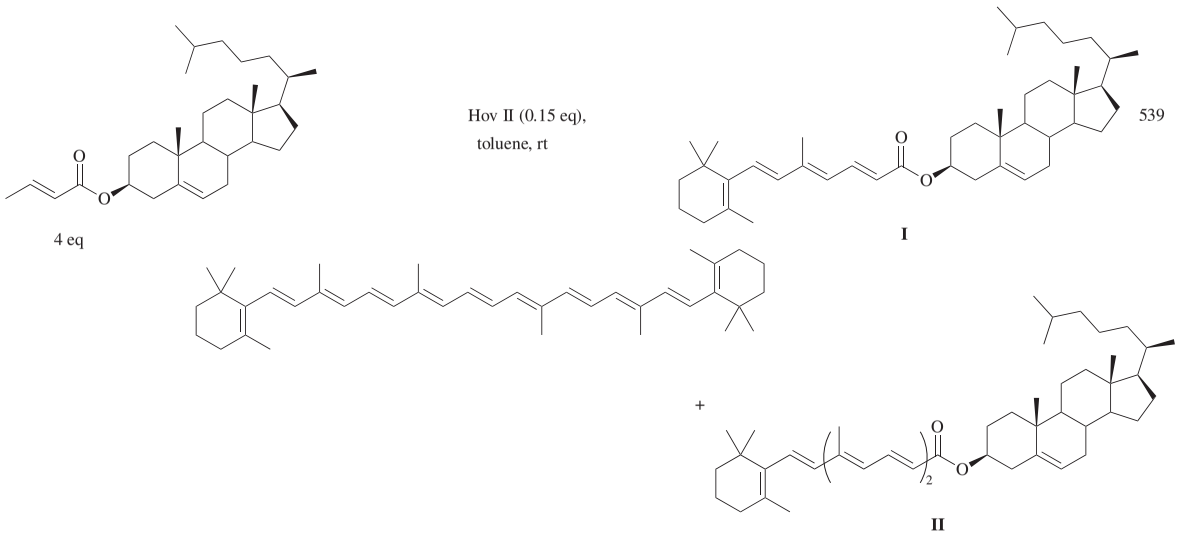
I		1. Ru cat **364** (0.01 eq), (Z)-2-butene (5 eq), THF, 22°, 1 h 2. Ru cat **364** (0.04 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 7 h 3. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 11 h		(61) (Z)/(E) = 98:2	1037
 5 eq		1. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 11 h 2. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 11 h		(76) (Z)/(E) > 98:2	1037
 **I**		1. Ru cat **364** (0.01 eq), (Z)-2-butene (5 eq), THF, 22°, 1 h 2. Ru cat **364** (0.04 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 7 h 3. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 11 h		(61) (Z)/(E) > 98:2	1037
 5 eq		1. Gr II (0.05 eq), DCM, 50°, 20 h 2. Gr II (0.05 eq), Et_3SiH (5 eq), DCM, 150° (MW), 0.5 h 3. TFA (10%), DCM, 1 h 4. CH_2N_2, DCM, 0°, 0.5 h		(93)	636

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 5 eq		1. Gr II (0.05 eq), DCM, 50°, 20 h 2. Gr II (0.05 eq), Et_3SiH (5 eq), DCM, 150° (MW), 0.5 h 3. TFA (10%), DCM, 1 h 4. CH_2N_2, DCM, 0°, 0.5 h	 (51)	636
 2.4 eq		Gr II (0.04 eq), DCM, 45°, 3 h	 (89) (*E*) only	974
5 eq		Gr II (0.1 eq), DCM, 40°, 18 h	 (44)	644
 2 eq		Catalyst (0.1 eq), DCM, reflux	 Catalyst: Gr I (8); Gr II (92); Hov II (70)	541
 2 eq		Catalyst (0.03–0.05 eq), solvent	 (*E*) only	163

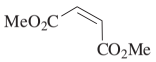
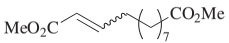
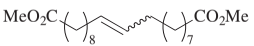
Catalyst	Solvent	Temp (°)	Time (h)	
Gr II	DCM	40	2.5	(94)
Ru cat **68**	DCE	80	5.5	(58)
Ru cat **125**	DCM	40	5.5	(73)



Time (h)	**I**	(*E*)/(*Z*) **I**	**II**	(*E*)/(*Z*) **II**
24	(9)	86:14	(30)	91:9
96	(12)	83:17	(8)	89:11

TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

A. ESTERS (*Continued*)

Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 *x* eq		Catalyst (0.01 eq), $PhSiCl_3$ (*y* eq), toluene	 **I** +  **II**	1091

x	Concn (M)	Catalyst	*y*	Temp (°)	Time (h)	Conv. (%)[b]	**I**	**II**
5	0.1	Ind II	—	80	1	44	(8)	(18)
5	0.25	Ind II	—	80	1	56	(16)	(19)
5	0.5	Ind II	—	80	1	81	(51)	(14)
5	0.75	Ind II	—	80	1	>99	(99)	(1)
5	1	Ind II	—	80	1	>99	(99)	(1)
10	1	Gr II	—	50	3	71	(32)	(13)
10	1	Ind II	—	50	3	92	(50)	(17)
10	1	Ru cat **313**	100	50	3	49	(26)	(0)
10	1	Ru cat **305**	100	50	3	>99	(99)	(0)
10	1	Ru cat **301**	100	50	3	49	(18)	(1)
10	0.1	Ind II	100	50	3	11	(3)	(7)
10	0.25	Ind II	100	50	3	34	(10)	(14)
10	0.5	Ind II	100	50	3	59	(26)	(19)
10	0.75	Ind II	100	50	3	80	(50)	(19)
10	1.5	Ind II	100	50	3	96	(70)	(14)
10	2	Ind II	100	50	3	>99	(99)	(2)

[a] The conversion was determined by ^1H NMR analysis.

[b] The conversion was determined by GC analysis.

[c] The conversion was determined by TLC analysis.

[d] The yield and selectivity were determined by GC analysis.

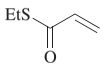
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

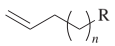
B. THIOESTERS

Thioester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

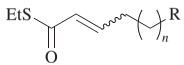
C_3





2.5 eq

Catalyst (*x* eq), DCM

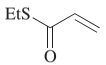
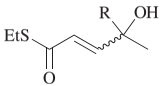
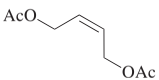
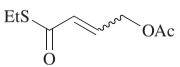
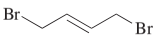
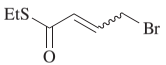


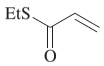
1132

R	*n*	Catalyst	*x*	Temp (°)	Time (h)	
TMS	0	Hov II	0.02	45	2	(92)
TsHN	0	Hov II	2 x 0.02	45	24	(59)
OHC	1	Hov II	2 x 0.02	45	24	(75)
HO_2C	1	Hov II	2 x 0.02	45	24	(83)
MeO_2C	1	Hov II	0.02	45	4	(91)
AcO	2	Hov II	0.02	45	4	(86)
HO	3	Hov II	2 x 0.02	45	24	(93)
Br	3	Hov II	2 x 0.02	45	24	(75)
Me	4	Gr I	0.02	rt	20	(0)
Me	4	Hov I	0.02	rt	20	(0)
Me	4	Gr II	0.02	rt	20	(76)
Me	4	Hov II	0.02	rt	20	(93)
Me	4	Ru cat **88**	0.02	rt	20	(72)
Me	4	Hov II	0.02	reflux	1	(94)
Me	4	Hov II	0.01	reflux	2	(94)
Me	4	Hov II	0.02	reflux	24	(42)

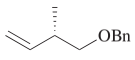
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

B. THIOESTERS (*Continued*)

Thioester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
	 2.5 eq	Hov II (2 x 0.02 eq), DCM, 45°, 24 h	 R: H (66); Me (71)	1132
	 2.5 eq	Hov II (2 x 0.02 eq), DCM, 45°, 24 h	 (65)	1132
	 1.5 eq	Hov II (2 x 0.02 eq), DCM, 45°, 24 h	 (64)	1132

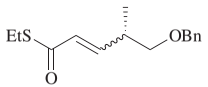


2 eq



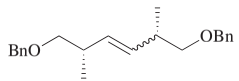
er 97.0:3.0

Hov II (0.1 eq),
DCM, reflux, 6 h



(83)

\+



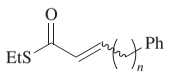
(5)

975



2.5 eq

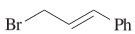
Hov II (0.02 eq),
DCM, 45°



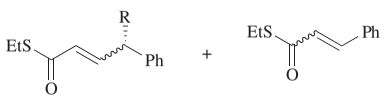
n	Time (h)	
0	18	(72)
1	1	(95)

1132

2 eq



1. RMgBr (1.2 eq),
(*R*,*R*)-Taniaphos (0.012 eq),
CuBr•SMe_2 (0.01 eq),
DCM, –75°
2. Hov II (2 x 0.05 eq), DCM, rt



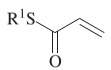
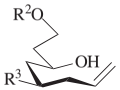
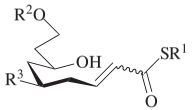
I er = 98.5:1.5 **II**

R	**I**	**I/II**
Me	(74)	>97:3
Et	(67)	80:20

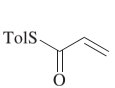
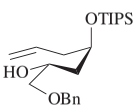
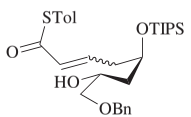
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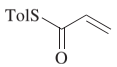
TABLE 20. CROSS-METATHESIS OF α,β-UNSATURATED ESTERS AND THIOESTERS (*Continued*)

B. THIOESTERS (*Continued*)

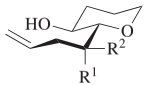
Thioester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 3 eq		Hov II (0.1 eq), DCM, 35°, 18 h		1134

R^1	R^2	R^3	
Et	MPM	H	(93)
Ph	MPM	H	(94)
4-MeC_6H_4	MPM	H	(92)
4-$MeOC_6H_4$	MPM	H	(82)
4-$O_2NC_6H_4$	MPM	H	(94)
1-Naph	MPM	H	(87)
Tol	TBS	H	(90)
Tol	TBS	TIPSO	(84)

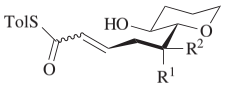
 3 eq		Hov II (0.1 eq), DCM, 35°, 18 h		(82)	1134



3 eq



Hov II (0.1 eq),
DCM, 35°, 18 h

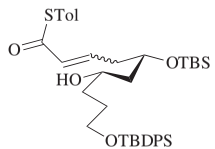


R^1	R^2		
H	H	(93)	1134
H	HO	(94)	
HO	H	(82)	

3 eq



Hov II (0.1 eq),
DCM, 35°, 18 h



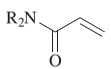
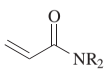
(79) 1134

TABLE 21. CROSS-METATHESIS OF α,β-UNSATURATED AMIDES

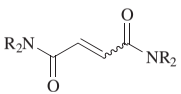
Amide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

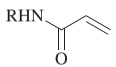
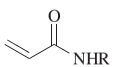
C_3

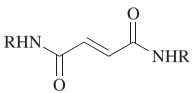
Hov II (*x* eq), DCM, 100° (MW), 15 min



R	*x*		Refs.
H	0.05	(87)	165
H	0.025	(80)	
H	0.005	(63)	
Me	0.05	(<5)	

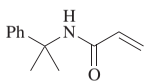
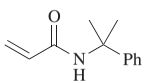



Catalyst (0.025 eq), DCM, 40°, 4 h

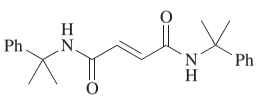


1135

R	Catalyst		(*E*)/(*Z*)
t-Bu	Ru cat **35**	(<10)	—
n-C_6H_{13}	Ru cat **35**	(96)	(*E*) only
Bn	Gr I	(15)	(*E*) only
Bn	Ru cat **35**	(98)	(*E*) only
n-C_8H_{17}	Ru cat **35**	(93)	(*E*) only

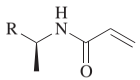



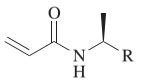
Ru cat **35** (0.025 eq), DCM, 40°, 4 h



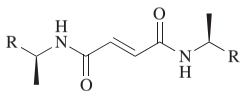
(94) (*E*) only

1135





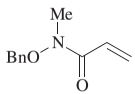
Ru cat **35** (*x* eq),
DCM, 40°, 4 h



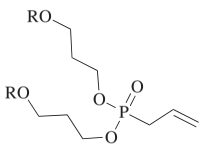
(*E*) only

1135

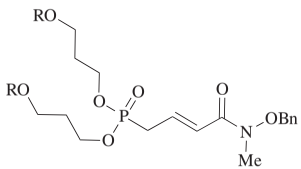
R	*x*	
Ph	0.025	(95)
Ph	0.000375	(94)
1-Naph	0.025	(95)



4 eq



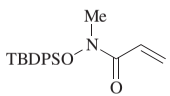
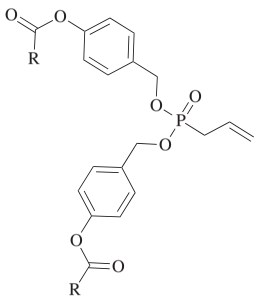
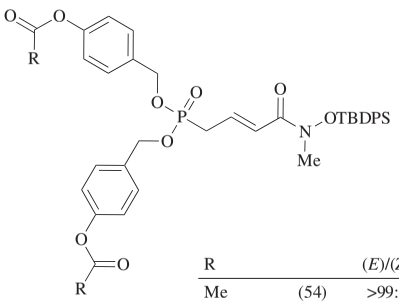
Hov II (0.05 eq),
toluene, 70°, overnight



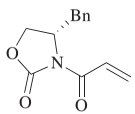
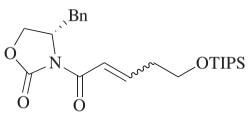
1136

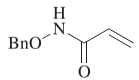
R		(*E*)/(*Z*)
n-C_4H_9	(67)	>99:1
n-C_8H_{17}	(76)	>99:1
n-$C_{12}H_{25}$	(59)	>99:1
n-$C_{16}H_{33}$	(55)	>99:1

TABLE 21. CROSS-METATHESIS OF α,β-UNSATURATED AMIDES (*Continued*)

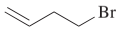
Amide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 4 eq		Hov II (0.05 eq), toluene, 70°, overnight		1136

R		(*E*)/(*Z*)
Me	(54)	>99:1
i-Pr	(54)	>99:1
t-Bu	(60)	>99:1
Ph	(51)	>99:1
n-C_8H_{17}	(64)	>99:1

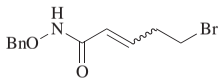
 1.3 eq		Gr II (0.1 eq), DCM, 40°, 24 h		(59)	268



2 eq



Gr II (0.02 eq), DCM, reflux, 3 h



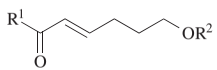
(72) 1133



x eq

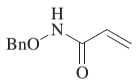
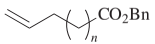
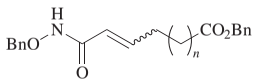
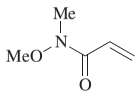
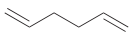
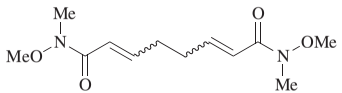
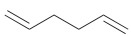
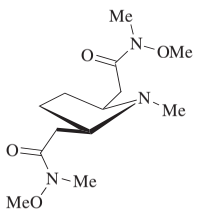


Catalyst (0.05 eq), solvent

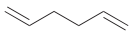


R^1	*x*	R^2	Catalyst	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
Me_2N	0.5	Bz	Hov II	DCM	40	—	(>98)	>95:5	1135
Me_2N	0.5	Bz	Ru cat **243**	DCM	45	12	(40)	95:5	923
Me_2N	0.5	Bz	Ru cat **191**	DCM	45	12	(42)	95:5	923
i-PrHN	0.5	Bz	Ru cat **243**	DCM	45	12	(96)	95:5	923
i-PrHN	0.5	Bz	Ru cat **191**	DCM	45	12	(0)	—	924
Me_2N	—	Bz	Ru cat **185**	BMI•PF_6/toluene	rt	6	(0)	—	924
H_2N	1.5	TBS	Hov II	DCM	rt	16	(71)	—	174
MeHN	1.5	TBS	Hov II	DCM	rt	16	(11)	—	174
Me_2N	1.5	TBS	Hov II	DCM	rt	16	(tr)	—	174

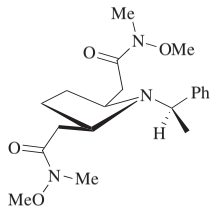
TABLE 21. CROSS-METATHESIS OF α,β-UNSATURATED AMIDES (*Continued*)

Amide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 2 eq		Gr II (0.02 eq), DCM, reflux, 3 h		1133
			n 1 (79) 2 (73) 3 (70)	
 3 eq		Catalyst (2 x 0.025 eq), $CDCl_3$, 100° (MW), 3 h		926
			Catalyst — Conv. (%): Gr II 72; Hov II 100; Ind II 100; Ru cat **93** 87; Ru cat **170** 94; Ru cat **172** 100	
3 eq		1. Ind II (2 x 0.025 eq), $CDCl_3$, 100° (MW), 2 h 2. CH_3NH_2 (3 eq), THF, 100° (MW), 2 h	 (65)	926

3 eq



1. Ind II (2 x 0.025 eq), $CDCl_3$, 100° (MW), 2 h
2. (1*R*)-phenylethylamine (3 eq), THF, 100° (MW), 2 h

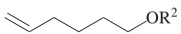


(67)

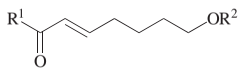
926



1.25 eq



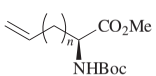
Gr II (0.05 eq), DCM, 40°, 15 h



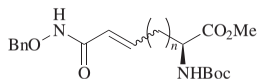
166

R^1	R^2		(*E*)/(*Z*)
H_2N	Ac	(89)	(*E*) only
i-PrHN	THP	(80)	(*E*) only
(MeO)MeN	THP	(89)	98:2
PhHN	THP	(90)	(*E*) only
PhMeN	THP	(97)	97:3
Ph_2N	THP	(87)	98:2

2 eq



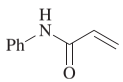
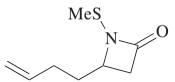
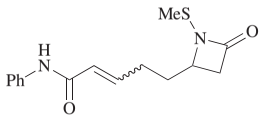
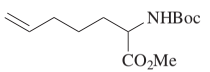
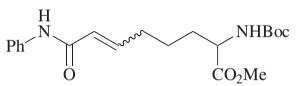
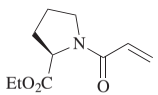
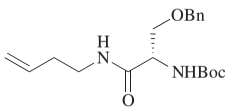
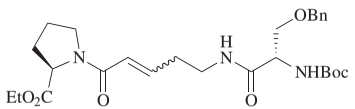
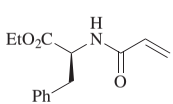
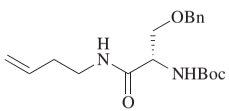
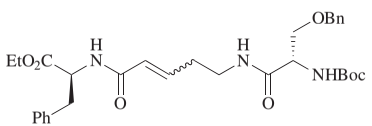
Gr II (0.02 eq), DCM, reflux, 3 h



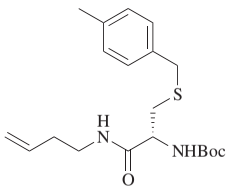
n	
2	(78)
3	(78)

1133

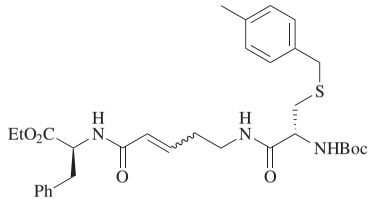
TABLE 21. CROSS-METATHESIS OF α,β-UNSATURATED AMIDES (*Continued*)

Amide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 2 eq		Gr II (0.05 eq), DCM, 40°, 14 h	 (51)	422
1.5 eq		Gr II (0.025 eq) DCM, reflux, 2 h	 (88)	1067
 1.2 eq		Gr II (0.19 eq), DCM, 80° (MW), 2 h	 (50)	1137
 1.1 eq		Gr II (0.19 eq), DCM, 90° (MW), 0.5 h	 (73)	1137

1.3 eq



Gr II (0.19 eq),
DMF (3 drops), DCM,
90° (MW), 0.5 h



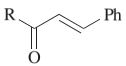
(51) 1137





x eq

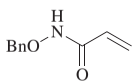
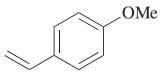
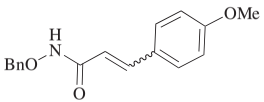
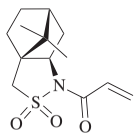
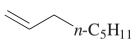
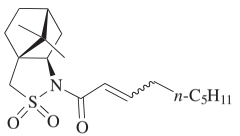
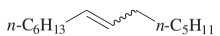
Catalyst (0.05 eq),
DCM



(*E*) only

R	*x*	Catalyst	Temp (°)	Time (h)		
Me_2N	2.5	Gr II	100 (MW)	0.5	(30)	971
Me_2N	2.5	Hov II	100 (MW)	0.5	(65)	971
Me_2N	2.5	Ru cat **86**	100 (MW)	0.5	(45)	971
Me_2N	1.9	Gr II	40	15	(25)	166
Cy_2N	1.9	Gr II	40	15	(57)	166
i-PrHN	1.9	Gr II	40	15	(62)	166
(MeO)MeN	1.9	Gr II	40	15	(66)	166
H_2N	1.9	Gr II	40	15	(69)	166
PhHN	1.9	Gr II	40	15	(69)	166
MePhN	1.9	Gr II	40	15	(83)	166
Ph_2N	1.9	Gr II	40	15	(87)	166
	1.9	Gr II	40	15	(40)	166

TABLE 21. CROSS-METATHESIS OF α,β-UNSATURATED AMIDES (*Continued*)

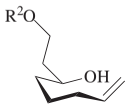
Amide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 2 eq		Gr II (0.02 eq), DCM, reflux, 3 h	 (57)	1133
	 1.2 eq	Catalyst (0.025 eq), EtOAc, reflux	 **I** +  **II**	1138

Catalyst	Time (h)	**I**	**I/II**
Gr I	24	(0)	**II** only
Gr II	24	(28)	26:74
Hov I	24	(0)	**II** only
Hov II	12	(89)	91:9
Ru cat **86**	10	(90)	91:9

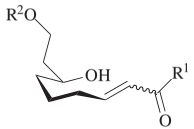
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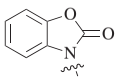
3 eq



Hov II (0.1 eq),
DCM, 35°

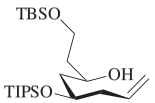
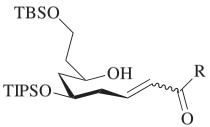
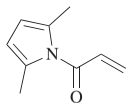
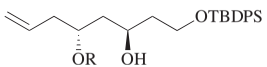
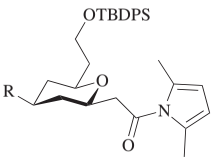


1134

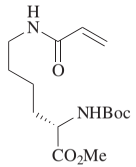
R^1	R^2	Time (h)	
	TBS	25	(96)
	TBS	6.5	(62)
	TBS	26	(86)
	TBS	40	(91)
	TBS	25	(85)

R^1	R^2	Time (h)	
	TBS	25	(76)
	TBS	24	(76)
	MPM	18	(84)
	MPM	18	(66)

TABLE 21. CROSS-METATHESIS OF α,β-UNSATURATED AMIDES (*Continued*)

Amide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 3 eq		Hov II (0.1 eq), DCM, 35°, 18 h	 R:  (81);  (70)	1134
 3–10 eq		Hov II (0.1 eq), additive (0.03–0.1 eq), solvent		947

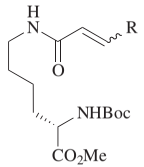
R	Additive	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)
H	—	toluene	80–100	11–24	(36)	88:12
H	CSA	DCM	25–35	—	(72)	>95:5
TIPS	—	DCM	100 (MW)	0.5	(23)	75:25
TIPS	—	toluene	80–100	11–24	(10)	91:9
TIPS	CSA	DCM	25–35	—	(73)	>95:5

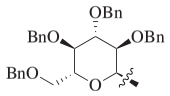


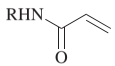


3 eq

Gr II (0.2 eq),
DCM, 40°, 6 h



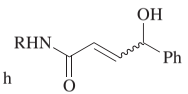
R		
$MeO_2C(CH_2)_8$	(69)	429
	(55)	



2.5 eq

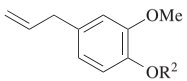


Ru cat **353** (0.06 eq),
DCM, hν (350 nm), 3.5 h



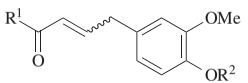
R		
H	(55)	911
i-Pr	(57)	





x eq

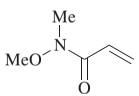
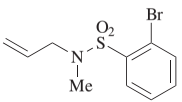
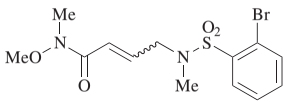
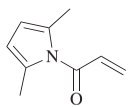
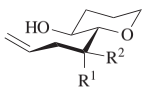
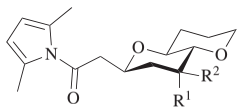
Hov II (0.02 eq),
BQ (0.05 eq),
DCM, 80°



1074

R^1	R^2	*x*	Time (h)	
H_2N	H	1	4	(40)
H_2N	H	1	4	(60)
H_2N	Ac	1.25	17	(65)
H_2N	*i*-Pr	1.25	17	(57)
i-PrHN	H	1.25	17	(70)
i-PrHN	Ac	1.25	5	(53)
i-PrHN	*i*-Pr	1.25	17	(53)

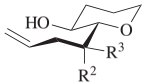
TABLE 21. CROSS-METATHESIS OF α,β-UNSATURATED AMIDES (*Continued*)

Amide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 3 eq		Gr II (0.05 eq), DCM, 40°	 (43)	634
 3–10 eq		Hov II (0.1 eq), additive (0.03–0.1 eq), solvent		947

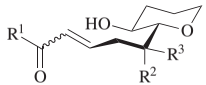
R^1	R^2	Additive	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)
H	HO	—	toluene	80–100	11–24	(71)	88:12
H	HO	CSA	DCM	25–35	—	(63)	>95:5
HO	H	—	toluene	80–100	11–24	(52)	>95:5
HO	H	CSA	DCM	25–35	—	(56)	>95:5



3 eq



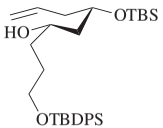
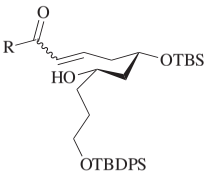
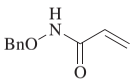
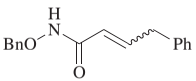
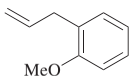
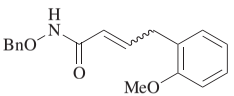
Hov II (0.1 eq),
DCM, 35°, 18 h

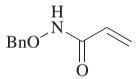


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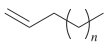
R^1	R^2	R^3	
	H	HO	(85)
	H	HO	(71)
	HO	H	(81)
	HO	H	(64)
	H	H	(68)

TABLE 21. CROSS-METATHESIS OF α,β-UNSATURATED AMIDES (*Continued*)

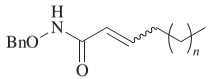
Amide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 3 eq		Hov II (0.1 eq), DCM, 35°, 18 h	 R =  (85);  (68)	1134
 2 eq		Gr II (0.02 eq), DCM, reflux, 3 h	 (77)	1133
2 eq		Gr II (0.02 eq), DCM, reflux, 3 h	 (72)	1133



2 eq



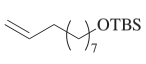
Gr II (0.02 eq),
DCM, reflux, 3 h



n	
6	(81)
8	(85)

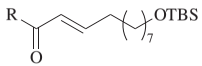
1133





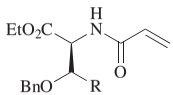
x eq

Ru cat **35** (*y* eq),
DCM, rt, 12 h

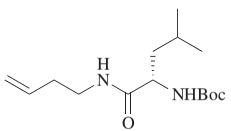


166

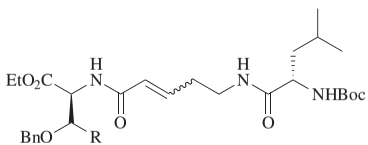
R	*x*	*y*		(*E*)/(*Z*)
Me_2N	1.25	0.05	(39)	96:4
Me_2N	1.5	0.1	(83)	96:4
$(n\text{-}C_6H_{13})_2N$	1.25	0.05	(77)	—
	1.25	0.05	(87)	98:2



1.1 eq



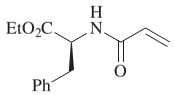
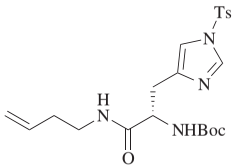
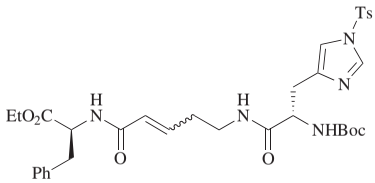
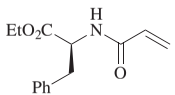
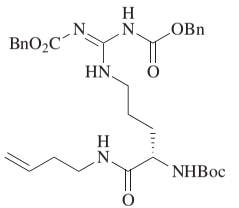
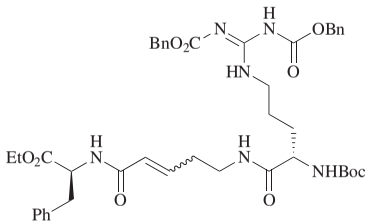
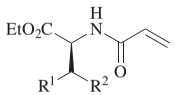
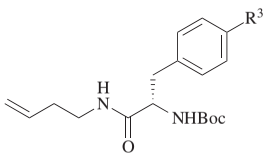
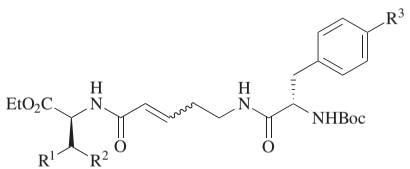
Gr II (0.19 eq),
DCM,
90° (MW), 0.5 h



R	
H	(75)
Me	(61)

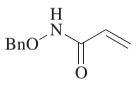
1137

TABLE 21. CROSS-METATHESIS OF α,β-UNSATURATED AMIDES (*Continued*)

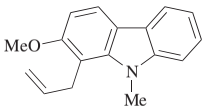
Amide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
	 1.3 eq	Gr II (0.19 eq), DMF (3 drops), DCM, 90° (MW), 0.5 h	 (41)	1137
 1.1 eq		Gr II (0.19 eq), DCM	 (see table below)	1137
 *x* eq		Gr II (0.19 eq), DCM, 80° (MW), 2 h	 (see table below)	1137

Temp (°)	Time (h)	
reflux	96	(70)
90 (MW)	—	(43)

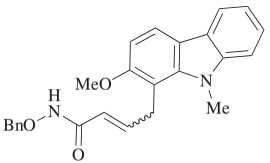
R^1	R^2	R^3	*x*	
H	Ph	H	1.3	(86)
H	Ph	BnO	1.3	(82)
Me	Me	H	1.1	(34)



2 eq



Gr II (0.02 eq),
DCM, reflux, 3 h

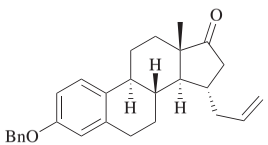


(78)

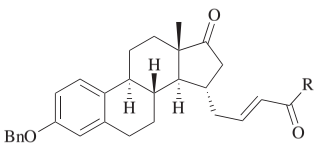
1133



2 eq



Catalyst (0.03–0.05 eq),
solvent



163

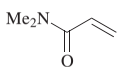
R	Catalyst	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)
H_2N	Gr II	DCM	40	2.5	(61)	100:0
H_2N	Ru cat **68**	DCE	80	5.5	(0)	—
H_2N	Ru cat **125**	DCM	40	5.5	(12)	100:0
PhHN	Gr II	DCM	40	2.5	(62)	100:0
PhHN	Ru cat **68**	DCE	80	5.5	(58)	100:0
PhHN	Ru cat **125**	DCM	40	5.5	(85)	100:0
	Gr II	DCM	40	2.5	(51)	100:0
	Ru cat **68**	DCE	80	5.5	(1)	100:0
	Ru cat **125**	DCM	40	5.5	(3)	100:0

TABLE 21. CROSS-METATHESIS OF α,β-UNSATURATED AMIDES (*Continued*)

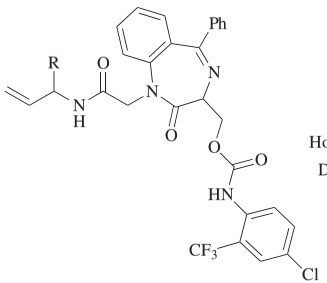
Amide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

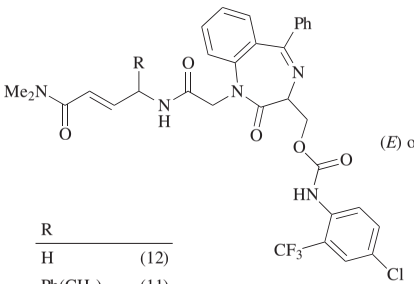
C_3



10 eq

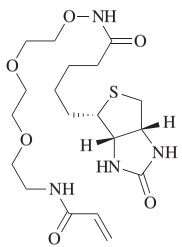


Hov II (0.2 eq),
DCM, 100° (MW), 1 h

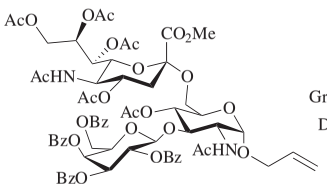


R	
H	(12)
$Ph(CH_2)_2$	(11)

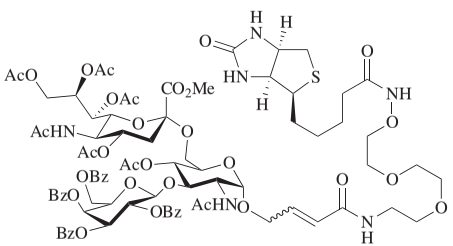
(*E*) only 987



10 eq

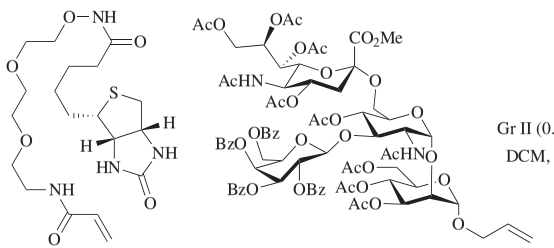


Gr II (0.1 eq),
DCM, 50°, 12 h



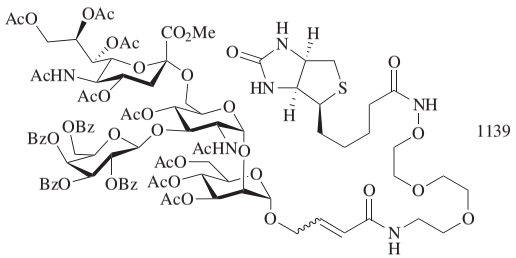
1139

(>99)



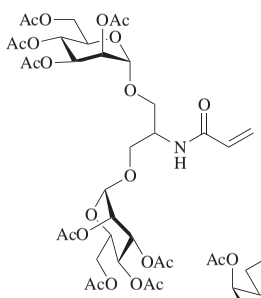
10 eq

Gr II (0.1 eq),
DCM, 50°, 12 h



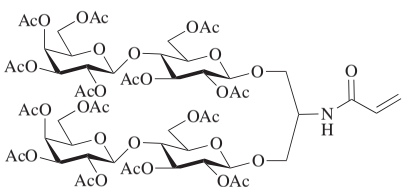
1139

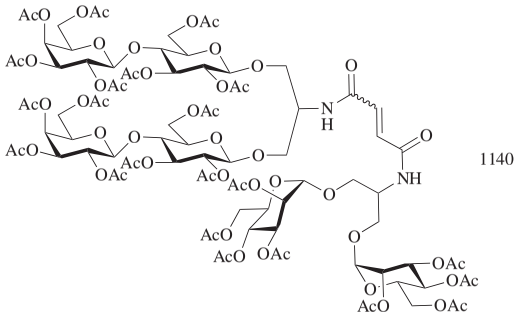
(85)



2 eq

Hov II (0.13 eq),
DCM, 40°, 24 h

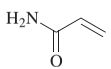
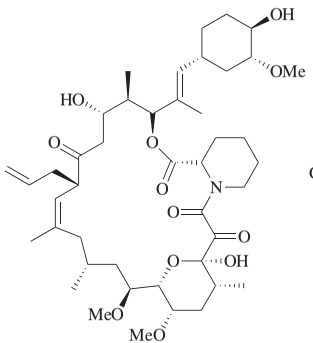
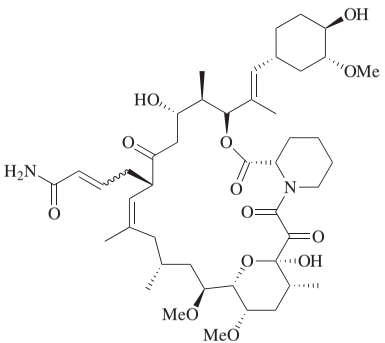
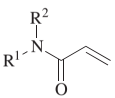
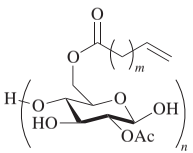
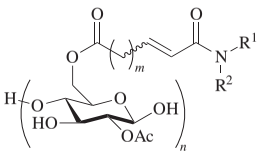




1140

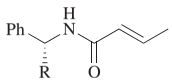
(59)

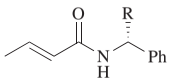
TABLE 21. CROSS-METATHESIS OF α,β-UNSATURATED AMIDES (*Continued*)

Amide	Cross Partner	Conditions	Product(s) and Yield(s) (%)		Refs.
Please refer to the charts preceding the tables for the catalyst structures.					
C_3					
 20 eq		Gr II (0.1 eq), DCB, MW (20 W)		(99)	432
 40 eq		Hov II (*x* eq), BHT (0.12 eq), solvent, 30°			1034

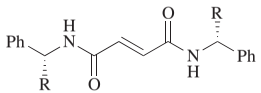
R^1	R^2	*x*	Solvent	Time (h)	Conv. (%)[a]
H	H	0.06 + 0.06	THF	1 + 1	50
H	H	0.06 + 0.06	AcOH	1 + 1	95
Me	Me	0.03	THF	1	39
Me	Me	0.03	AcOH	1	68
i-Pr	H	0.06 + 0.06	THF	1 + 1	82
i-Pr	H	0.06 + 0.06	AcOH	1 + 1	73
Ph	H	0.03	THF	1	50
Ph	H	0.03	AcOH	1	37

C_4





Ru cat **35** (0.025 eq), DCM, 40°, 4 h



(*E*) only

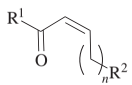
R		
H	(92)	1135
Me	(88)	



I



1. Ru cat **364** (0.01 eq), (*Z*)-2-butene (5 eq), THF, 22°, 1 h
2. Ru cat **364** (0.05 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 7 h

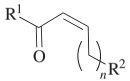


(*Z*)/(*E*) > 98:2

1037

R^1	R^2	*n*	
PMBHN	HO	3	(55)
BnHN	BnO_2C	2	(49)
MeO(Me)N	Ph	2	(49)

TABLE 21. CROSS-METATHESIS OF α,β-UNSATURATED AMIDES (*Continued*)

Amide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 **I**		1. Ru cat **364** (0.01 eq), (*Z*)-2-butene (5 eq), THF, 22°, 1 h 2. Ru cat **364** (0.04 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 7 h 3. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 11 h	 (*Z*)/(*E*) > 98:2	1037

R^1	R^2	*n*	
PMBHN	HO	3	(76)
BnHN	HO	3	(70)
BnHN	BnO_2C	2	(61)
PMBHN	Ph	2	(61)
MeO(Me)N	Ph	2	(82)
MeO(Me)N	Me	8	(80)
MeO(Me)N	OHC	8	(58)
MeO(Me)N	HO_2C	8	(54)

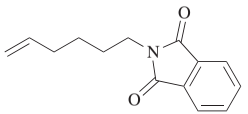
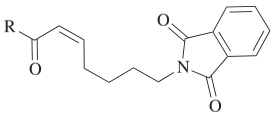
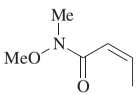
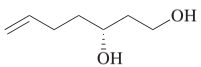
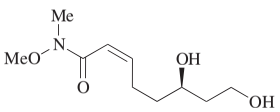
I		1. Ru cat **364** (0.01 eq), (*Z*)-2-butene (5 eq), THF, 22°, 1 h 2. Ru cat **364** (0.04 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 7 h 3. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 11 h	 R = BnHN (55); MeO(Me)N (69)	(*Z*)/(*E*) > 98:2	1037
 **I**		1. Ru cat **364** (0.01 eq), (*Z*)-2-butene (5 eq), THF, 22°, 1 h 2. Ru cat **364** (0.04 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 7 h 3. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 11 h		(73) (*Z*)/(*E*) > 98:2	1037

TABLE 21. CROSS-METATHESIS OF α,β-UNSATURATED AMIDES (*Continued*)

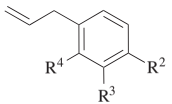
Amide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

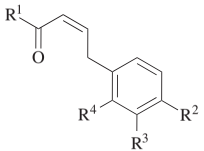
C_4



I

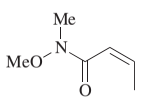


1. Ru cat **364** (0.01 eq), (*Z*)-2-butene (5 eq), THF, 22°, 1 h
2. Ru cat **364** (0.04 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 7 h
3. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 11 h

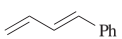


1037

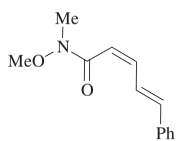
R^1	R^2	R^3	R^4		(*Z*)/(*E*)
H_2N	H	H	HO	(67)	98:2
H_2N	HO	H	H	(61)	98:2
BnHN	MeO	MeO	H	(59)	98:2
PMBHN	MeO	MeO	H	(63)	>98:2
i-BuHN	MeO	MeO	H	(69)	97:3
MeO(Me)N	MeO	MeO	H	(67)	>98:2



I

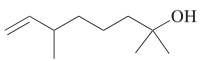
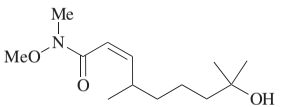
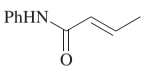
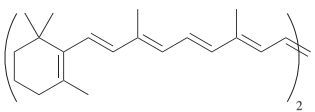
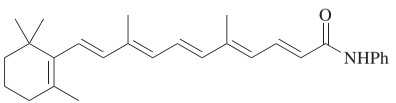
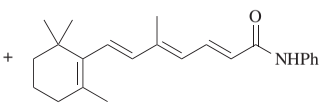


1. Ru cat **364** (0.01 eq), (*Z*)-2-butene (5 eq), THF, 22°, 1 h
2. Ru cat **364** (0.04 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 7 h
3. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h; then ambient pressure, 11 h



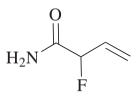
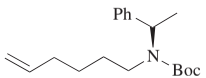
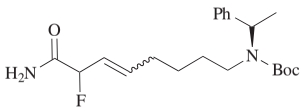
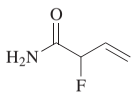
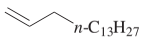
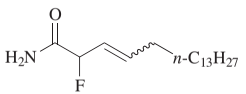
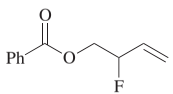
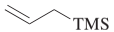
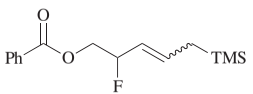
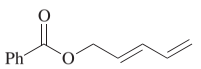
(58) (*Z*)/(*E*) > 98:2

1037

5 eq		1. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 11 h 2. Ru cat **364** (0.04 eq), THF, 100 torr, 22°, 1 h, ambient pressure, 11 h		(80) (*Z*)/(*E*) > 98:2	1037
 1.1 eq		Hov II (0.15 eq), toluene, DCM, rt, 72 h	 (21) (*E*)/(*Z*) = 75:25 +  (19) (*E*)/(*Z*) = 75:25		539

[a] The conversion was determined by ^{1}H NMR analysis.

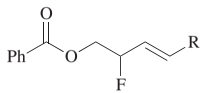
TABLE 22. CROSS-METATHESIS OF SECONDARY ALLYLIC HALIDES

Allylic Halide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
		Hov II (0.05 eq), DCM, 40°		(81)	1141
	 1.5 eq	Hov II (0.07 eq), DCM, 25°, 24 h		(43)	1142
	 5 eq	Hov II (0.02 eq), DCM, 100°, 16 h		(0)	142
			+ 	(40) (*E*)/(*Z*) = 95:5	



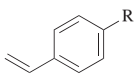
5 eq

Hov II (*x* eq),
DCM, 100°



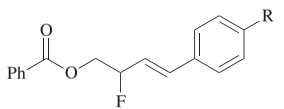
142

R	*x*	Time (h)		(*E*)/(*Z*)
$BocMeNCH_2$	0.04	48	(53)	95:5
$Br(CH_2)_2$	0.02	12	(85)	90:10
$BzO(CH_2)_2$	0.04	24	(67)	67:33



x eq

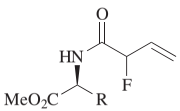
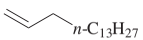
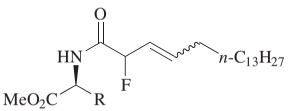
Catalyst (*y* eq),
DCM, 12 h



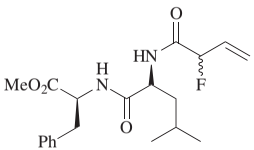
142

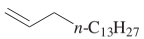
R	*x*	Catalyst	*y*	Temp (°)	Time (h)		(*E*)/(*Z*)
H	5	Gr II	0.02	40	12	(30)	(*E*) only
H	5	Hov II	0.02	25	12	(30)	(*E*) only
H	5	Gr II	0.02	100	12	(69)	(*E*) only
H	1	Gr II	0.02	100	12	(43)	(*E*) only
H	5	Hov II	0.02	100	12	(69)	95:5
CF_3	5	Hov II	0.03	100	16	(70)	95:5
MeO	5	Hov II	0.06	100	48	(0)	—

TABLE 22. CROSS-METATHESIS OF SECONDARY ALLYLIC HALIDES (*Continued*)

Allylic Halide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
	 1.5 eq	Catalyst (*x* eq), DCM, 25°		1142

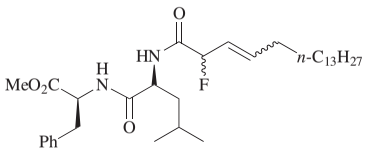
R	Catalyst	*x*	Time (h)	
$TBSOCH_2$	Hov II	0.07	24	(53)
MeO_2CCH_2	Hov II	0.07	24	(54)
i-Pr	Hov II	0.07	24	(48)
Ph	Hov II	0.07	24	(55)
$PhCH_2$	Hov II	0.07	24	(4)
$PhCH_2$	Gr II	0.07	24	(15)
$PhCH_2$	Ru cat **199**	0.07	24	(28)
$PhCH_2$	Ru cat **93**	0.07	24	(45)
$PhCH_2$	Hov II	0.017	24	(65)
$PhCH_2$	Hov II	0.025	24	(38)
$PhCH_2$	Hov II	0.15	24	(63)
$PhCH_2$	Hov II	0.07	2	(57)
$PhCH_2$	Hov II	0.07	6	(61)
$PhCH_2$	Hov II	0.07	10	(64)





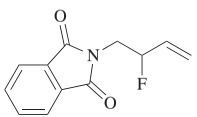
1.5 eq

Hov II (0.07 eq),
DCM, 25°, 24 h



(54)

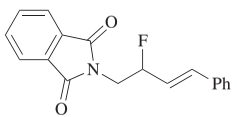
1142





5 eq

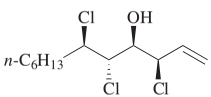
Hov II (0.04 eq),
DCM, 100°, 24 h

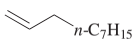


(87) (*E*)/(*Z*) = 95:5

142

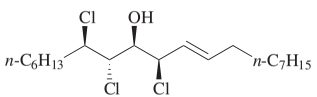
C_{12}





10 eq

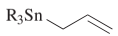
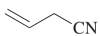
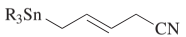
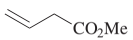
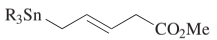
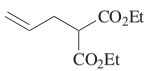
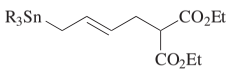
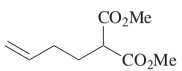
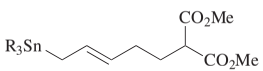
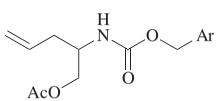
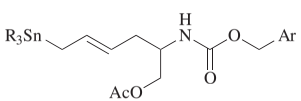
Catalyst (0.1 eq),
toluene, rt, 40 h



915

Catalyst		(*E*)/(*Z*)
Gr II	(43)	(*E*) only
Hov II	(60)	84:16

TABLE 23. CROSS-METATHESIS OF ALLYLSTANNANES

Allylstannane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 2 eq		Mo cat **1** (0.05 eq), DCM, reflux	 R: *n*-Bu (72) (*E*)/(*Z*) 50:50; Ph (22) 64:35	212
2 eq		Mo cat **1** (0.05 eq), DCM, reflux	 R: *n*-Bu (74) (*E*)/(*Z*) 69:31; Ph (78) 73:27	212
2 eq		Mo cat **1** (0.05 eq), DCM, reflux	 R: *n*-Bu (15) (*E*)/(*Z*) 60:40; Ph (31) 63:37	212
2 eq		Mo cat **1** (0.05 eq), DCM, reflux	 R: *n*-Bu (41) (*E*)/(*Z*) 67:33; Ph (49) (*E*) only	212
2 eq	 Ar = 9-fluorenyl	Mo cat **1** (0.05 eq), DCM, reflux	 R: *n*-Bu (13) (*E*)/(*Z*) 53:47; Ph (50) 58:42	212

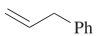
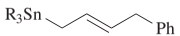
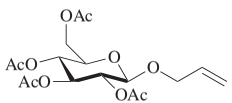
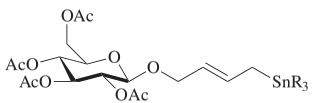
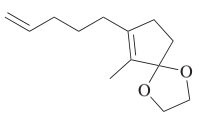
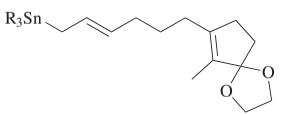
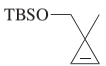
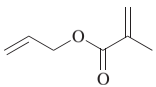
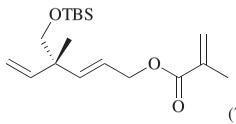
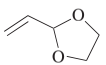
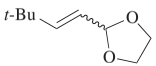
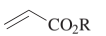
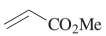
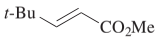
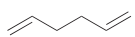
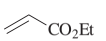
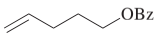
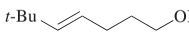
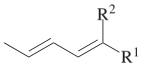
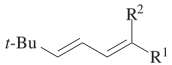
2 eq		Mo cat **1** (0.05 eq), DCM, reflux		R / (*E*)/(*Z*) *n*-Bu (55) 58:42 Ph (74) 55:45	212
2 eq		Mo cat **1** (0.05 eq), DCM, reflux		R / (*E*)/(*Z*) *n*-Bu (21) (*Z*) only Ph (67) 70:30	212
2 eq		Mo cat **1** (0.05 eq), DCM, reflux		R / (*E*)/(*Z*) *n*-Bu (21) 57:43 Ph (71) 63:37	212

TABLE 24. CROSS-METATHESIS OF ALKENES WITH QUATERNARY ALLYLIC CARBON CENTERS

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
	 2.05 eq	Ru cat **213** (0.05 eq), THF, 0°, 48 h	 (76) (*E*)/(*Z*) = 80:20 er (*E*) 93.0:7.0	1143
C_6				
t-Bu excess		Gr II (0.03–0.05 eq), 40°, 12 h	 (75)	36
excess		Gr II (0.03–0.05 eq), 40°, 12 h	 R: H (73); *t*-Bu (73)	36
	 10 eq	Gr II (0.001 eq), *p*-cresol (*x* eq), 50°, 2 h	 (*E*)/(*Z*) = 98:2 *x*: —, Conv. (%)[a] 11; 500, 18	130
t-Bu excess + 	 1 eq	Gr II (0.075 eq), neat, 23°, 12 h	 (67) (*E*) only	36

excess		Gr II (0.03–0.05 eq), DCM, 40°, 12 h		(99) (*E*) only	36
1.9 eq		Gr II (2 x 0.05 eq), DCM, 40°, 24 h			649

R^1	R^2		$(E)/(Z)$
Br	NC–	(16)	82:18
NC–	Br	(19)	80:20

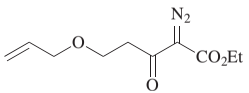
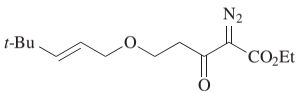
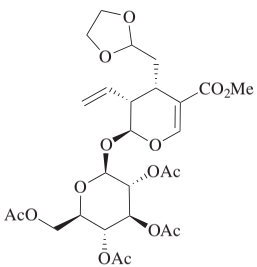
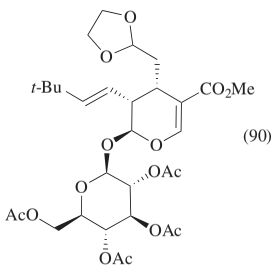
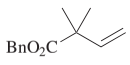
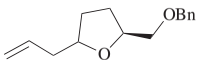
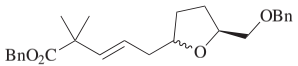
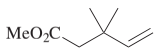
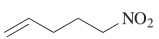
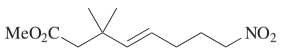
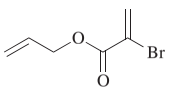
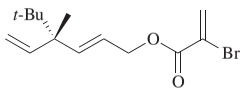
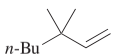
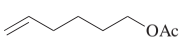
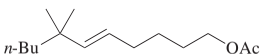
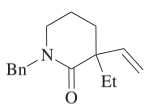
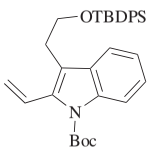
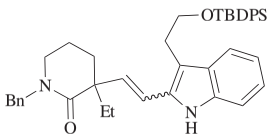
 10 eq		Gr II (0.05 eq), DCM, 18 h, reflux		(50) $(E)/(Z) > 99:1$	569
		Gr II (0.1 eq), toluene, 100°		(90) $(E)/(Z) = 95:5$	410

TABLE 24. CROSS-METATHESIS OF ALKENES WITH QUATERNARY ALLYLIC CARBON CENTERS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)		Refs.
Please refer to the charts preceding the tables for the catalyst structures.					
C_6					
 3.95 eq		Gr II (0.1 eq), Cy_2BCl (0.1 eq), toluene, 90° (MW), 9 h	 (22) (*E*) only		1144
C_7					
 3.6 eq		Gr II (0.052 eq), DCM, reflux, 18 h	 (73) (*E*) only		146
C_8					
	 2.05 eq	Ru cat **213** (0.05 eq), THF, 22°, 16 h	 (61) (*E*)/(*Z*) = 67:33, er (*E*) 95.0:5.0		1143
C_9					
 2 eq		Gr II (0.03–0.05 eq), DCM, 40°, 12 h	 (90) (*E*) only		36
 10 eq		Hov II (0.3 eq), 140°, 3 h		(42)	1145

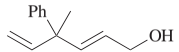
C_{10}



1.5 eq



Hov II (0.005 eq), toluene, 22°, 5 min



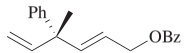
624

>98% conv.[b], (*E*)/(*Z*) = 67:33



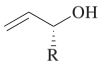
2.05 eq

Ru cat **213** (0.05 eq), THF, 0°, 48 h



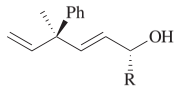
1143

(76) (*E*)/(*Z*) = 75:25, er (*E*) 70.0:30.0



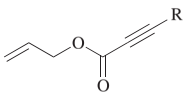
1.5 eq

Hov II (0.005 eq), toluene, 22°, 15 min



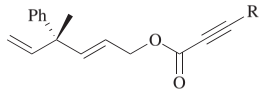
624

R		(*E*)/(*Z*)	dr
Me	(64)	86:14	95:5
$TBSOCH_2$	(71)	92:8	89:11
$Ph(CH_2)_2$	(80)	80:20	91:9



2.05 eq

Ru cat **213** (0.05 eq), THF, 0°, 48 h



1143

R		(*E*)/(*Z*)	er (*E*)
H	(65)	80:20	93.0:7.0
TMS	(63)	80:20	69.0:31.0
Me	(72)	67:33	86.0:14.0

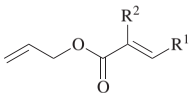
TABLE 24. CROSS-METATHESIS OF ALKENES WITH QUATERNARY ALLYLIC CARBON CENTERS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

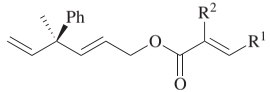
C_{10}





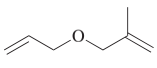
2.05 eq

Ru cat **213** (0.05 eq), THF, 0°, 48 h



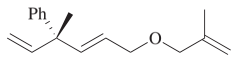
1143

R^1	R^2		$(E)/(Z)$	er (E)	er (Z)
H	H	(71)	82:18	8.0:92.0	—
H	Me	(77)	83:17	8.0:92.0	—
H	CF_3	(63)	86:14	9.0:91.0	65.0:34.0
H	Br	(80)	88:12	1.0:99.0	—
Br	H	(69)	86:14	1.0:99.0	75.0:25.0



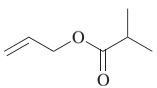
2.05 eq

Ru cat **213** (0.05 eq), THF, 0°, 48 h



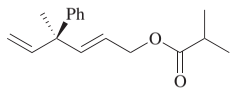
1143

(76) $(E)/(Z)$ = 67:33, er (E) 64.0:36.0



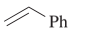
2.05 eq

Ru cat **213** (0.05 eq), THF, 0°, 48 h



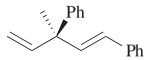
1143

(59) $(E)/(Z)$ = 75:25, er (E) 35.0:65.0



2.05 eq

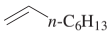
Ru cat **213** (0.05 eq),
THF, 0°, 48 h



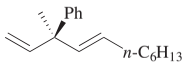
(90) (*E*)/(*Z*) > 95:5, er (*E*) 97.0:3.0

1143

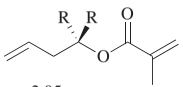
1.5 eq



Catalyst (*x* eq),
solvent

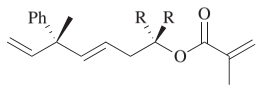


Catalyst	*x*	Solvent	Temp (°)	Time (h)	Conv. (%)[b]		(*E*)/(*Z*)	er (*E*)	
Ru cat **213**	0.05	THF	0	48	—	(59)	60:40	60.0:40.0	1143
Hov II	0.005	toluene	22	4	83	(—)	75:25	—	624



2.05 eq

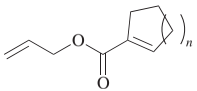
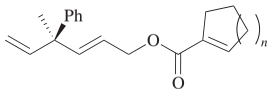
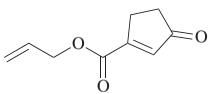
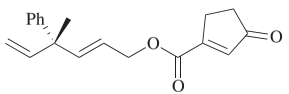
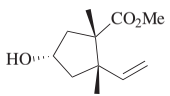
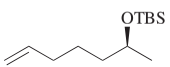
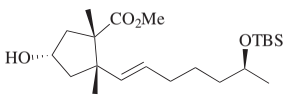
Ru cat **213** (0.05 eq),
THF, 0°, 48 h



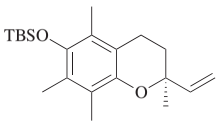
1143

R		(*E*)/(*Z*)	er (*E*)
H	(71)	80:20	80.0:20.0
Me	(60)	83:17	90.0:10.0

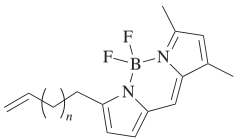
TABLE 24. CROSS-METATHESIS OF ALKENES WITH QUATERNARY ALLYLIC CARBON CENTERS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{10}				
	 2.05 eq	Ru cat **213** (0.05 eq), THF, 0°, 48 h		1143
			n (72) (*E*)/(*Z*) 83:17 er (*E*) 5.0:95.0 er (*Z*) 74.0:26.0 2 (83) 75:25 6.0:94.0 70.0:30.0	
	 2.05 eq	Ru cat **213** (0.05 eq), THF, 0°, 48 h	 (63) (*E*)/(*Z*) = 67:33, er (*E*) 83.0:17.0	1143
	 3 eq	Gr II (0.05 eq), DCM, reflux	 (24) (*E*)/(*Z*) = 80:20	462

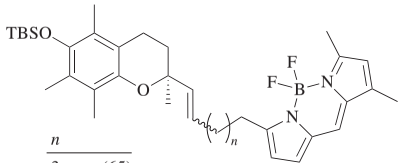
C_{15}



2 eq



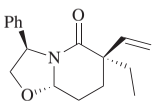
Gr II (0.1 eq),
DCM, reflux, 6 h

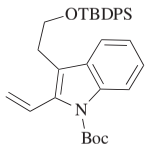


1146

n	
3	(65)
4	(53)
5	(48)

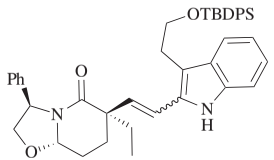
C_{17}





3.5 eq

Hov II (0.06 eq),
xylene, 140°, 3 h



(65)

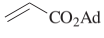
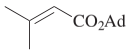
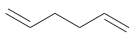
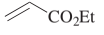
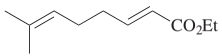
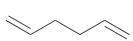
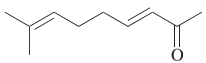
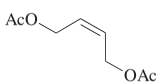
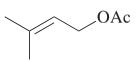
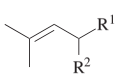
1145

[a] The conversion was determined by GC/GC-MS analysis.

[b] The conversion was determined by ^{1}H NMR analysis.

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS

A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 excess		Gr II (0.01 eq), neat, 40°, 12 h	 (83)	129
 excess +  3 eq		Gr II (0.05 eq), neat, 40°, 12 h	 (60) (*E*) only	36
 excess +  3 eq		Gr II (0.07 eq), neat, 40°, 12 h	 (89) (*E*) only	36
 excess		Gr II (0.01 eq), neat, 40°, 12 h	 (88)	129
excess		Gr II (0.01 eq), neat, 40°, 12 h		129

R^1	R^2	
BzO	Me	(99)
$TBSO(CH_2)_2$	Me	(72)
$AcO(CH_2)_3$	H	(97)

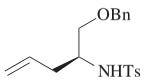
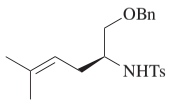
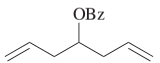
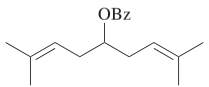
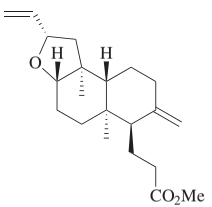
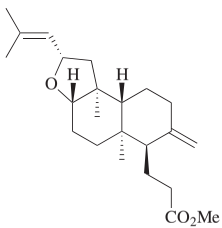
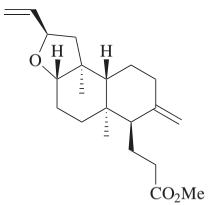
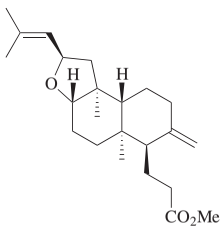
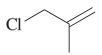
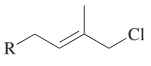
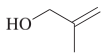
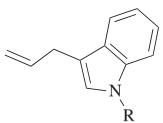
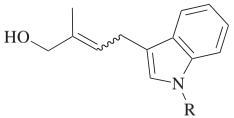
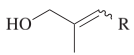
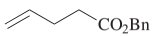
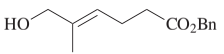
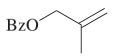
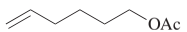
20 eq		Hov II (0.05 eq) DCM, 40°, 16 h		(83)	1147
excess		Gr II (0.01 eq), neat, 40°, 12 h		(96)	1147
excess		Gr II (0.15 eq), 2-methylpropene/DCM (1:1), reflux, 72 h		(91)	622
excess		Gr II (0.15 eq), 2-methylpropene/DCM (1:1), reflux, 72 h		(85)	622

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 6 eq		Ru cat **139** (0.02 eq), DCM, reflux, 5 h		620
			R (79) (*E*)/(*Z*) *n*-C_7H_{15} 75:25 $NC(CH_2)_7$ 75:25 $MeO_2C(CH_2)_7$ 74:26 3-MeO-4-$AcOC_6H_3$ 75:25	
 20 eq		Gr II (0.1 + 0.1 + 0.05 eq) DCE, 40°, 6 + 6 + 12 h		R (52) H MeO (56) 1148
C_{4-5}				
 5 eq		Hov II (0.05 eq) DCM, 40°, 12 h		1149
			R (61) (*E*)/(*Z*) H 87:13 (*Z*)-Me (64) 88:12 (*E*)-Me (71) 91:9	

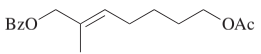
C_4





2 eq

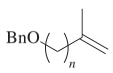
Gr II (0.03–0.05 eq), DCM, 40°, 12 h



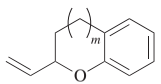
(80) (*E*)/(*Z*) = 80:20

36, 241

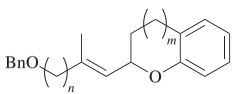
C_{4-5}



x eq



Gr II (0.05 eq), neat, 60°



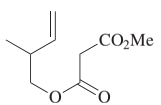
832

x	*n*	*m*	Time (h)		(*E*)/(*Z*)
4	1	0	37	(57)	80:20
6	2	0	48	(58)	68:32
4	1	1	70	(51)	78:22
6	2	1	14	(38)	52:48

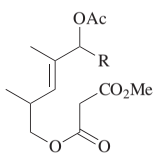
C_{4-9}



4 eq

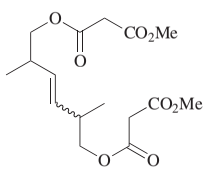


Gr II (0.04 eq), DCM, reflux, 15 h



I

+

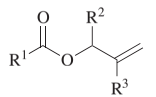
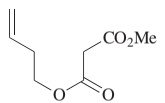
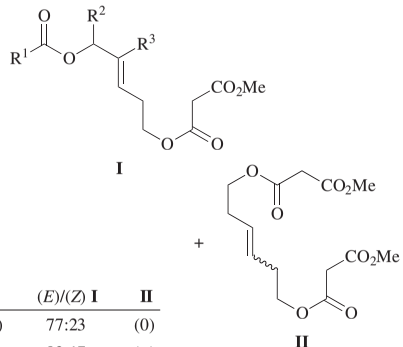


II

586

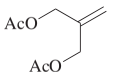
R	**I**	**II**	(*E*)/(*Z*) **I**
H	(43)	(45)	80:20
n-Bu	(28)	(68)	(*E*) only
c-C_5H_9	(0)	(53)	—

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

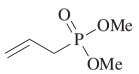
Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{4-14}				
 *x* eq	 *y* eq	Gr II (*z* eq), DCM, reflux	 **I** + **II**	586

R^1	R^2	R^3	*x*	*y*	*z*	Time (h)	**I**	(*E*)/(*Z*) **I**	**II**
Me	H	Me	1	3.3	0.03	15	(28)	77:23	(0)
Me	H	Me	1	4	0.04	15	(78)	83:17	(tr)
Me	H	Me	2	1	0.04	15	(28)	77:23	(57)
EtO	H	Me	1	3.1	0.03	22	(24)	78:22	(0)
EtO	H	Me	1	4	0.04	15	(58)	78:22	(15)
Ph	H	Me	1	3.4	0.03	15	(20)	77:23	(—)
Ph	H	Me	2.5	1	0.04	15	(43)	79:21	(—)
BnO	H	Me	2	1	0.04	15	(40)	78:22	(42)
Me	H	Et	4	1	0.04	15	(59)	50:50	(0)
Me	H	*n*-Bu	4	1	0.04	15	(36)	50:50	(51)
Me	H	*c*-C_5H_9	4	1	0.04	15	(0)	—	(63)
Me	Et	Me	4	1	0.04	15	(31)	95:5	(39)
Me	*n*-Bu	Me	4	1	0.04	15	(38)	95:5	(42)
Me	*n*-$C_{10}H_{21}$	Me	4	1	0.04	15	(38)	95:5	(30)
BnO	*n*-Bu	Me	4	1	0.04	15	(34)	96:4	(44)
Me	*i*-Pr	Me	4	1	0.04	15	(11)	100:0	(74)
Me	*c*-C_5H_9	Me	4	1	0.04	15	(7)	94:6	(80)

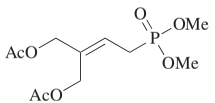
C_4



2 eq

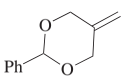


Catalyst (*x* eq),
solvent

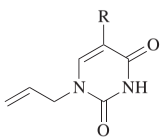


1150

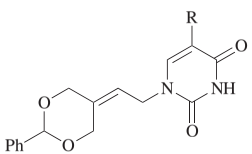
Catalyst	*x*	Solvent	Temp (°)	Time (h)	
Ru cat **35**	0.05	DCM	40	24	(9)
Hov II	0.05	DCM	40	24	(16)
Ru cat **35**	3 x 0.05	DCM	40	24	(23)
Ru cat **35**	3 x 0.05	DCE	40	24	(32)
Ru cat **35**	0.1	DCM	110 (MW)	4	(38)
Hov II	0.1	DCM	110 (MW)	4	(70)
Ru cat **35**	3 x 0.05	DCM	55 (U/S)	20	(92)
Ru cat **35**	3 x 0.03	DCM	55 (U/S)	20	(90)
Ru cat **35**	3 x 0.02	DCM	55 (U/S)	20	(86)
Hov II	3 x 0.02	DCM	55 (U/S)	20	(93)
Ru cat **35**	0.05	DCM	55 (U/S)	20	(49)
Ru cat **35**	3 x 0.01	DCM	55 (U/S)	20	(76)



5 eq



Ru cat **35** (0.1 eq),
DCM, 40°, 5 h



(*E*) only

R		
H	(53)	628
F	(70)	
I	(57)	
Me	(64)	

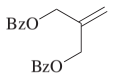
TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)

A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

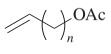
Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

C_4

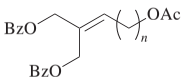


x eq

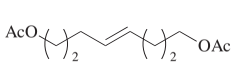


y eq

Catalyst (*z* eq), solvent



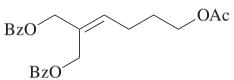
x	*n*	*y*	Catalyst	*z*	Solvent	Temp (°)	Time		
1	3	3	Hov II	0.05	DCM	reflux	24 h	(73)	177
1	3	3	Ru cat **271**	0.05	DCM	reflux	24 h	(54)	177
1	3	3	Ru cat **187**	0.05	DCM	reflux	24 h	(96)	177
3	3	1	Ru cat **98**	0.05	DCM	40	24 h	(32)	957
3	3	1	Ru cat **170**	0.05	DCM	40	24 h	(10)	957
3	3	1	Ru cat **170**	0.05	DCM	40	10 h	(3)	957
1	3	3	Ru cat **170**	0.05	DCM	40	10 h	(43)	957
1	3	3	Hov II	0.05	DCM	40	24 h	(32)	957
1	3	3	Ind II	4 x 0.02	$C_6F_5CF_3$	120	4 x 10 min	(41)	40
1	3	3	Ind II	4 x 0.02	$C_6F_5CF_3$	120 (MW)	4 x 10 min	(62)	40
1	4	2	Gr II	0.03	DCM	40	12 h	(48)	129



x eq

(*E*)/(*Z*) = 75:25

Catalyst (0.05 eq), DCM, 40°



957

x	Catalyst	Time (h)	
3	Ru cat **170**	10	(54)
2	Ru cat **98**	24	(32)
2	Ru cat **170**	24	(33)

C_5

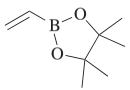
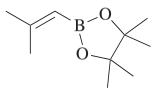
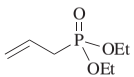
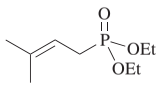
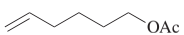
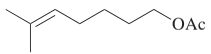
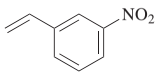
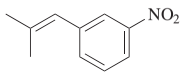
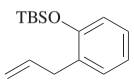
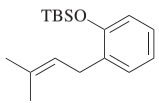
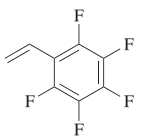
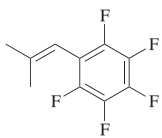
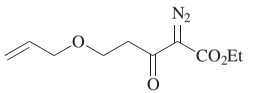
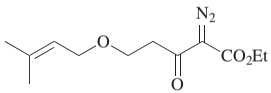
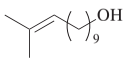
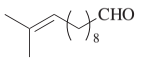
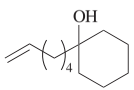
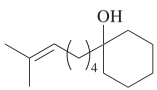
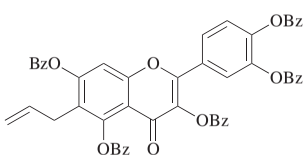
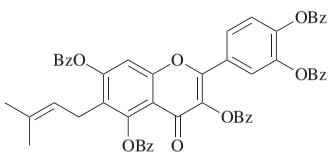
 *x* eq		Gr II (0.05 eq), DCM, reflux, 12 h		*x* 1 (26) 0.5 (22) 2 (48)	132
excess		Gr II (0.01 eq), neat, 23°, 12 h		(97)	129
excess		Gr II (0.01 eq), neat, 23°, 12 h		(97)	129
excess		Gr II (0.01 eq), neat, 23°, 12 h		(96)	129
excess		Gr II (0.01 eq), neat, 23°, 12 h		(99)	129
excess		Gr II (0.01 eq), 23°, 12 h		(91)	129

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5  10 eq		Gr II (0.05 eq), DCM, reflux, 18 h	 (82)	569
excess		Ru cat **88** (0.01 eq), neat, 25°, 1 h	 (99)	171
excess		Gr II (0.01 eq), 23°, 12 h	 (91)	129
excess		Ru cat **88** (0.01 eq), neat, 25°, 1 h	 (99)	171
107 eq		Gr II (0.03 eq), DCM, rt, 48 h	 (88)	1151

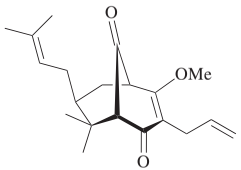
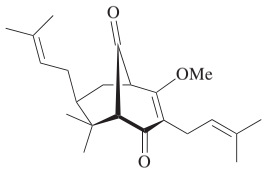
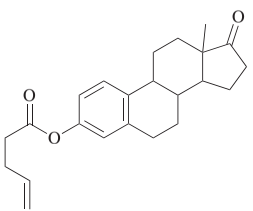
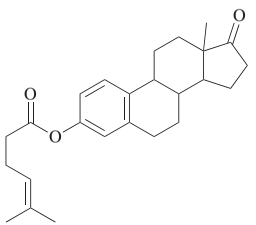
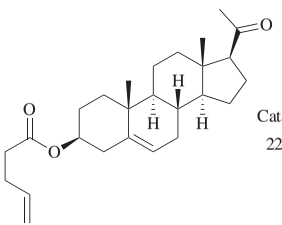
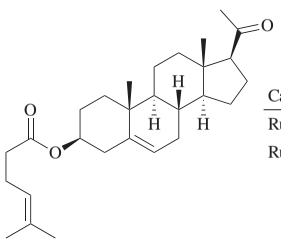
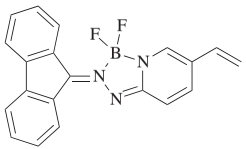
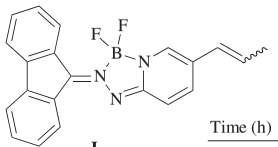
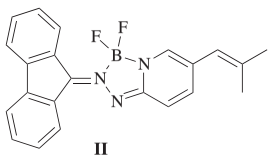
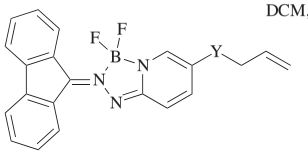
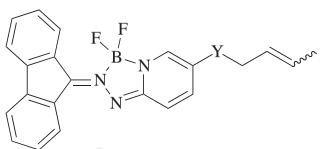
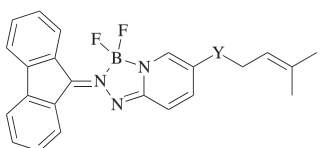
excess		Gr II (0.1 eq), 38°, 2 h		(88) 1152
20 eq		Catalyst (0.01 eq), TMSCl (0.1 eq) DCM, 40°, 2 h		Catalyst Ru cat **194** (96) 526 Ru cat **196** (83)
60 eq		Catalyst (0.025 eq), 22°, 2 h		Catalyst Ru cat **327** (81) 593 Ru cat **328** (78)

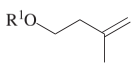
TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)

A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
		Hov II (0.05 eq), DCM, 40°	 **I** +  **II**	1153
		Hov II (0.05 eq), DCM, 40°	 **I** +  **II**	1153

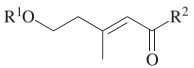
Time (h)	I	II
0.5	(66)	(27)
8	(52)	(40)

Y	Time (h)	**I**	**II**
S	0.5	(24)	(57)
S	8	(17	(61)
SO_2	0.5	(25)	(72)
SO_2	8	(1)	(98)



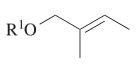


Catalyst (*y* eq), solvent



x eq

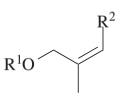
R^1	R^2	*x*	Catalyst	*y*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
PNP	Et	0.5	Hov II	0.04	DCM	40	15	(65)	56:44	932
PNP	MeO	1	Hov II	0.04	DCM	40	15	(50)	50:50	932
Bz	MeO	2	Ind II	0.05	DCM	40	8	(0)	—	161
Bz	MeO	2	Ru cat **286**	0.05	DCE	80	8	(0)	—	161
Bz	MeO	0.5	Ind II	0.05	DCM	40	8	(0)	—	161
Bz	MeO	0.5	Ru cat **286**	0.05	DCE	80	8	(0)	—	161
Bz	MeO	2	Hov II	0.01	DCM	20	24	(0)	—	1040
Bz	MeO	2	Ru cat **85**	0.01	DCM	20	24	(0)	—	1040



I



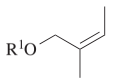
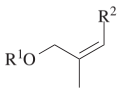
1. Ru cat **354** (0.01 eq),
(*Z*)-butene (5 eq),
THF, 22°, 1 h
2. Ru cat **354** (0.05 eq),
I (5 eq), THF,
100 torr, 22°, 1 h
3. Ambient pressure, 15 h



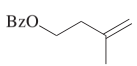
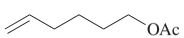
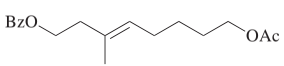
(*Z*)/(*E*) > 98:2

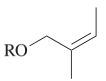
R^1	R^2		
H	$BnO_2C(CH_2)_2$	(75)	1149
H	$Br(CH_2)_6$	(63)	
H	$OHC(CH_2)_8$	(60)	
PMB	$HO(CH_2)_6$	(50)	
PMB	$Br(CH_2)_6$	(54)	

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

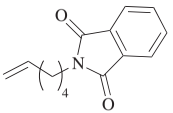
Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
 **I**		1. Ru cat **354** (0.01 eq), (*Z*)-butene (*x* eq), THF, 22°, 1 h 2. Ru cat **354** (0.05 eq), **I** (*y* eq), THF, 100 torr, 22°, 1 h 3. Ambient pressure, 15 h	 (*Z*)/(*E*) > 98:2	1149

R^1	R^2	*x*	*y*	
H	$BnO_2C(CH_2)_2$	5	5	(74)
H	$HO(CH_2)_6$	5	10	(70)
H	$PMBO(CH_2)_7$	5	5	(78)
H	$Br(CH_2)_6$	10	5	(68)
H	$CF_3O_2C(CH_2)_9$	5	5	(55)
H	$OHC(CH_2)_8$	10	5	(70)
H	$Ph(CH_2)_2$	5	5	(63)
H	$PhCH(OBOM)CH_2$	5	5	(40)
Bn	$BnO_2C(CH_2)_2$	5	5	(72)
Bn	$HO_2C(CH_2)_3$	5	10	(38)
PMB	$HO(CH_2)_6$	5	5	(50)
PMB	$BocHN(CH_2)_2$	5	5	40
AcO	$HO(CH_2)_6$	5	20	(48)

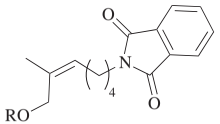
	 2 eq	Gr II (0.03–0.05 eq), DCM, 40°, 12 h	 (80) (*E*)/(*Z*) = 74:26	241



I

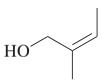


1. Ru cat **354** (0.01 eq),
(*Z*)-butene (5 eq),
THF, 22°, 1 h
2. Ru cat **354** (0.05 eq),
I (5 eq), THF,
100 torr, 22°, 1 h
3. Ambient pressure, 15 h

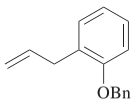


(*Z*)/(*E*) > 98:2

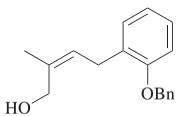
R		
H	(77)	1149
PMB	(51)	



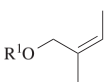
I



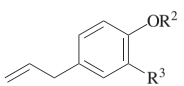
1. Ru cat **354** (0.01 eq),
(*Z*)-butene (5 eq),
THF, 22°, 1 h
2. Ru cat **354** (0.03 eq),
I (10 eq), THF,
100 torr, 22°, 1 h
3. Ambient pressure, 15 h



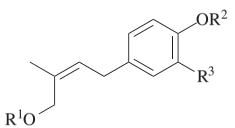
(62) (*Z*)/(*E*) > 98:2 1149



I



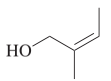
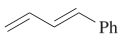
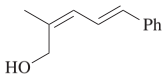
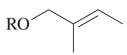
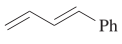
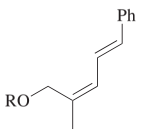
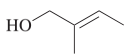
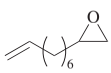
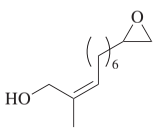
1. Ru cat **354** (0.01 eq),
(*Z*)-butene (5 eq),
THF, 22°, 1 h
2. Ru cat **354** (0.05 eq),
I (*x* eq), THF,
100 torr, 22°, 1 h
3. Ambient pressure, 15 h

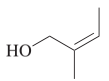


(*Z*)/(*E*) > 98:2 1149

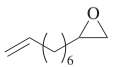
R^1	R^2	R^3	*x*	
H	H	H	10	(55)
H	Me	MeO	5	(81)
Bn	Me	MeO	5	(55)

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

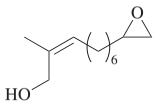
Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
 **I**		1. Ru cat **354** (0.01 eq), (*Z*)-butene (5 eq), THF, 22°, 1 h 2. Ru cat **354** (0.05 eq), **I** (10 eq), THF, 100 torr, 22°, 1 h 3. Ambient pressure, 15 h	 (58) (*Z*)/(*E*) > 98:2	1149
 **I**		1. Ru cat **354** (0.01 eq), (*Z*)-butene (5 eq), THF, 22°, 1 h 2. Ru cat **354** (0.05 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h 3. Ambient pressure, 15 h	 (*Z*)/(*E*) > 98:2 R: H (52), PMB (41)	1149
 **I**		1. Ru cat **354** (0.01 eq), (*Z*)-butene (5 eq), THF, 22°, 1 h 2. Ru cat **354** (0.05 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h 3. Ambient pressure, 15 h	 (77) (*Z*)/(*E*) > 98:2	1149



I

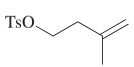


1. Ru cat **354** (0.01 eq), (*Z*)-butene (5 eq), THF, 22°, 1 h
2. Ru cat **354** (0.05 eq), **I** (5 eq), THF, 100 torr, 22°, 1 h
3. Ambient pressure, 15 h

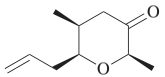


(75) (*Z*)/(*E*) > 98:2

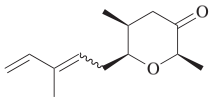
1149



10 eq



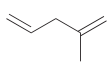
1. Gr II (0.1 eq), DCM, reflux, 12 h
2. *t*-BuOK, DMSO, 75°



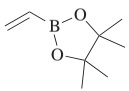
(41)

829, 546

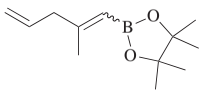
C_6



1.4 eq



Hov II (0.02 eq), DCM, reflux, 20 h

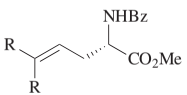


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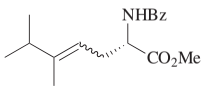
1154



30 eq



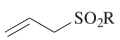
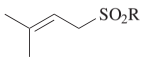
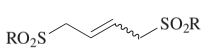
Hov II (0.05 eq), benzene, 100°, 14 h



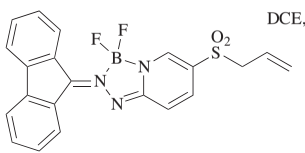
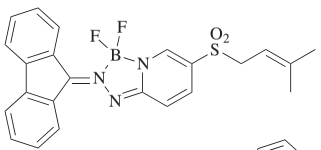
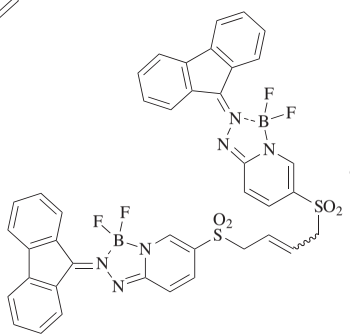
R	
H	(0)
Me	(71)

337

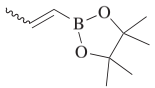
TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6				
		Hov II (0.05 eq), DCE, 60°, 4 h	 +  **I** **II**	1153

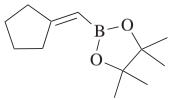
R	I	II
Me	(45)	(38)
Ph	(51)	(40)

	Hov II (0.05 eq), DCE, 60°, 4 h	 (59)		1153
		 + (31)		





Gr II (0.05 eq), DCM, reflux



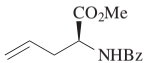
(80)

687

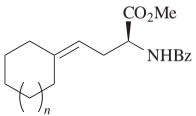
$C_{6–8}$



10 eq



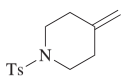
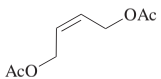
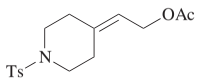
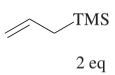
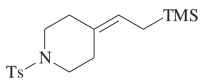
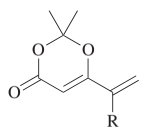
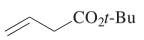
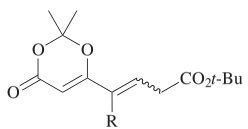
Catalyst (x eq), DCM



1155

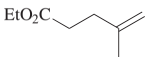
n	Catalyst	x	Temp (°)	Time (h)	Conv. (%)[a]	
0	Hov II	0.1	100 (MW)	4	—	(95)
1	Hov II	0.1	100 (MW)	4	—	(96)
2	Hov II	0.1	100 (MW)	4	—	(79)
1	Gr II	0.05	reflux	48	40	(—)
1	Gr II	0.05	100 (MW)	2	60	(—)
1	Hov II	0.05	100 (MW)	2	76	(—)
1	Hov II	0.05	100 (MW)	4	79	(—)
1	Hov II	0.05	100 (MW)	2 + 2	96	(—)

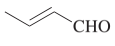
TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6 	 2 eq	Catalyst (*x* eq), DCM, 40°		
		Catalyst / *x* / Time (h): Ru cat **88** 0.05 16 (47)		171
		Hov II 0.05 16 (54)		171
		Ru cat **166** 0.1 7 (63)		1060
		Ru cat **167** 0.1 7 (62)		1060
	 2 eq	Catalyst (0.05 eq), DCM, 40°, 16 h	 Catalyst: Ru cat **88** (5); Gr II (0)	171
$C_{6–12}$  *x* eq		Hov II (*y* eq), solvent		792

R	*x*	*y*	Solvent	Time (h)	Temp (°)	
Me	1.5	0.05	DCM	2.5	40	(0)
Me	1.5	0.05	$C_6F_5CF_3$	16	70	(43)
Me	3	0.1	$C_6F_5CF_3$	2	70	(68)
Bn	3	0.1	$C_6F_5CF_3$	2	70	(61)

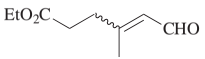
C_6





10 eq

Hov II (0.05 eq),
DCM, 40°, 4 h

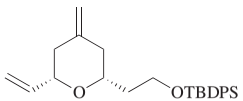


(32)

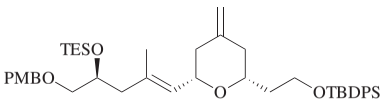
942



10 eq



Gr II (0.01 eq),
DCM, reflux, 9 h

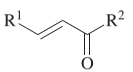


(57) (*E*)/(*Z*) = 63:37

1156

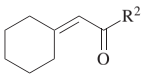
C_7





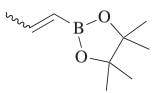
2 eq

Gr II (0.05 eq),
DCM, reflux, 3 h

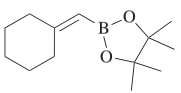


R^1	R^2	
H	*t*-BuO	(75)
H	HO	(83)
Me	Et	(99)

170



Gr II (0.05 eq),
DCM, reflux



(91)

687

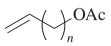
TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

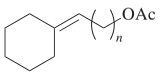
C_7





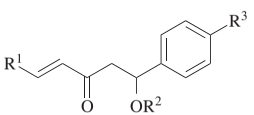
x eq

Catalyst (*y* eq), solvent

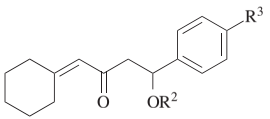


n	*x*	Catalyst	*y*	Solvent	Temp (°)	Time		
3	3	Hov II	0.05	DCM	reflux	24 h	(78)	177
3	3	Ru cat **271**	0.05	DCM	reflux	24 h	(60)	177
3	3	Ru cat **187**	0.05	DCM	reflux	24 h	(98)	177
3	3	Hov II	0.05	DCM	40	24 h	(78)	845
3	3	Ind II	4 x 0.02	$C_6F_5CF_3$	120	4 x 10 min	(50)	845
3	3	Ind II	4 x 0.02	$C_6F_5CF_3$	120 (MW)	4 x 10 min	(56)	845
4	2	Gr II	0.03	DCM	40	12	(65)	129

2 eq

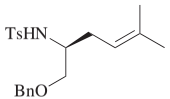


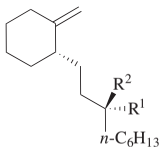
Hov II (0.05 eq),
DCM, reflux, 18–24 h



1021

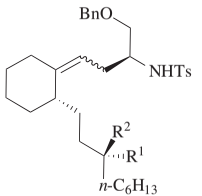
R^1	R^2	R^3	
H	H	MeO	(50)
Me	H	MeO	(42)
Me	H	O_2N	(55)
Me	TBS	MeO	(90)





2 eq

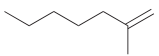
Hov II (0.25 eq)
toluene, 120°, 48 h



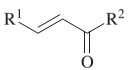
R^1	R^2	
H	BzO	(74)
BzO	H	(70)

1147

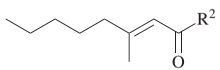
C_8



4 eq



Gr II (0.05 eq),
DCM, 40°



(*E*)/(*Z*) = 67:33

36, 170

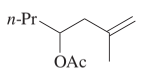
R^1	R^2	Time (h)	
H	HO	3	(83)
H	Et	12	(26)
H	EtO	12	(55)
Me	Et	3	(68)
Me	EtO	3	(83)

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

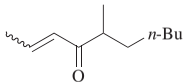
Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

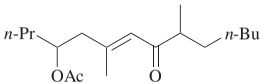
C_8



x eq

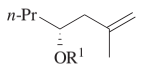


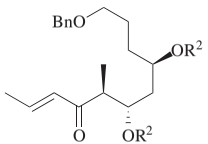
Gr II (0.05 eq),
DCM, 40°, overnight



x		(*E*)/(*Z*)
2	(15)	50:50
4	(28)	75:25

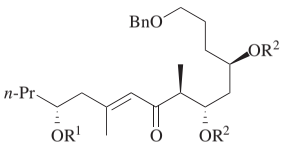
1157





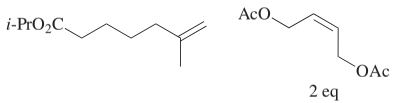
6 eq

Catalyst (*x* eq),
DCM, 40°, 72 h

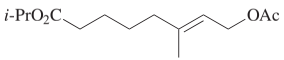


1157

R^1	R^2	Catalyst	*x*		(*E*)/(*Z*)
TBS	Ac	Hov II	0.05	(—)	—
TBS	Ac	Hov II	0.15	(26)	79:21
TBS	Ac	Gr II	0.3	(39)	80:20
TBS	TES	Hov II	0.05	(—)	—
TBS	TES	Hov II	0.3	(46)	(*E*) only
TBS	TES	Hov II	0.45	(47)	(*E*) only
PMB	TBS	Hov II	0.3	(45)	(*E*) only



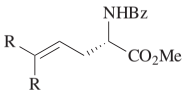
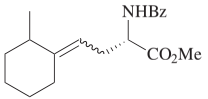
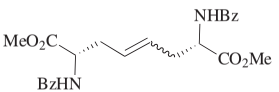
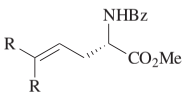
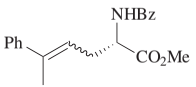
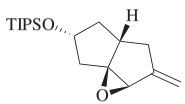
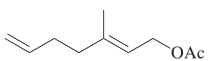
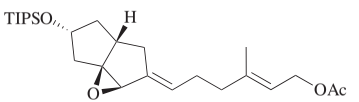
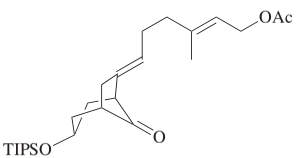
Catalyst (0.05 eq), solvent



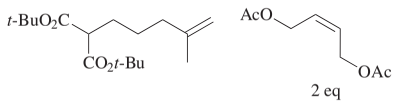
171, 140

Catalyst	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)
Ru cat **115**	DCE	70	3	(24)	75:25
Ru cat **115**	toluene	70	3	(46)	75:25
Ru cat **115**	perfluorobenzene	70	3	(52)	75:25
Hov II	DCE	70	3	(12)	75:25
Hov II	toluene	70	3	(29)	75:25
Hov II	perfluorobenzene	70	3	(42)	75:25
Gr II	DCE	70	3	(31)	75:25
Gr II	toluene	70	3	(40)	75:25
Gr II	perfluorobenzene	70	3	(50)	75:25
Ind II	DCE	70	3	(27)	75:25
Ind II	toluene	70	3	(40)	75:25
Ind II	perfluorobenzene	70	3	(0)	—
Ru cat **282**	DCE	70	3	(29)	75:25
Ru cat **282**	toluene	70	3	(40)	75:25
Ru cat **282**	perfluorobenzene	70	3	(40)	75:25
Ru cat **88**	DCM	40	16	(37)	70:30
Hov II	DCM	40	16	(17)	70:30

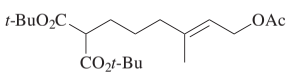
TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
 30 eq		Hov II (0.05 eq), benzene, 100°, 14 h	 **I** +  **II**	R: H — **I** (7), **II** (55); R: Me — **I** (55), **II** (0) 337
C_9				
 30 eq		Hov II (0.05 eq), benzene, 100°, 14 h		R: H — (0); R: Me — (97) 337
 1.5 eq		Catalyst (*x* eq), solvent, reflux, 4 h	 **I** +  **II** (*E*)/(*Z*) = 83:17	1158

Catalyst	x	Solvent	**I**	$(E)/(Z)$ **I**	**II**
Gr II	0.1	DCM	(44)	83:17	(27)
Hov II	0.05	$CHCl_3$	(0)	—	(75)



Catalyst (0.05 eq),
solvent, 70°, 3 h



$(E)/(Z)$ = 75:25 140, 141

Catalyst	Solvent	
Ru cat **115**	DCE	(13)
Ru cat **115**	toluene	(42)
Ru cat **115**	perfluorobenzene	(47)
Ru cat **115**	perfluorotoluene	(50)
Hov II	DCE	(7)
Hov II	toluene	(20)
Hov II	perfluorobenzene	(39)
Hov II	perfluorotoluene	(44)
Gr II	DCE	(27)
Gr II	toluene	(37)

Catalyst	Solvent	
Gr II	perfluorobenzene	(45)
Gr II	perfluorotoluene	(50)
Ind II	DCE	(25)
Ind II	toluene	(38)
Ind II	perfluorobenzene	(47)
Ind II	perfluorotoluene	(51)
Ru cat **282**	DCE	(24)
Ru cat **282**	toluene	(39)
Ru cat **282**	perfluorobenzene	(32)
Ru cat **282**	perfluorotoluene	(13)

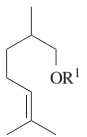
TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)

A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

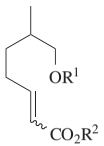
C_9





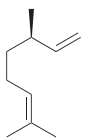
2 eq

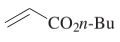
Catalyst (*x* eq),
additive (0.03 eq),
solvent



R^1	R^2	Catalyst	*x*	Additive	Solvent	Temp (°)	Time (h)		
H	Me	Hov II	0.02	—	DCM	35	15	(0)	1159
H	Me	Hov II	0.02	—	toluene	40	15	(0)	1159
H	Me	Hov II	0.02	—	DMC	40	15	(0)	1159
H	Me	Hov II	0.02	—	DMC	60	15	(68)	1159
H	Me	Hov II	0.02	—	toluene	60	15	(50)	1159
H	Me	Hov II	0.02	—	DMC	80	15	(60)	1159
H	Me	Hov II	0.005	—	DMC	80	24	(53)	1159
TBS	Et	Gr II	0.03	—	2.5 % aq. PTS	22	12	(82)	931
TBS	*t*-Bu	Gr II	0.03	—	2.5 % aq. PTS	22	12	(84)	931
TBS	*t*-Bu	Gr II	0.03	NaCl	2.5 % aq. PTS	22	12	(86)	931
Ac	*t*-Bu	Gr II	0.03	—	2.5 % aq. PTS	22	12	(80)	931
Ac	2-ethylhexyl	Gr II	0.03	—	2.5 % aq. PTS	22	12	(78)	931
Ac	*n*-Bu	Ru cat **170**	0.01	—	AcOEt	80	1	(43)	751

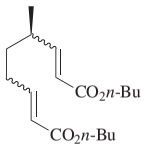
C_{10}





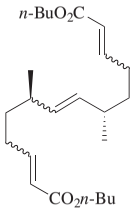
x eq

Ru cat **170** (0.01 eq), 17 h



I

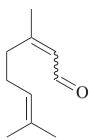
+

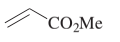


II

751

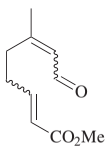
x	Temp (°)	**I**	**II**
1	rt	(15)	(<25)
4	rt	(22)	(—)
4	60	(32)	(—)





x eq

Hov II (0.02 eq), solvent, 8 h



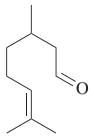
x	Solvent	Temp (°)		
2	toluene	80	(40)	1159
4	toluene	80	(44)	
2	DMC	80	(42)	
10	DMC	80	(43)	
2	DMC	60	(35)	

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

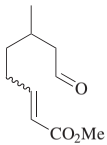
C_{10}





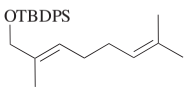
x eq

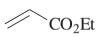
Catalyst (*y* eq), solvent



1159

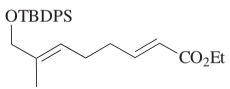
x	Catalyst	*y*	Solvent	Temp (°)	Time (h)	
2	Hov II	0.02	DCM	35	15	(54)
2	Hov II	0.02	toluene	40	15	(70)
2	Hov II	0.02	DMC	40	15	(74)
2	Hov II	0.02	DMC	60	15	(68)
2	Hov II	0.005	DMC	80	3	(70)
4	Hov II	0.005	DMC	80	3	(70)
10	Hov I	0.005	DMC	80	3	(45)
2	Gr II	0.005	DMC	80	3	(20)
2	Ind II	0.005	DMC	80	3	(10)
2	Ru cat **89**	0.005	DMC	80	3	(80)





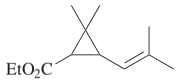
1 eq

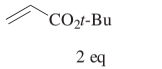
Gr II (0.05 eq),
DCM, 23°, 12 h



(61) (*E*) only

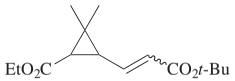
902





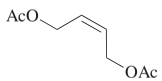
2 eq

Gr II (0.03 eq),
2.5 % aq. PTS,
22°, 12 h



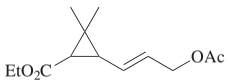
(50)

931



2 eq

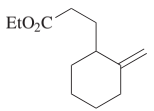
Ind II (4 x 0.05 eq),
solvent, 120°

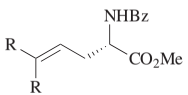


(*E*)/(*Z*) = 82:18

40

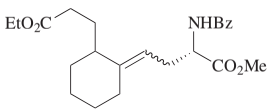
Solvent	Time	MW	
$C_6D_5CD_3$	24 h	—	(10)
$C_6F_5CF_3$	4 x 10 min	200 W	(51)



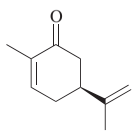


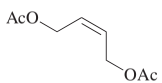
30 eq

Hov II (0.05 eq),
benzene, 100°, 14 h



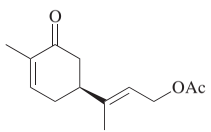
R		
H	(0)	337
Me	(57)	





2 eq

Ind II (*x* eq), solvent

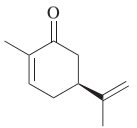
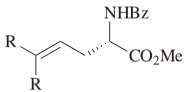
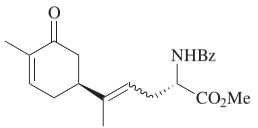
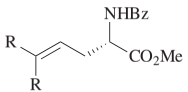
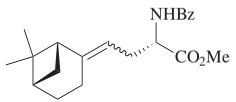
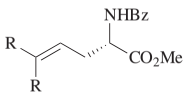
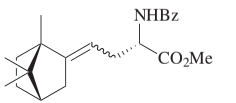
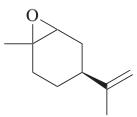
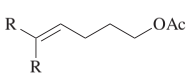
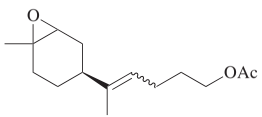


(*E*) only

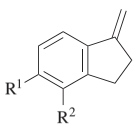
40

x	Solvent	Temp (°)	Time	
0.2	CD_2Cl_2	40	6 h	(10)
4 x 0.05	$C_6F_5CF_3$	120	4 x 10 min	(35)
4 x 0.05	$C_6F_5CF_3$	120 (MW)	4 x 10 min	(46)

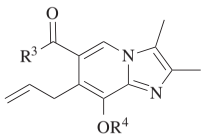
TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)			Refs.
Please refer to the charts preceding the tables for the catalyst structures.						
C_{10}						
 30 eq		Hov II (0.05 eq), benzene, 100°, 14 h		R H Me	(0) (43)	337
 30 eq		Hov II (0.05 eq), benzene, 100°, 14 h		R H Me	(0) (36)	337
 30 eq		Hov II (0.05 eq), benzene, 100°, 14 h		R H Me	(0) (24)	337
 30 eq		Hov II (0.05 eq), benzene, 100°, 14 h		R H Me	(0) (87)	337

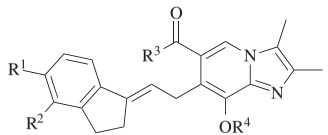
C_{10-11}



x eq



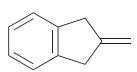
Catalyst (*y* eq), solvent



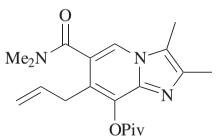
502

R^1	R^2	*x*	R^3	R^4	Catalyst	*y*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)
H	H	3.7	Me_2N	Piv	Gr II	0.08	DCE	80	2	(25)	(*E*) only
H	H	3	Me_2N	TDS	Gr II	0.09	DCM	40	18	(72)	(*E*) only
H	H	3.7	EtO	TDS	Gr II	0.08	DCM	40	18	(68)	—
H	H	2.2	EtO	TDS	Hov II	0.056	DCM	40	24	(40)	(*E*) only
F	H	2.8	EtO	TDS	Hov II	0.07	DCM	40	24	(34)	—
H	Me	2.2	EtO	TDS	Hov II	0.056	DCM	40	17	(43)	—

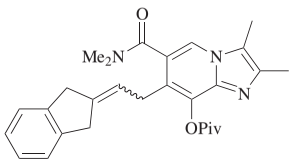
C_{10}



x eq



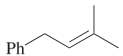
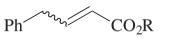
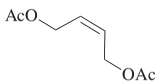
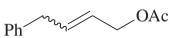
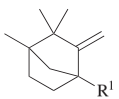
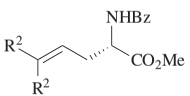
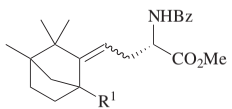
Catalyst (*y* eq),
DCE, 80°, 4 h



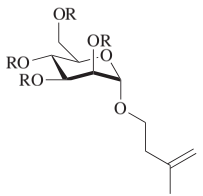
502

x	Catalyst	*y*	
4	Gr II	0.08	(44)
5	Hov II	0.082	(27)

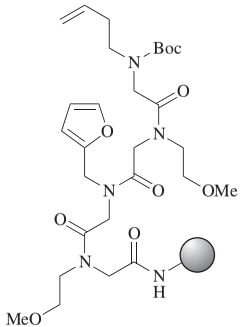
TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{10}				
	 2 eq	Gr II (0.03 eq), 2.5 % aq. PTS, 22°, 12 h	 R: *t*-Bu (88); 2-ethylhexyl (88)	931
2 eq		Gr II (0.03 eq), 2.5 % aq. PTS, 22°, 12 h	 (84)	931
C_{11-12}				
 30 eq		Hov II (0.05 eq), benzene, 100°, 14 h	 R^1 / R^2: H/H (0); H/Me (34); Me/Me (0)	337

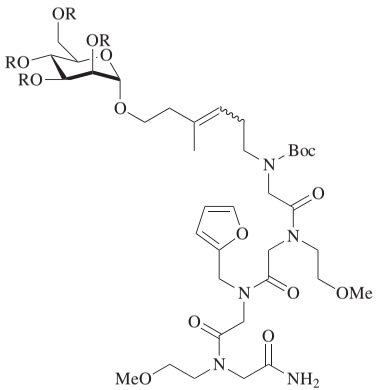
C_{11}



20 eq



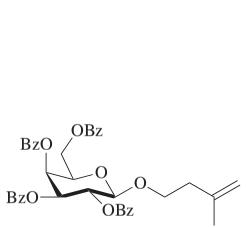
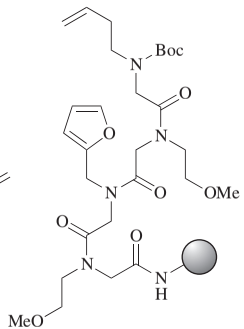
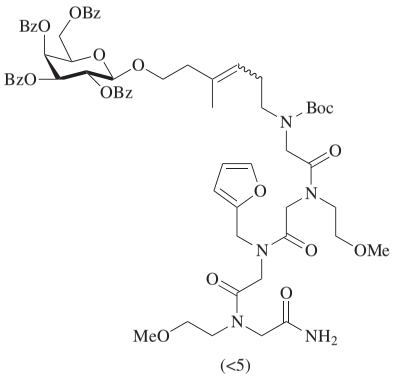
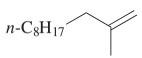
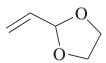
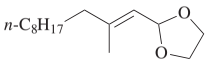
1. Hov II (0.05 eq), DCM, 40°, 8 h
2. TFA (92%), H_2O (5%), TIS (3%), 1–2 h

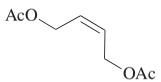


12

R	
Bz	(<5)
Ac	(<5)

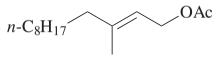
TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{11}				
 20 eq		1. Hov II (0.05 eq), DCM, 40°, 8 h 2. TFA (92%), H_2O (5%), TIS (3%), 1–2 h	 (<5)	12
C_{12}				
 3 eq		Gr II (0.03–0.05 eq), DCM, 40°, 12 h	 (67) (*E*)/(*Z*) = 75:25	36, 241



2 eq

Gr II (0.05 eq),
DCM, 40°, 12 h

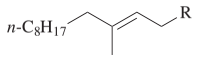


(53) (*E*)/(*Z*) = 71:29 241



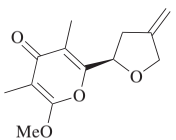
2 eq

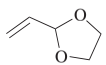
Gr II (0.05 eq),
DCM, 40°, 12 h



241

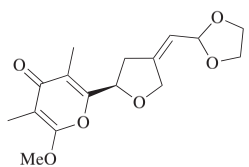
R		(*E*)/(*Z*)
PhO_2S	(87)	77:23
$AcO(CH_2)_3$	(60)	70:30



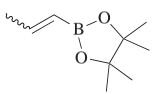


2 eq

Gr II (0.05 eq),
DCM, reflux

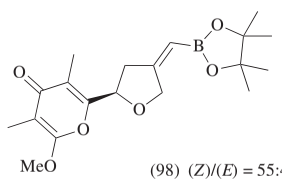


(65) (*Z*)/(*E*) = 55:45 1160



2 eq

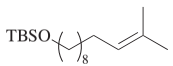
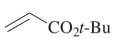
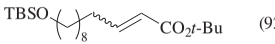
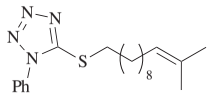
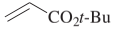
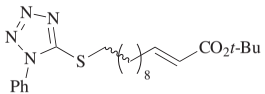
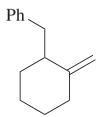
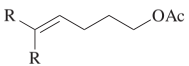
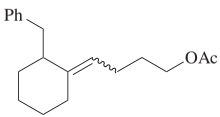
Gr II (0.05 eq),
DCM, reflux



1160

(98) (*Z*)/(*E*) = 55:45

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{13}				
	 2 eq	Gr II (0.03 eq), 2.5 % aq. PTS, 22°, 12 h	 (92)	931
C_{14}				
	 2 eq	Gr II (0.03 eq) 2.5% aq PTS, 22°, 12 h	 (55)	931
	 *x* eq	Catalyst (0.05 eq), solvent		

R	*x*	Catalyst	Solvent	Temp (°)	Time (h)		
H	3	Hov II	DCM	reflux	24	(17)	177
H	3	Ru cat **271**	DCM	reflux	24	(0)	177
H	3	Ru cat **187**	DCM	reflux	24	(7)	177
H	0.03	Hov II	benzene	100	14	(17)	337
H	0.03	Ru cat **271**	benzene	100	14	(0)	337
Me	0.03	Hov II	benzene	100	14	(90)	337

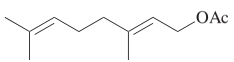
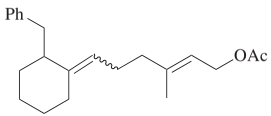
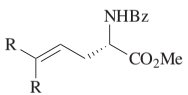
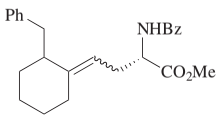
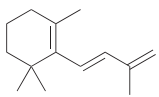
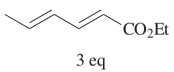
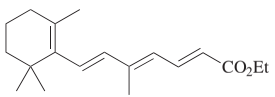
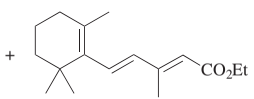
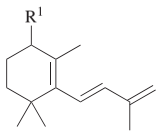
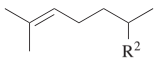
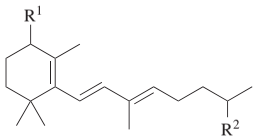
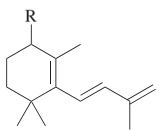
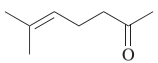
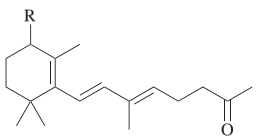
30 eq		Hov II (0.05 eq), benzene, 100°, 14 h		(53)	337
30 eq		Hov II (0.05 eq), benzene, 100°, 14 h		R H (0) Me (50)	337
	 3 eq	Hov II (0.1 eq), toluene, 50°, 16 h	 (*E*)/(*Z*) = 52:48 +  (*E*)/(*Z*) = 81:19	~5% conv.[a]	542

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)

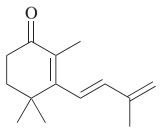
A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

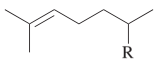
Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{14}				
	 *x* eq	Gr II (0.05 eq), DCM, 35°, 18 h		337

R^1	R^2	*x*		(*E*)/(*Z*)
H	H	2.1	(95)	64:36
H	TBSO	2.1	(75)	64:36
TBSO	H	2.1	(95)	73:27
TBSO	TBSO	1.5	(75)	76:23

	 *x* eq	Gr II (0.05 eq), DCM, 35°, 18 h		337

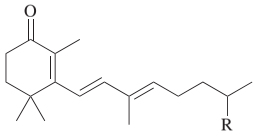
R	*x*		(*E*)/(*Z*)
H	2.1	(75)	55:45
TBSO	1.5	(70)	71:29





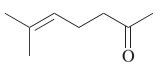
2.1 eq

Gr II (0.05 eq),
DCM, 35°, 18 h



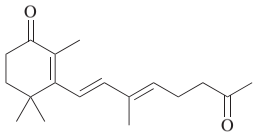
R		(*E*)/(*Z*)
H	(69)	77:23
TBSO	(89)	76:24

337



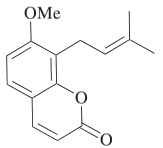
2.1 eq

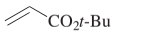
Gr II (0.05 eq),
DCM, 35°, 18 h



(57) (*E*)/(*Z*) = 64:36

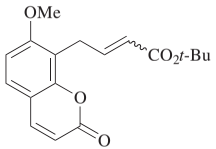
337





3 eq

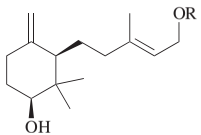
Gr II (0.03 eq),
CuI (0.04 eq),
Et_2O, 35°, 24 h

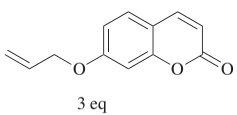


(81)

167

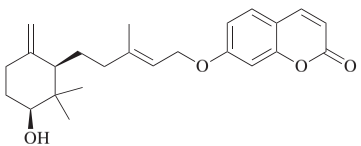
C_{15}





3 eq

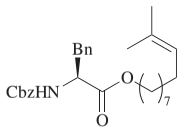
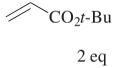
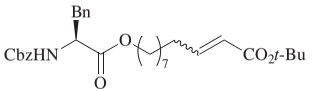
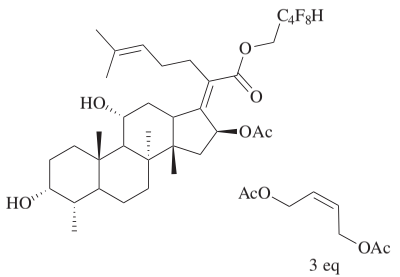
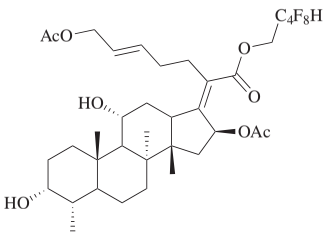
Catalyst (0.1 eq),
DCM, reflux, 48 h



R	Catalyst		(*E*)/(*Z*)
H	Gr I	(0)	—
H	Gr II	(0)	—
Ac	Gr II	(19)	60:40

578

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
A. ALKENES WITH FUNCTIONAL GROUPS IN ALLYLIC AND MORE DISTANT POSITIONS (*Continued*)

Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{21} 	 2 eq	Gr II (0.03 eq) 2.5% aq PTS, 22°, 12 h	 (97)	931
C_{28} 	3 eq	Gr II (0.05 eq), solvent, 6 h	 (*E*) only	140

Solvent	Temp (°)	Conv. (%)[a]	
DCM	40	28	(—)
$C_6F_5CF_3$	70	92	(71)

[a] The conversion was determined by ^{1}H NMR analysis

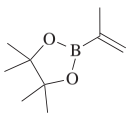
TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)

B. BORONIC ESTERS

Boronic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

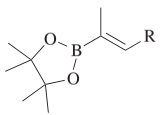
C_3





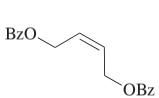
x eq

Gr II (0.05 eq),
DCM, reflux, 12 h



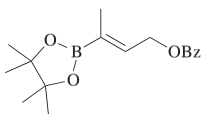
R	*x*		(*E*)/(*Z*)	
$TIPSCH_2$	1	(59)	>95:5	125
$TMSCH_2$	2	(59)	>95:5	125
Ph	2	(30)	>95:5	125
$BzO(CH_2)_2$	1	(46)	>95:5	125
$AcO(CH_2)_4$	0.5	(58)	>95:5	125
$AcO(CH_2)_4$	—	(64)	—	902

2 eq



(*Z*)/(*E*) = 94:6

Gr II (0.05 eq),
DCM, reflux, 12 h



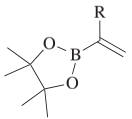
(30) (*E*)/(*Z*) = 67:33 902

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
B. BORONIC ESTERS (*Continued*)

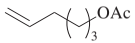
Boronic Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

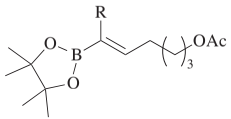
C_{3-8}



x eq



Gr II (*y* eq),
DCM, reflux, 12 h



125

R	*x*	*y*		(*E*)/(*Z*)
Me	2	0.05	(58)	>95:5
$HOCH_2$	2	0.05	(0)	—
$AcOCH_2$	2	0.05	(40)	50:50
$TBSOCH_2$	2	0.05	(0)	—
$HO(CH_2)_2$	2	0.05	(0)	—
$AcO(CH_2)_2$	2	0.05	(0)	—
$TBSO(CH_2)_2$	1.3	0.05	(17)	83:17
$TBSO(CH_2)_3$	1.2	0.05	(35)	80:20
n-C_6H_{13}	2	0.05	(40)	75:25
n-C_6H_{13}	2	0.2	(54)	80:20

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
C. LACTONES WITH AN EXOCYCLIC C–C DOUBLE BOND

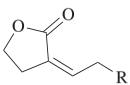
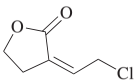
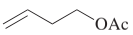
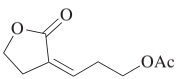
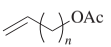
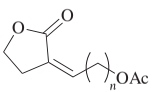
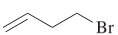
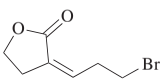
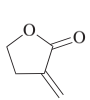
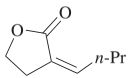
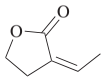
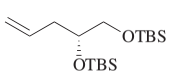
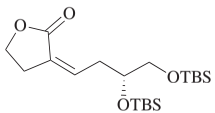
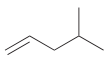
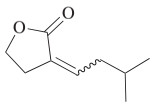
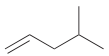
Lactone	Cross Partner	Conditions	Product(s) and Yield(s) (%)		Refs.
Please refer to the charts preceding the tables for the catalyst structures.					
C_5					
	 1.5 eq	Gr II (*x* eq), ClBcat (0.05 eq), DCM, 40°, 14 h	 (*Z*)/(*E*) = 83:17	R — *x*: TMS — 0.025 (64); TMS — 2 x 0.025 (81); $(EtO)_2OP$ — 0.025 (45); $(EtO)_2OP$ — 2 x 0.025 (59)	173
	 1.5 eq	Hov II (2 x 0.05 eq), 2,6-Cl_2-BQ (0.1 eq), DCM, reflux, 12 h		(44) (*Z*)/(*E*) > 95:5	1162
	 1.5 eq	Gr II (*x* eq), ClBcat (0.05 eq), DCM, 40°, 14 h	 (*Z*)/(*E*) = 90:10	*x*: 0.025 (28); 2 x 0.025 (68)	173
	 1.5 eq	Hov II (2 x 0.05 eq), 2,6-Cl_2-BQ (0.1 eq), DCM, reflux, 12 h		*n*: (75) (*Z*)/(*E*) 91:9; 8 (80) 94:6	1162
	 1.5 eq	Hov II (2 x 0.05 eq), 2,6-Cl_2-BQ (0.1 eq), DCM, reflux, 12 h		(43) (*Z*)/(*E*) > 95:5	1162

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
C. LACTONES WITH AN EXOCYCLIC C–C DOUBLE BOND (*Continued*)

Lactone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
	 1.5 eq	Hov II (2 x 0.05 eq), 2,6-Cl_2-BQ (0.1 eq), DCM, reflux, 12 h	 (83) (*Z*)/(*E*) > 95:5	1162
	 10 eq	Hov II (2 x 0.05 eq), 2,6-Cl_2-BQ (0.1 eq), DCM, reflux, 12 h	 (93) (*Z*)/(*E*) = 86:14	1162
	 1.5 eq	Gr II (0.025 eq), ClBcat (0.05 eq), DCM, 40°, 14 h	 (72) (*Z*)/(*E*) = 89:11	173, 1163
I	 1.5 eq	Catalyst (*x* eq), CD_2Cl_2, 40°, 20 h	 **II** +  **III**	173

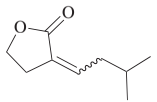
Catalyst	*x*	**I/II/III**[a]
Gr I	0.1	**I** only
Gr II	0.1	10:42:48
Gr II	0.05	9:55:36
Gr II	0.025	31:50:19
Gr II	0.01	46:44:10
Hov II	0.1	**I** only

I



1.5 eq

Gr II (0.025 eq),
additive (0.05 eq),
CD_2Cl_2, 40°, 14 h



II

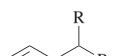
+



III

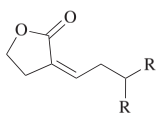
173

Additive	**II**	**I/II/III**[a]
—	(48)	31:50:19
Cy_2PCl	(14)	0:16:84
Ph_3PO	(56)	0:60:40
Cy_3PO	(64)	0:67:33
Ph_3As	(63)	0:69:31
Ph_2PCl	(71)	0:88:12
2,6-Cl_2-BQ	(77)	14:86:0
ClBcat	(87)	0:91:9



1.5 eq

Gr II (*x* eq),
ClBcat (0.05 eq),
DCM, 40°, 14 h



173

R	*x*		(*Z*)/(*E*)
Me	0.025	(87)	>95:5
MeO_2C	0.025	(24)	86:14
MeO_2C	2 x 0.025	(41)	86:14

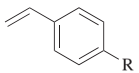
TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
C. LACTONES WITH AN EXOCYCLIC C–C DOUBLE BOND (*Continued*)

Lactone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

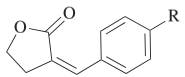
C_5





1.5 eq

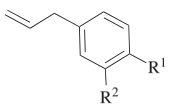
Gr II (0.025 eq),
ClBcat (0.05 eq),
DCM, 40°, 14 h



(*Z*)/(*E*) > 95:5

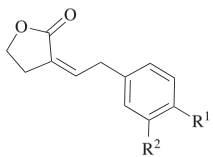
R		
H	(67)	
F	(65)	
MeO	(85)	

173



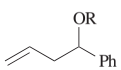
1.5 eq

Gr II (*x* eq),
ClBcat (0.05 eq),
DCM, 40°, 14 h



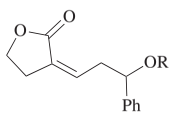
R^1	R^2	*x*		(*Z*)/(*E*)
HO	MeO	0.025	(86)	>95:5
MeO	H	0.025	(54)	91:9
MeO	H	2 x 0.025	(70)	91:9

173



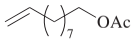
1.5 eq

Gr II (*x* eq),
ClBcat (0.05 eq),
DCM, 40°, 14 h



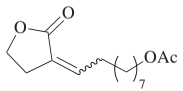
R	*x*		(*Z*)/(*E*)
MOM	0.025	(51)	>95:5
MOM	2 x 0.025	(88)	>95:5
TBS	0.025	(94)	91:9

173



1.5 eq

Catalyst (x eq),
2,6-Cl_2-BQ (y eq),
CD_2Cl_2, 40°



I

+

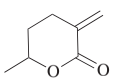


II

1162

Catalyst	x	y	**I/II**[a]
Gr II	0.05	—	0:92
Hov II	0.05	—	0:87
Gr II	0.05	10	23:25
Hov II	0.05	10	67:0
Hov II	2 x 0.05	10	98:0

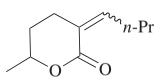
C_7





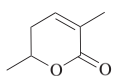
1.5 eq

Catalyst (x eq),
additive (y eq),
solvent, 40°



I

+

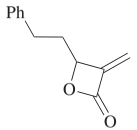
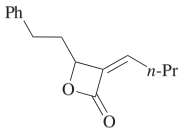
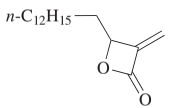
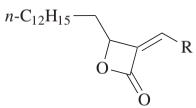
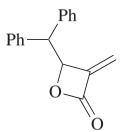
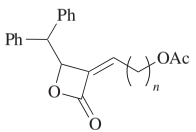


II

1162

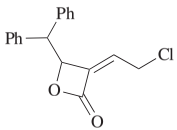
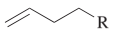
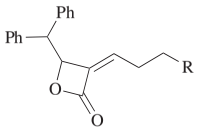
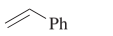
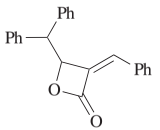
Catalyst	x	Additive	y	Solvent	Time (h)	**I/II**[a]
Gr II	0.05	—	—	CD_2Cl_2	48	19:0
Hov II	0.05	—	—	CD_2Cl_2	48	11:0
Gr II	0.05	—	—	tol-d_8	48	0:66
Gr II	0.05	2,6-Cl_2-BQ	0.1	tol-d_8	48	0:26
Gr II	0.05	Ti(O*i*-Pr)$_4$	0.2	CD_2Cl_2	48	0:0
Gr II	0.05	Ti(O*i*-Pr)$_4$	0.2	tol-d_8	8	**II** only
Gr II	0.05	2,6-Cl_2-BQ, Ti(O*i*-Pr)$_4$	0.1, 0.2	tol-d_8	8	**II** only
Gr II	2 x 0.05	HOAc	1.5	CD_2Cl_2	36	54:tr

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
C. LACTONES WITH AN EXOCYCLIC C–C DOUBLE BOND (*Continued*)

Lactone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{12} 	 1.5 eq	Gr II (0.05 eq), DCM, 40–55°, 12–24 h	 (76) (*Z*)/(*E*) = 82:18	172
C_{17} 	 2 eq	Gr II (0.05 eq), DCM, reflux, overnight		1164
	 1.5 eq	Gr II (0.05 eq), DCM, 40–55°, 12–24 h		172

R		(*Z*)/(*E*)
n-C_6H_{13}	(97)	76:24
Ph	(40)	(*Z*) only
$Ph(CH_2)_3$	(51)	(*Z*) only
$Ph(CH_2)_4$	(68)	(*Z*) only
n-$C_{18}H_{37}$	(74)	69:31

n		(*Z*)/(*E*)
1	(84)	>95:5
2	(90)	>95:5
3	(85)	93:7
7	(84)	>95:5

 1.5 eq	Hov II (0.05 eq), DCM, 40–55°, 12–24 h		(80) (*Z*)/(*E*) = 92:8	172
 1.5 eq	Gr II (0.05 eq), DCM, 40–55°, 12–24 h		R (88) (*Z*)/(*E*) TBSO (88) 90:10 Br (93) >95:5 Me (94) 92:8	172
 1.5 eq	Gr II (0.05 eq), DCM, 40–55°, 12–24 h		(55) (*Z*)/(*E*) > 95:5	172

[a] The ratio was determined by ^{1}H NMR analysis.

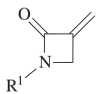
TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)

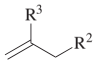
D. LACTAMS WITH AN EXOCYCLIC C–C DOUBLE BOND

Lactam	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

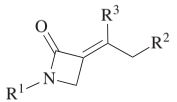
C_4





2 eq

Catalyst (*x* eq),
DCM, reflux



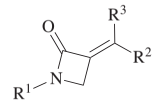
1165

R^1	R^2	R^3	Catalyst	*x*		(*E*)/(*Z*)
H	Cl	H	Hov II	0.06	(25)	52:48
H	Cl	H	Hov II	0.09	(60)	52:48
Boc	Cl	CH_3	Hov II	0.1	(58)	39:61
Boc	TMS	CH_3	Hov II	0.1	(73)	39:61
Boc	HO	CH_3	Hov II	0.1	(86)	39:61
Boc	Cl	H	Gr II	0.15	(0)	—
Boc	Cl	H	Hov II	0.06	(78)	55:45
Ph	Cl	H	Hov II	0.06	(54)	52:48
4-$MeOC_6H_4$	Cl	H	Hov II	0.06	(48)	52:48
Bn	Cl	H	Hov II	0.06	(58)	52:48



2 eq

Catalyst (x eq),
DCM, reflux



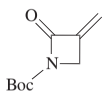
R^1	R^2	R^3	Catalyst	x		(E)/(Z)
Boc	$AcO(CH_2)_2$	H	Gr II	0.1	(57)	67:33
Boc	$AcO(CH_2)_2$	H	Hov II	0.03	(90)	67:33
H	$AcO(CH_2)_2$	H	Hov II	0.03	(90)	67:33
Bn	$AcO(CH_2)_2$	H	Hov II	0.03	(77)	60:40
Ph	$AcO(CH_2)_2$	H	Hov II	0.03	(76)	67:33
4-$MeOC_6H_4$	$AcO(CH_2)_2$	H	Hov II	0.03	(57)	60:40
4-$MeOC_6H_4$	$AcO(CH_2)_2$	H	Hov II	0.1	(72)	60:40
Boc	*n*-Pr	H	Gr II	0.02	(84)	71:29
H	*n*-Pr	H	Gr II	0.06	(61)	67:33
H	*n*-Pr	H	Hov II	0.03	(89)	67:33
Bn	*n*-Pr	H	Gr II	0.04	(89)	67:33
Ph	*n*-Pr	H	Gr II	0.04	(82)	75:25
4-$MeOC_6H_4$	*n*-Pr	H	Gr II	0.04	(80)	71:29
Boc	*i*-Pr	Me	Hov II	0.1	(0)	—
Boc	*n*-Pr	Me	Hov II	0.1	(85)	50:50
Bn	*n*-Pr	Me	Hov II	0.1	(74)	55:45
Boc	Et	Et	Hov II	0.1	(65)	—

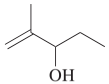
TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
D. LACTAMS WITH AN EXOCYCLIC C–C DOUBLE BOND (*Continued*)

Lactam	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

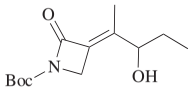
C_4





2 eq

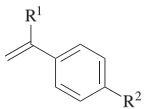
Hov II (*x* eq),
DCM, reflux



(*E*)/(*Z*) = 71:29

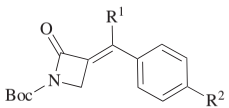
x		
0.1	(40)	
0.15	(69)	

1165



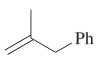
2 eq

Hov II (*x* eq),
DCM, reflux



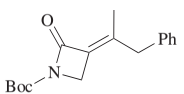
R^1	R^2	*x*		(*E*)/(*Z*)
H	MeO	0.03	(87)	83:17
H	F	0.03	(90)	75:25
Me	H	0.1	(0)	—

1165



2 eq

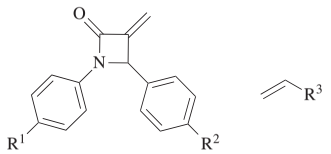
Hov II (0.1 eq),
DCM, reflux, 12 h



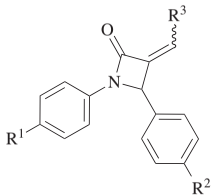
(81) (*E*)/(*Z*) = 60:40

1165

C_{16}



Hov II (3 x 0.03 eq),
solvent, 100°, 40 h

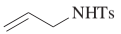
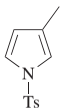
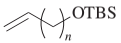
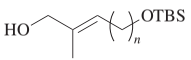
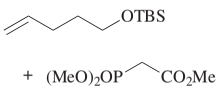
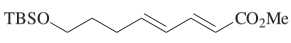
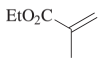
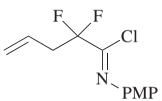
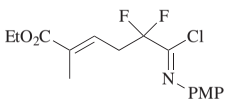


1166

R^1	R^2	R^3	Solvent	
H	H	Ph	$C_6F_5CF_3$	(88)
H	H	4-$O_2NC_6H_4$	toluene	(66)
H	H	4-$O_2NC_6H_4$	$C_6F_5CF_3$	(51)
H	H	4-NCC_6H_4	$C_6F_5CF_3$	(83)
H	H	4-$CF_3C_6H_4$	$C_6F_5CF_3$	(62)
H	H	4-ClC_6H_4	$C_6F_5CF_3$	(41)
H	H	4-$MeO_2CC_6H_4$	$C_6F_5CF_3$	(51)
H	H	4-$AcOC_6H_4$	$C_6F_5CF_3$	(52)
H	H	4-$MeOC_6H_4$	$C_6F_5CF_3$	(0)
H	H	2-naphthyl	$C_6F_5CF_3$	(0)
H	H	Bn	toluene	(43)
H	H	Bn	$C_6F_5CF_3$	(43)
H	H	*rac*-PhCH(HO)CH_2	toluene or $C_6F_5CF_3$	(0)
H	H	*rac*-PhCH(AcO)CH_2	toluene or $C_6F_5CF_3$	(0)
H	H	*rac*-PhCH(BnO)CH_2	toluene or $C_6F_5CF_3$	(0)
H	H	*rac*-PhCH(TBSO)CH_2	toluene	(72)
H	H	*rac*-PhCH(TBSO)CH_2	$C_6F_5CF_3$	(57)
F	TBSO (*rac*)	(*S*)-4-FC_6H_4CH(TBSO)CH_2	toluene	(67)
F	TBSO (*R*)	(*S*)-4-FC_6H_4CH(TBSO)CH_2	toluene	(65)

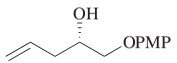
TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)

E. α-METHACRYLATES

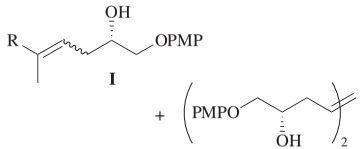
Acrylate	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 5 eq		Hov II (0.05 eq), $(PhO)_3B$ (0.1 eq), toluene, 80°, 0.75 h	 (70)	899
3 eq		1. Gr II (0.05 eq), DCM, reflux, 3 h 2. DIBAL-H (3.75 eq), DCM, –78°, 2 h	 $(E)/(Z) > 95:5$ *n*: 2 (56); 3 (69); 4 (59)	940, 941
3 eq	 + $(MeO)_2OP$ CO_2Me **I**	1. Gr II (0.05 eq), DCM, 40°, 3 h 2. **I** (1.4 eq), NaH (1.4 eq), THF, 0° to rt, 0.5 + 15 h	 (81) $(E)/(Z) = 95:5$	940
 excess		Gr II (0.1 eq), neat, reflux, 96 h	 (85) $(E)/(Z) > 95:5$	392



3 eq



Hov II (0.025 eq), DCM, rt, 36 h



II (*E*)/(*Z*) = 80:20

626

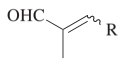
R	**I**	**II**
OHC	(2)	(40)
MeO_2C	(0)	(51)



2 eq



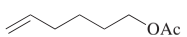
Hov II (0.02 eq), rt, 8 h



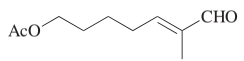
R	
n-Bu	(25)
n-C_6H_{13}	(35)
n-C_8H_{17}	(30)

927

2.6 eq



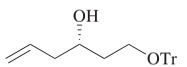
Gr II (0.05 eq), HCl/Et_2O (0.25 eq), benzene/THF, 45°, 14 h



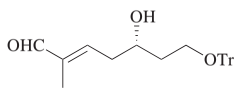
(82) (*E*)/(*Z*) > 95:5

928

3 eq

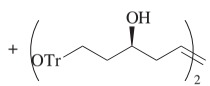


Hov II (0.025 eq), DCM, rt, 36 h



(2) (*E*)/(*Z*) >97:3

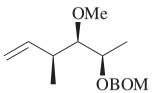
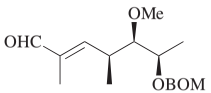
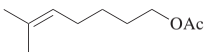
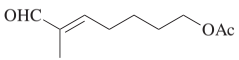
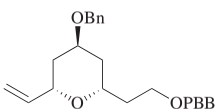
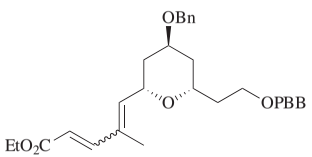
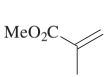
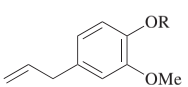
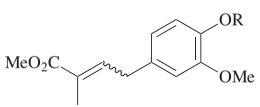
626



(25) (*E*)/(*Z*) = 80:20

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)

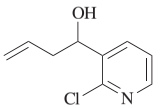
E. α-METHACRYLATES (*Continued*)

Acrylate	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 36 eq		Hov II (0.02 eq), DCM, 45°, 16 h	 (58) (*E*)/(*Z*) = 85:15	1167
— eq		Gr II (0.05 eq), DCM, 40°, 12 h	 (97) (*E*) only	36, 902
3 eq	 +  **I**	1. Hov II (0.05 eq), DCM, reflux, 12 h 2. **I** (1.43 eq), NaH (1.43 eq), THF, rt, 1 h	 (80)	1168
 *x* eq		Gr II (0.05 eq), neat, 90°, 16 h		1074

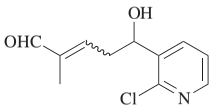
R	*x*	
H	31	(60)
Ac	39	(72)
i-Pr	39	(78)



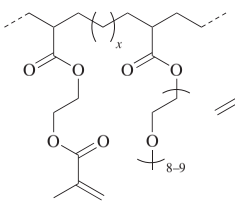
3 eq

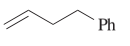


Hov II (0.1 eq),
DCM, 50°, 24 h



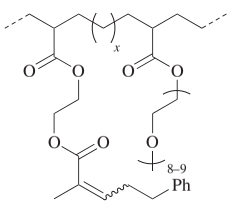
(52) 603



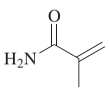


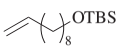
10 eq

Gr II (0.1 eq),
DCE, 70°, 12 h



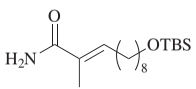
(15) 1169





1.2 eq

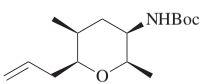
Gr II (0.05 eq),
DCM, reflux, 12 h



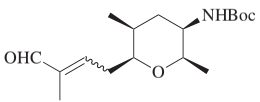
(71) (*E*)/(*Z*) > 95:5 36



10 eq

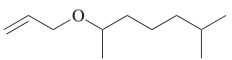
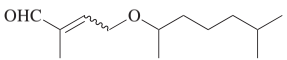
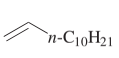
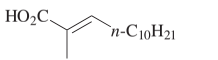
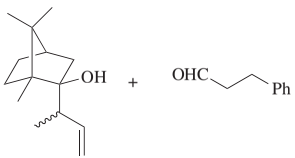
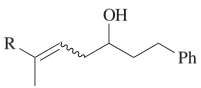
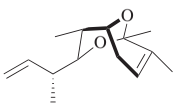
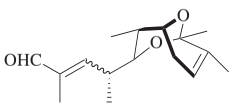
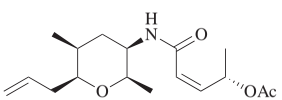
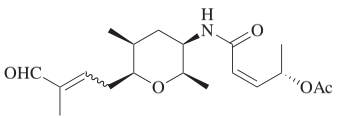


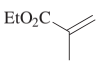
Gr II (0.05 eq),
DCE, 40°



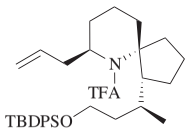
(67) 828

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)
E. α-METHACRYLATES (*Continued*)

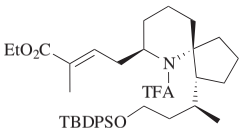
Acrylate	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 — eq		Hov II (0.02 eq), rt, 8 h	 (15)	927
	 1.1 eq	Gr II (0.05 eq), DCM, 40°, 12 h	 (23) (*E*)/(*Z*) = 80:20	36
 3 eq	 3 eq	1. CSA (0.1 eq), DCM, 25°, 122 h 2. Gr II (0.2 eq), DCM, 4 h		936
			R / (%) / er MeO_2C (0) — OHC (30) 97.0:3.0	
 4 eq		Ru cat **271** (0.1 eq), DCM, 40°	 (61)	1170
20 eq		Ru cat **88** (0.05 eq), DCM, 23°	 (57)	756, 828



20 eq



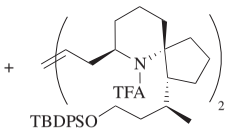
Hov II (0.1 eq),
neat, reflux, 13 h



(74) (*E*) only

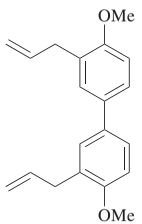
811

+

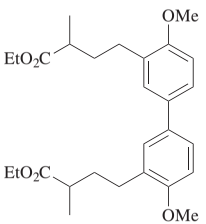


(14) (*E*) only

4 eq



1. Gr II (0.028 eq),
DCE, reflux, 10 h
2. 10% Pd/C, H_2,
AcOEt, rt, 10 h

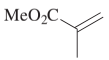
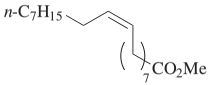
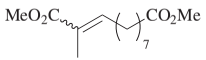
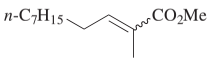


(60)

1120

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)

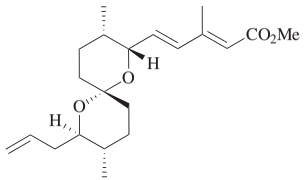
E. α-METHACRYLATES (*Continued*)

Acrylate	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4  4 eq		Catalyst (*x* eq), toluene, 60°, 4 h	 **I** +  **II** +  **III** +  **IV**	1119

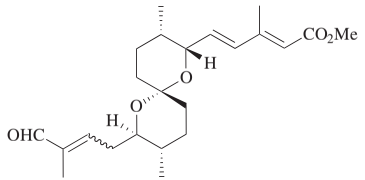
Catalyst	*x*	**I** + **II**[a]	Selectivity **I** + **II**[a]	**III** + **IV**[a]	TON	Productive TON
Ru cat **139**	0.26	(96)	97	(3)	420	360
Ru cat **139**	0.026	(95)	99	(1)	3640	3600
Ru cat **139**	0.0026	(96)	96	(4)	37000	35450
Ru cat **139**	0.0003	(53)	16	(84)	177700	28300
Ru cat **320**	0.0029	(96)	97	(3)	330	320
Ru cat **320**	0.029	(97)	97	(3)	3300	3200
Ru cat **320**	0.0029	(96)	97	(3)	33000	31100
Ru cat **320**	0.0003	(26)	4	(96)	88500	3470



5 eq



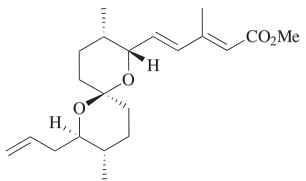
Ru cat **35** (0.05 eq),
DCM, reflux



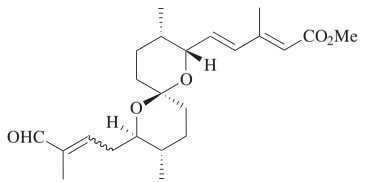
(74)

753

5 eq



Ru cat **35** (0.05 eq),
DCM, reflux

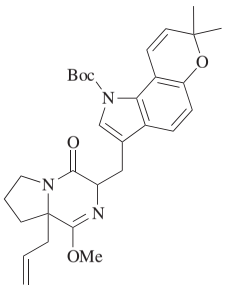
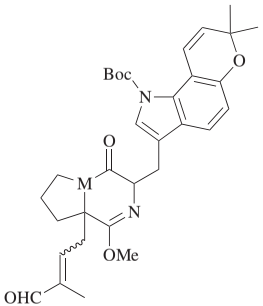
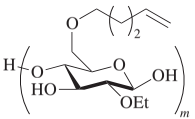
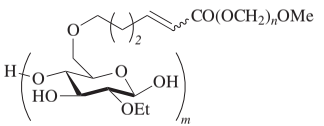


(74)

753

TABLE 25. CROSS-METATHESIS OF GEMINAL–DISUBSTITUTED COMPOUNDS (*Continued*)

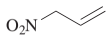
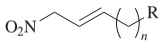
E. α-METHACRYLATES (*Continued*)

Acrylate	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 12.5 eq		Catalyst (*x* eq), DCM		1171
		Catalyst: Gr II; *x*: 0.2; Temp (°): reflux; Time (h): 24; (65)		
		Catalyst: Hov II; *x*: 0.05; Temp (°): reflux; Time (h): 48; (71)		
		Catalyst: Hov II; *x*: 0.05; Temp (°): 100 (MW); Time (h): 0.33; (73)		
 40 eq		Hov II (0.1 eq), DCM, 37°		1033
		Time (h): 2; Conv. (%)[b]: 85		
		Time (h): 12; Conv. (%)[b]: 100		

[a] The yield and selectivity were determined by GC analysis.

[b] The conversion was determined by ^{1}H NMR analysis.

TABLE 26. CROSS-METATHESIS OF ALLYLIC NITRO COMPOUNDS

Nitro Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 2 eq		Ru cat **88** (0.05 eq), $B(OPh)_3$ (0.25 eq), DCM, 40°, 5 h		179

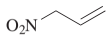
n	R		(*E*)/(*Z*)
1	Ph	(66)	93:7
1	$(EtCO_2)_2CH$	(52)	84:16
2	Ac	(71)	94:6
2		(43)	89:11
3	MeO_2C	(62)	93:7
8	Br	(70)	88:12
10	Me	(73)	84:16

TABLE 26. CROSS-METATHESIS OF ALLYLIC NITRO COMPOUNDS (*Continued*)

Nitro Compound	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

C_3



2 eq



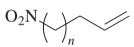
Catalyst (*x* eq), additive (*y* eq), solvent, 5 h



179

Catalyst	*x*	Additive	*y*	Solvent	Temp (°)	Conv. (%)[a]	
Gr II	0.05	—	—	DCM	40	1	(—)
Hov II	0.05	—	—	DCM	40	37	(—)
Ru cat **88**	0.05	—	—	DCM	40	44	(—)
Ru cat **88**	0.1	—	—	DCM	40	51	(—)
Ru cat **88**	0.05	—	—	toluene	70	36	(—)
Ru cat **88**	0.05	—	—	$C_6F_5CF_3$	70	60	(—)
Ru cat **88**	0.05	$Ti(O\textit{i}\text{-}Pr)_4$	0.1	DCM	40	19	(16)
Ru cat **88**	0.05	Ph_2SnCl_2	0.1	DCM	40	62	(58)
Ru cat **88**	0.05	$BF_3{\bullet}Et_2O$	0.1	DCM	40	86	(58)
Ru cat **88**	0.05	$B(OMe)_3$	0.1	DCM	40	26	(26)
Ru cat **88**	0.05	$B(OPh)_3$	0.1	DCM	40	68	(68)
Ru cat **88**	0.05	$B(OPh)_3$	0.05	DCM	40	70	(65)
Ru cat **88**	0.05	$B(OPh)_3$	0.25	DCM	40	80	(74)
Ru cat **88**	0.05	$B(OPh)_3$	0.5	DCM	40	83	(74)
Ru cat **88**	0.05	$B(OPh)_3$	1.0	DCM	40	81	(78)
Ru cat **88**	0.05	PhO_2BCl	0.01	DCM	40	54	(54)

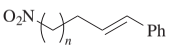
C_{4-6}





x eq

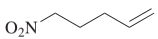
Gr II (*y* eq), DCM, reflux, 18 h



(*E*) only 146

n	*x*	*y*	
1	4	0.048	(68)
2	3.6	0.052	(63)
3	3.5	0.077	(69)

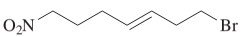
C_5



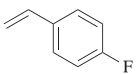


3.6 eq

Gr II (0.052 eq), DCM, refux, 18 h

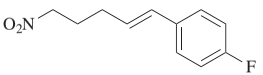


(79) (*E*) only 146

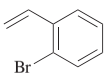


3.6 eq

Gr II (0.052 eq), DCM, reflux, 18 h

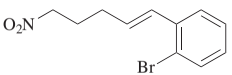


(69) (*E*) only 146



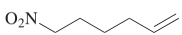
3.6 eq

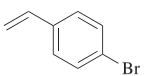
Gr II (0.052 eq), DCM, reflux, 18 h



(68) (*E*) only 146

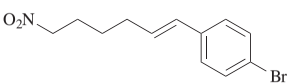
C_6





4 eq

Gr II (0.052 eq), DCM, reflux, 18 h



(65) (*E*) only 146

[a] The conversion was determined by ^{1}NMR analysis.

TABLE 27. CROSS-METATHESIS OF ACRYLONITRILE AND METHACRYLONITRILE

Nitrile	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

C_3



Catalyst (*x* eq), solvent



Catalyst	*x*	Solvent	Temp (°)	Time (h)		(*Z*)/(*E*)	
Gr I	0.02	DCM	45	12	(0)	—	151
Gr I	0.1	DCM	45	24	(0)	—	151
Gr II	0.02	DCM	45	12	(2)	—	151
Gr II	0.1	DCM	45	24	(12)	—	151
Hov II	0.02	DCM	45	24	(21)	—	151
Ru cat **30**	0.1	DCM	45	24	(15)	—	151
Ru cat **65**	0.02	DCM	45	24	(39)	—	151
Ru cat **65**	0.1	toluene	110	12	(38)	—	151
Ru cat **69**	0.02	DCM	45	12	(12)	75:25	1172
Ru cat **69**	0.1	DCM	45	12	(36)	75:25	1172

2 eq 

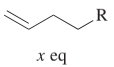
Ru cat **69** (*x* eq), DCM, 45°, 12 h



I **II**

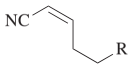
1172

R	*x*	**I**	(*Z*)/(*E*) **I**	**II**
$HOCH_2$	0.02	(56)	75:25	(5)
$HOCH_2$	0.1	(68)	75:25	(3)
MeO_2C	0.02	(60)	80:20	(—)
MeO_2C	0.1	(71)	80:20	(—)
OHC	0.02	(61)	80:20	(—)
OHC	0.1	(77)	80:20	(—)
HO_2C	0.02	(35)	75:25	(11)
HO_2C	0.1	(55)	75:25	(7)



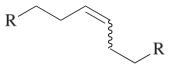
x eq

Catalyst (*y* eq), solvent



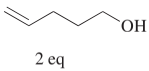
I

+



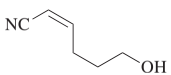
II

R	*x*	Catalyst	*y*	Solvent	Temp (°)	Time (h)	**I**	(*Z*)/(*E*) **I**	**II**	
Br	2	Mo cat **1**	0.05	DCM	rt	3	(18)	90:10	(20)	149
BnO	2	Mo cat **1**	0.05	DCM	rt	3	(40)	80:20	(—)	149
TBSO	2	Mo cat **1**	0.05	DCM	rt	3	(73)	84:16	(10)	149
TMS	2	Mo cat **1**	0.05	DCM	rt	3	(76)	75:25	(—)	149
BnO_2C	2	Mo cat **1**	0.05	DCM	rt	3	(44)	85:15	(6)	149
TMS	2	Mo cat **1**	0.05	DME	rt	4	(76)	82:18	(—)	208
BzO	2	Ru cat **286**	0.02	DCM	40	24	(0)	—	(—)	161
BzO	—	Ru cat **98**	0.02	DCM	40	24	(40)	80:20	(—)	965
BzO	2	Ru cat **99**	0.02	DCM	40	24	(48)	80:20	(—)	965
BzO	2	Ru cat **189**	0.02	DCM	40	24	(84)	80:20	(—)	965
OHC	2	Hov II	0.05	DCM	45	2	(91)	80:20	(—)	153



2 eq

Hov II (0.05 eq),
DCM, reflux, 3 h



182

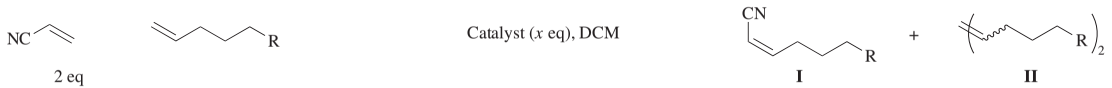
Concn (M)		(*Z*)/(*E*)
0.5	(35)	67:33
0.07	(74)	71:29
0.24	(60)	67:33

TABLE 27. CROSS-METATHESIS OF ACRYLONITRILE AND METHACRYLONITRILE (*Continued*)

Nitrile	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

C_3



R	Catalyst	*x*	Temp (°)	Time (h)	**I**	(*Z*)/(*E*) **I**	**II**	
Br	Mo cat **1**	0.05	rt	3	(45)	88:12	(11)	149
BnO	Mo cat **1**	0.05	rt	3	(60)	88:12	(<1)	149
TBSO	Mo cat **1**	0.05	rt	3	(68)	85:15	(—)	149
HO	Hov II	0.05	45	2	(81)	75:25	(—)	153
BzO	Hov II	0.05	45	2	(88)	80:20	(—)	153
BzO	Ru cat **243**	0.05	45	12	(15)	—	(—)	923
BzO	Ru cat **191**	0.05	45	12	(98)	—	(—)	923
BzO	Ru cat **98**	0.02	40	24	(39)	80:20	(—)	965
BzO	Ru cat **99**	0.02	40	24	(42)	80:20	(—)	965
BzO	Ru cat **100**	0.02	40	24	(24)	80:20	(—)	965
BzO	Ru cat **101**	0.02	40	24	(47)	80:20	(—)	965
BzO	Ru cat **102**	0.02	40	24	(49)	80:20	(—)	965

x eq		Gr II (0.01 eq), CuCl (*y* eq), DCM, 40°		150

x	R	*y*	Time (h)	Conv. (%)[a]
1	H	0.04	16	53
1	H	—	16	29
1	Bz	—	3	40
1	Bz	0.04	3	65
1	Bz	0.08	3	63
1	Bz	0.16	3	46
4	Bz	0.04	3	30
1	Bz	0.04	16	65
1	Bz	—	16	45

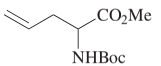
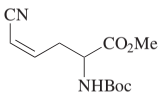
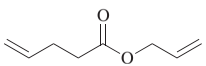
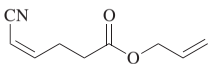
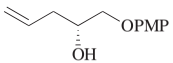
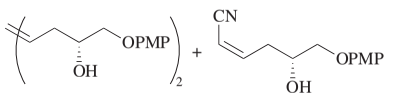
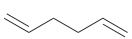
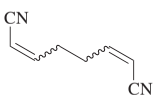
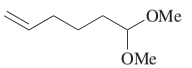
2 eq		Hov II (0.08 eq), DCM, 45°, 6 h		(83) (*Z*)/(*E*) = 75:25	153
3 eq		Hov II (0.05 eq), DCM, 45°, 2 h		(60) (*Z*)/(*E*) = 80:20	153
2 eq		Hov II (0.025 eq), DCM, rt, 15 h	 (49) (*E*)/(*Z*) = 80:20 (20) (*Z*) only		626
3 eq		Ru cat **93** (4 x 0.01 eq), $CDCl_3$, 100° (MW), 4 h		(55)	926

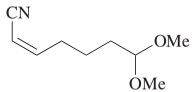
TABLE 27. CROSS-METATHESIS OF ACRYLONITRILE AND METHACRYLONITRILE (*Continued*)

Nitrile	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
		Hov II (0.02 eq), rt, 8 h	 R: *n*-Pr (48); *n*-C_5H_{11} (65); *n*-C_7H_{15} (80)	927
2 eq		Catalyst (*x* eq), DCM	 **I** + **II**	

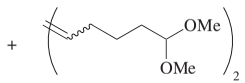
R	Catalyst	*x*	Temp (°)	Time (h)	**I**	(*Z*)/(*E*) **I**	**II**	
BnO	Mo cat **1**	0.05	rt	3	(77)	90:10	—	149
TBSO	Mo cat **1**	0.05	rt	3	(90)	87:13	(7)	149
TBSO	Ru cat **88**	0.05	25	2	(83)	73:27	—	171
TBSO	Ru cat **122**	0.05	40	8	(91)	73:27	—	171
H	Ru cat **65**	0.02	45	12	(37)	25:75	(7)	1172
H	Ru cat **65**	0.1	45	12	(51)	25:75	(5)	1172
TBSO	Ru cat **158**	0.01	25	2	(65)	7:93	—	590
TBSO	Ru cat **157**	0.005	25	2	(57)	7:93	—	590
TBSO	Ru cat **138**	0.03	25	5	(95)	75:25	—	590
TBSO	Ru cat **115**	0.01	25	24	(59)	75:25	—	609
TBSO	Ru cat **130**	0.03	25	24	(48)	75:25	—	609
TBSO	Ru cat **116**	0.01	25	5	(45)	75:25	—	609
TBSO	Ru cat **116**	0.01	25	24	(51)	75:25	—	609
TBSO	Ru cat **115**	0.03	25	5	(94)	75:25	—	1061
TBSO	Ru cat **286**	0.02	25	5	(13)	—	—	161
TBSO	Ru cat **286**	0.02	40	8	(23)	74:26	—	161
TBSO	Ru cat **286**	0.05	40	8	(42)	73:27	—	161
TBSO	Ru cat **106**	0.05	20	3	(77)	72:28	—	216

2 eq 

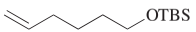
Mo cat **1** (0.05 eq),
DCM, rt, 3 h



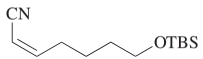
(79) (*Z*)/(*E*) = 88:12 149



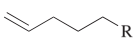
(11)

2 eq 

Gr II (0.05 eq).
toluene, 80°, 16 h



(68) (*Z*)/(*E*) = 73:27 171



Gr II (0.01 eq),
CuCl (*x* eq),
DCM, 40°, 16 h



150

R	*x*	
HO_2C	4	(34)
HO_2C	—	(10)
$AcOCH_2$	4	(64)
$AcOCH_2$	—	(52)

TABLE 27. CROSS-METATHESIS OF ACRYLONITRILE AND METHACRYLONITRILE (*Continued*)

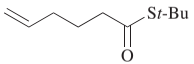
Nitrile	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

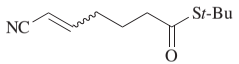
C_3



2 eq



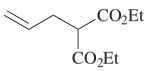
Catalyst (0.05 eq), toluene, 80°, 6 h



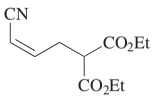
1060

Catalyst	
Ru cat **166**	(70)
Ru cat **167**	(72)
Ru cat **168**	(69)

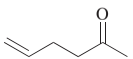
2 eq



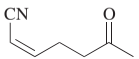
Catalyst (*x* eq), DCM



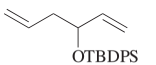
Catalyst	*x*	Temp (°)	Time (h)		(*Z*)/(*E*)	
Hov II	0.08	45	6	(79)	75:25	153
Ru cat **88**	0.05	rt	0.5	(87)	67:33	160
Ru cat **114**	0.05	40	6	(79)	75:25	1173
Ru cat **88**	0.05	25	3	(85)	67:33	171

2 eq 

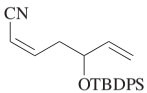
Catalyst (x eq),
CuCl (y eq), DCM



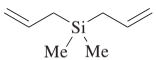
Catalyst	x	y	Temp (°)	Time (h)		(Z)/(E)	
Ru cat **149**	0.05	—	45	3	(73)	80:20	853
Hov II	0.01	4	40	16	(27)	—	150
Hov II	0.01	—	40	16	(16)	—	150

3 eq 

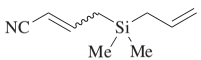
Hov II (0.05 eq),
DCM, 40°



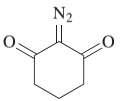
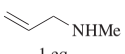
(23) (Z)/(E) = 75:25 169

3 eq 

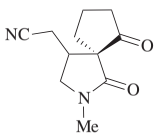
Hov II (0.025 eq),
DCM, rt, 4 h



(<1) 992

1 eq  + 
1 eq

1. DCM, MW (300 W), 0.25 h
2. Hov II (0.04 eq), 100°, 0.5 h
3. n-Bu_3P (0.2 eq), 100°, 0.25 h



(34) dr 55:45 955

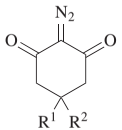
TABLE 27. CROSS-METATHESIS OF ACRYLONITRILE AND METHACRYLONITRILE (*Continued*)

Nitrile	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

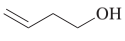
Please refer to the charts preceding the tables for the catalyst structures.

C_3

1 eq

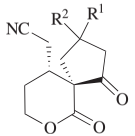


+



1 eq

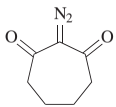
1. DCM, MW (300 W), 0.25 h
2. Hov II (0.04 eq), 100°, 0.5 h
3. Additive (0.2 eq), temp, time



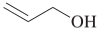
955

R^1	R^2	Additive	Temp (°)	Time (h)		dr
H	H	*n*-Bu_3P	100	0.25	(60)	>95:5
H	H	IPr	rt	20	(54)	>95:5
Me	H	*n*-Bu_3P	100	0.25	(41)	>74:21:4:1
Me	H	IPr	rt	20	(41)	>76:19:4:1
Me	Me	*n*-Bu_3P	100	0.25	(40)	>95:5
Me	Me	IPr	rt	20	(60)	>95:5

1 eq

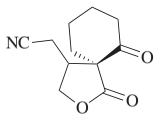


+



1 eq

1. DCM, MW (300 W), 0.25 h
2. Hov II (0.04 eq), 100°, 0.5 h
3. Additive (0.2 eq), temp, time



955

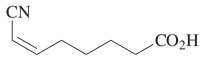
Additive	Temp (°)	Time (h)		dr
n-Bu_3P	100	0.25	(49)	64:36
IPr	rt	20	(50)	73:27



2 eq

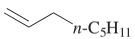


Hov II (0.05 eq),
DCM, 45°, 2 h

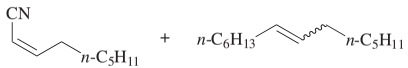


(76) (*Z*)/(*E*) = 75:25 153

x eq



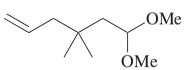
Catalyst (*y* eq), solvent



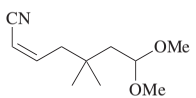
I **II**

x	Cat	*y*	Solvent	Temp (°)	Time (h)	**I**	(*Z*)/(*E*) **I**	**II**	
2	Mo cat **1**	0.02	DCM	rt	3	(56)	90:10	(4)	149
2	Mo cat **1**	0.02	Et_2O	rt	3	(75)	90:10	(4)	149
0.5	Ru cat **54**	0.01	DCM	40	12	(56)	76:24	(—)	1174
0.5	Ru cat **55**	0.01	DCM	40	12	(75)	67:33	(—)	1174
0.5	Ru cat **56**	0.01	DCM	40	12	(81)	74:26	(—)	1174
0.5	Ru cat **57**	0.01	DCM	40	12	(70)	75:25	(—)	1174
0.5	Ru cat **70**	0.01	DCM	40	12	(57)	73:27	(—)	1174

2 eq



Gr II (0.02 eq), DCM, rt, 12 h



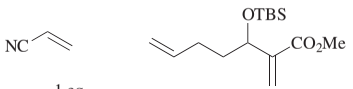
(64) (*Z*)/(*E*) = 75:25 149

TABLE 27. CROSS-METATHESIS OF ACRYLONITRILE AND METHACRYLONITRILE (*Continued*)

Nitrile	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

C_3

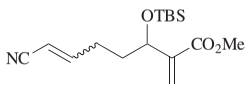


1 eq



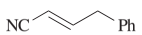
x eq

Gr II (0.01 eq), CuCl (*x* eq), DCM, 40°, overnight

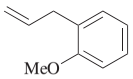


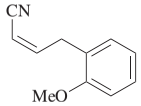
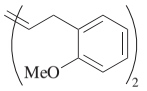
x		
4	(52)	150
—	(42)	

Catalyst (*y* eq), solvent, reflux



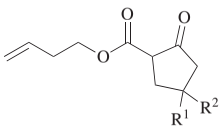
x	Catalyst	*y*	Solvent	Time (h)		(*E*)/(*Z*)	
2	Gr I	0.05	DCM	16	(60)	40:60	156
—	Gr II	0.03	DCM	—	(67)	37:63	853
—	Ru cat **33**	0.03	DCM	—	(7)	71:29	853
—	Hov II	0.03	DCM	—	(95)	44:56	853
—	Ru cat **223**	0.03	DCM	—	(20)	64:36	853
0.4	Gr II	0.01	DCM	5	(51)	75:25	971
0.4	Hov II	0.01	DCM	5	(67)	75:25	971
0.4	Ru cat **86**	0.01	DCM	5	(59)	75:25	971
1.1	Ru cat **227**	0.05	$CDCl_3$	—	(30)	55:45	600
1.1	Ru cat **228**	0.05	$CDCl_3$	—	(32)	38:62	600
1.1	Ru cat **223**	0.05	$CDCl_3$	—	(<33)	74:26	600
1.1	Hov II	0.05	$CDCl_3$	—	(<33)	64:36	600

2 eq 

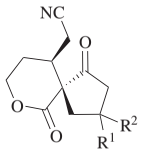
Mo cat **1** (0.05 eq), DCM, rt 3 h  + 

(72) (*Z*)/(*E*) = 90:10 (9)

149

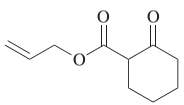
1 eq 

1. Hov II (0.03 + 0.01 eq), DCM, 100° (MW), 20 + 10 min
2. Additive (*x* eq), temp, time

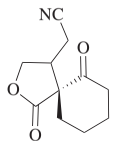


979

R^1	R^2	Additive	*x*	Temp (°)	Time		dr
H	H	*n*-Bu_3P	0.1	100 (MW)	10 min	(60)	>95:5
H	H	IPr	0.2	24	20 h	(40)	>95:5
Me	H	IPr	0.2	24	20 h	(44)	80:20
Me	Me	*n*-Bu_3P	0.2	100 (MW)	10 min	(41)	>95:5
Me	Me	IPr	0.2	24	20 h	(40)	>95:5

1 eq 

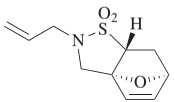
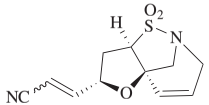
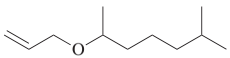
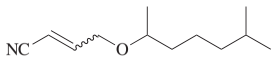
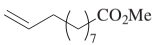
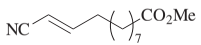
1. Hov II (0.03 + 0.01 eq), DCM, 100° (MW), 20 + 10 min
2. Additive (0.2 eq), temp, time



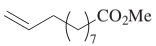
979

Additive	Temp (°)	Time		*cis*/*trans*
n-Bu_3P	100 (MW)	10 min	(52)	64:36
IPr	24	20 h	(50)	73:27

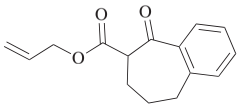
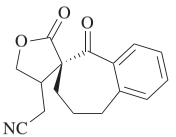
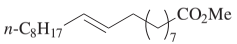
TABLE 27. CROSS-METATHESIS OF ACRYLONITRILE AND METHACRYLONITRILE (*Continued*)

Nitrile	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_3				
 10 eq	 (±)	Ru cat **35** (0.1 eq), DCM, 45°, 3h	 (±)	(67)	359
2 eq		Hov II (0.02 eq), rt, 8 h		(5)	927
3 eq		Catalyst (*x* eq), PC/EA/cyclohexane (1:1:1), 3 h			1090

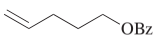
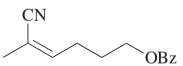
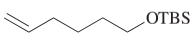
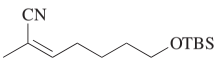
Catalyst	Temp (°)	Concn (mol/L)	Conv. (%)[b]	(*E*)/(*Z*)
Hov II	80	0.05	20	72:28
Ru cat **89**	80	0.05	27	72:28
Ru cat **89**	80	0.025	57	81:19
Ru cat **89**	80	0.01	79	90:10
Ru cat **89**	100	0.01	87	73:27
Ru cat **89**	100	0.01	34	86:14

2 eq		Catalyst (*x* eq), toluene, 70°, 2 h			152

Catalyst	*x*	Concn (mol/L)	Conv. (%)[b]
Ru cat **356**	0.0003	0.1	86
Ru cat **357**	0.0003	0.1	87
Ru cat **356**	0.000025	0.25	63
Ru cat **357**	0.000025	0.25	73

1 eq		1. Hov II (0.04 eq), DCM, 100° (MW), 0.5 h 2. *n*-Bu_3P (0.2 eq), 100° (MW), 0.33 h		(30) dr 54:46	955
5 eq		Hov II (0.01 eq), toluene, 95°, 2 h		>99% conv.[b]	536

C_4

		Hov II (0.05 eq), DCE, 70°, 4 h		(68) (*Z*)/(*E*) = 67:33	153
4 eq		Catalyst (0.05 eq), solvent			

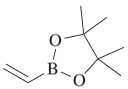
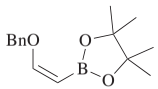
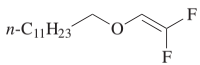
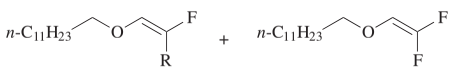
Catalyst	Solvent	Temp (°)	Time (h)		(*Z*)/(*E*)	
Ru cat **88**	DCM	40	16	(58)	67:33	160, 609
Ru cat **122**	DCM	40	16	(40)	67:33	171
Gr II	toluene	80	24	(0)	—	171
Ru cat **115**	DCM	40	16	(56)	67:33	1061
Gr II	DCM	40	24	(30)	67:33	609
Hov II	DCM	40	16	(40)	67:33	609

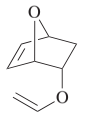
[a] The conversion was determined by ^1H NMR analysis.

[b] The conversion was determined by GC analysis.

TABLE 28. CROSS-METATHESIS OF VINYL ETHERS AND ESTERS

A. VINYL ETHERS

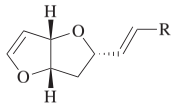
Vinyl Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 5 eq		Mo cat **5** (0.05 eq), benzene, 22°, 24 h	 (80) $(Z)/(E)$ = 93:7	547
	 2 eq	Catalyst (0.02 eq), C_6D_6, 60°, 1 h		1177
			Catalyst (25) TON: Hov II (25) 12.5; Ru cat **139** (27) 13.4; Ru cat **172** (23) 11.7; Gr II (6) 3.2; Ru cat **67** (2) 1.1; Ru cat **271** (2) 0.8	
	 10 eq	Ru cat **172** (0.1 eq), C_6D_6, 60°, 1 h	 **I** + **II**	1177
			R: **I** (64) $(Z)/(E)$ **I** —; **II** (64) TON 6.9 Cl: **I** (51) 61:39; **II** (11) 6.2 CF_3: **I** (22) 75:25; **II** (—) 2.2 H: **I** (72) 80:20; **II** (—) 7.2	





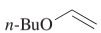
5 eq

Hov II (0.1 eq),
DCM, 40°, 24 h



R		(*E*)/(*Z*)
NC–	(72)	41:59
MeO_2C	(72)	(*E*) only
$AcOCH_2$	(85)	—

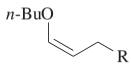
1176



10 eq



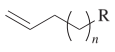
Mo cat **5** (*x* eq),
benzene, 22°, 2 h



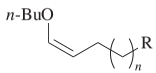
R	*x*		(*Z*)/(*E*)
TIPSO	0.025	(77)	94:6
PhHN	0.025	(51)	98:2
Ph	0.012	(57)	>98:2

5

10 eq



Mo cat **5** (*x* eq),
benzene, 22°, 2 h



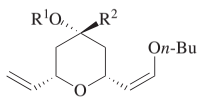
5

n	R	*x*		(*Z*)/(*E*)
2	PhO_2C	0.025	(73)	98:2
5	Me	0.025	(68)	98:2
5	Br	0.012	(70)	>98:2
5	TMS—≡	0.05	(59)	>98:2

20 eq



Ru cat **210** (0.05 eq),
benzene, 22°, 24 h

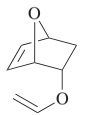
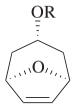
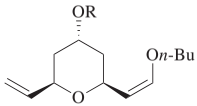


808,
1175

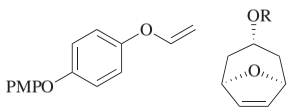
R^1	R^2		(*Z*)/(*E*)	er
TBS	H	(71)	87:13	93:7
TBS	Me	(72)	92:8	95:5
Bn	H	(62)	94:6	91:9

TABLE 28. CROSS-METATHESIS OF VINYL ETHERS AND ESTERS (*Continued*)

A. VINYL ETHERS (*Continued*)

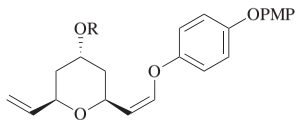
Vinyl Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 *x* eq		Mo cat **18** (0.006 eq), benzene, 22°		(*Z*)/(*E*) > 98:2	339

x	R	Time (min)	Conv. (%)[a]		er
1.1	TBS	30	>98	(53)	52.0:48.0
5	TBS	0.5	97	(83)	95.0:5.0
5	TBS	1	>98	(89)	90.0:10.0
5	TBS	3	>98	(96)	85.5:14.5
5	TBS	30	>98	(80)	62.5:37.5
10	TBS	30	>98	(80)	73.0:27.0
20	TBS	30	>98	(85)	84.5:15.5
30	TBS	30	>98	(88)	95.0:5.0
1.1	Bn	30	96	(54)	57.5:42.5
30	Bn	30	>98	(88)	95.0:5.0



x eq

Mo cat **18** (0.006 eq), benzene, 22°



(*Z*)/(*E*) > 98:2 339

x	R	Time (min)	Conv. (%)[a]		er
1.1	TBS	30	97	(86)	56.5:43.5
5	TBS	0.5	97	(86)	90.0:10.0
5	TBS	1	97	(82)	87.0:13.0
5	TBS	3	>98	(83)	86.0:14.0
5	TBS	30	>98	(87)	84.5:15.5
10	TBS	30	>98	(90)	91.5:8.5
20	TBS	30	>98	(87)	92.0:8.0
30	TBS	30	>98	(82)	91.5:8.5
1.1	Bn	30	94	(82)	82.0:18.0
20	Bn	30	>98	(87)	96.5:3.5

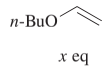
TABLE 28. CROSS-METATHESIS OF VINYL ETHERS AND ESTERS (*Continued*)

A. VINYL ETHERS (*Continued*)

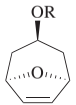
Vinyl Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

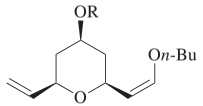
C_2



x eq

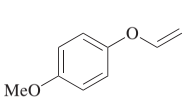


Catalyst (*y* eq),
solvent, 22°

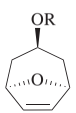


339

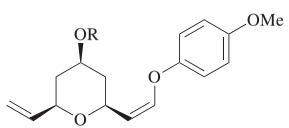
x	R	Catalyst	*y*	Solvent	Time (h)	Conv (%)[a]		(*Z*)/(*E*)	er
1.1	TBS	Hov II	0.01	benzene	0.5	69	(32)	25:75	—
1.1	TBS	Mo cat **1**	0.01	benzene	0.5	98	(10)	50:50	—
1.1	TBS	Mo cat **8**	0.01	benzene	12	<2	(0)	—	—
1.1	TBS	Mo cat **3**	0.01	benzene	0.5	>98	(48)	80:20	—
1.1	TBS	Mo cat **5**	0.01	benzene	0.5	85	(68)	>98:2	99.0:1.0
1.1	TBS	Mo cat **6**	0.01	benzene	0.5	<5	(0)	—	—
1.1	TBS	Mo cat **16**	0.0007	benzene	0.5	>98	(87)	>98:2	97.0:3.0
1.1	TBS	Mo cat **17**	0.005	benzene	0.5	>98	(87)	>98:2	98.0:2.0
1.1	TBS	Mo cat **18**	0.006	benzene	0.5	>98	(89)	>98:2	99.0:1.0
5	TBS	Mo cat **18**	0.0015	—	0.17	>98	(76)	>98:2	99.0:1.0
1.1	TBS	Mo cat **19**	0.007	benzene	0.5	>98	(87)	>98:2	98.0:2.0
1.1	Bn	Mo cat **18**	0.006	benzene	0.5	>98	(75)	>98:2	99.0:1.0
5	Bn	Mo cat **18**	0.0015	—	0.17	>98	(74)	>98:2	99.0:1.0



x eq



Catalyst (*y* eq),
solvent, 22°



339

x	R	Catalyst	*y*	Solvent	Time (h)	Conv. (%)[a]		(*Z*)/(*E*)	er
1.1	TBS	Hov II	0.01	benzene	0.5	95	(<5)	—	—
1.1	TBS	Mo cat **1**	0.01	benzene	0.5	98	(14)	80:20	—
1.1	TBS	Mo cat **8**	0.01	benzene	12	<2	(0)	—	—
1.1	TBS	Mo cat **3**	0.01	benzene	0.5	>98	(75)	82:18	—
1.1	TBS	Mo cat **5**	0.01	benzene	0.5	86	(47)	>98:2	99.0:1.0
1.1	TBS	Mo cat **6**	0.01	benzene	0.5	<5	(0)	—	—
1.1	TBS	Mo cat **16**	0.0007	benzene	0.5	60	(41)	>98:2	88.5:11.5
1.1	TBS	Mo cat **17**	0.005	benzene	0.5	>98	(80)	>98:2	92.0:8.0
1.1	TBS	Mo cat **18**	0.006	benzene	0.5	>98	(90)	>98:2	98.5:1.5
5	TBS	Mo cat **18**	0.0015	—	0.17	>98	(80)	>98:2	99.0:1.0
1.1	TBS	Mo cat **19**	0.007	benzene	0.5	>98	(85)	>98:2	99.0:1.0
1.1	Bn	Mo cat **18**	0.006	benzene	0.5	>98	(80)	>98:2	97.0:3.0
5	Bn	Mo cat **18**	0.0015	—	0.17	>98	(77)	>98:2	99.0:1.0

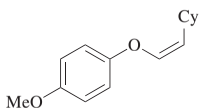
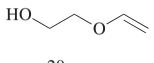
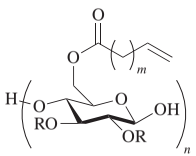
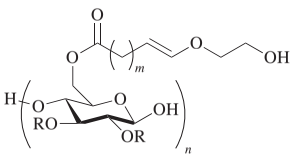
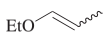
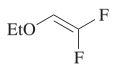
10 eq  Mo cat **5** (0.05 eq), benzene, 22°, 2 h  (75) (*Z*)/(*E*) > 98:2 5

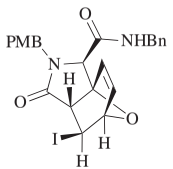
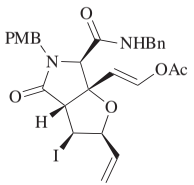
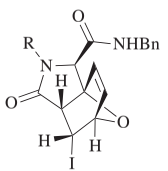
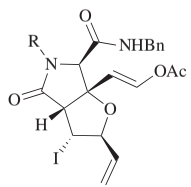
TABLE 28. CROSS-METATHESIS OF VINYL ETHERS AND ESTERS (*Continued*)

A. VINYL ETHERS (*Continued*)

Vinyl Ether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 20 eq		Gr II (0.05 eq), THF, rt, 1 h		1035
			m R (96) (*E*)/(*Z*) 2 H (96) 91:9 8 Me (97) 96:4	
C_3				
	 2 eq	Ru cat **172** (0.1 eq), C_6D_6, 60°, 1 h	 (27) TON = 2.7 +  (17)	1177

[a] The conversion was determined by ^{1}H NMR analysis.

TABLE 28. CROSS-METATHESIS OF VINYL ETHERS AND ESTERS (*Continued*)
B. VINYL ESTERS

Vinyl Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 5 eq		Hov II (0.02 eq), benzene, 60°, 4 h	 (99) (*E*)/(*Z*) = 80:20	1178
5 eq		Hov II (*x* eq), solvent		1178

R	*x*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)
PMB	0.02	benzene	60	4	(87)	93:7
$TBSO(CH_2)_2$	0.15	benzene, DCE	45	9	(74)	84:16

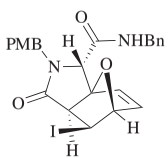
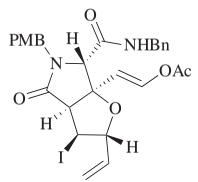
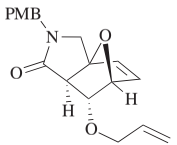
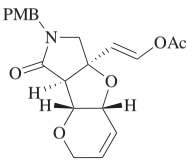
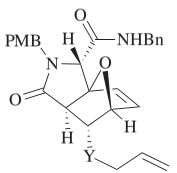
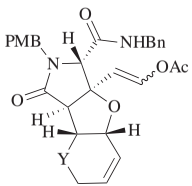
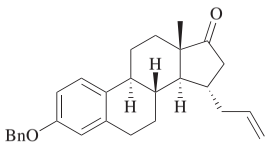
5 eq		Hov II (0.01 eq), benzene, rt, 14 h	 (87) (*E*)/(*Z*) = 93:7	664, 1179

TABLE 28. CROSS-METATHESIS OF VINYL ETHERS AND ESTERS (*Continued*)
B. VINYL ESTERS (*Continued*)

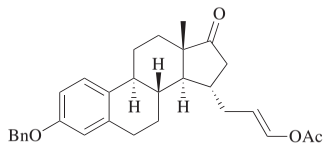
Vinyl Ester	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 5 eq		Hov II (0.005 eq), benzene, rt, 8.5 h	 (88) (*E*)/(*Z*) = 55:45	664, 1179
5 eq		1. Hov II (*x* eq), vinyl acetate (*y* eq), benzene, temp 1, time 1 2. Hov II (*z* eq), solvent, temp 2, time 2		664, 1179

Y	*x*	*y*	Temp 1 (°)	Time 1 (h)	*z*	Solvent	Temp 2 (°)	Time 2 (h)	
NsN	0.02	—	rt	11	—	—	—	—	(97)
NsN	0.01	5	69	25	0.01	benzene	80	10	(90)
TFAN	0.01	5	69	19	0.01	benzene	69	11	(85)
O	0.005	—	rt	4	—	benzene	—	—	(100)
O	0.01	5	69	46	0.01	benzene	69	21	(84)

2 eq



Catalyst (0.03 eq),
solvent



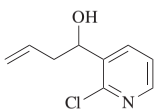
163

Catalyst	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)
Gr II	DCM	40	2.5	(86)	(*E*) only
Ru cat **68**	DCE	50	5.5	(0)	—
Ru cat **125**	DCM	40	5.5	(32)	(*E*) only

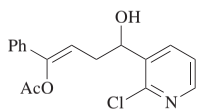
C_8



3 eq



Hov II (0.1 eq),
DCM, 50°, 24 h



(68) (*E*)/(*Z*) = 50:50

603

TABLE 29. CROSS-METATHESIS OF VINYLIC COMPOUNDS WITH A PERFLUORINATED CARBON CHAIN

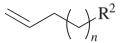
Perfluorinated Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

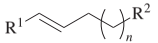
$C_{3–6}$



10 eq

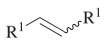


Catalyst (*x* eq), $C_6F_5CF_3$



I (*E*)/(*Z*) > 95:5

+



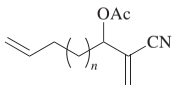
II

137

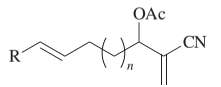
R^1	R^2	*n*	Catalyst	*x*	Temp (°)	Time (h)	**I**	**II**
CF_3	BzO	2	Hov II	0.05	45	3	(>95)	(0)
CF_3	BzO	2	Gr II	0.05	60	4	(85)	(5)
CF_3	HO_2C	2	Hov II	0.05	45	3	(70)	(19)
CF_3	HO_2C	2	Gr II	0.05	60	4	(58)	(23)
CF_3	HO	3	Hov II	0.05	45	3	(75)	(18)
CF_3	HO	3	Gr II	0.05	60	4	(50)	(50)
n-C_4F_9	BzO	2	Hov II	0.1	45	3	(>95)	(0)
n-C_4F_9	BzO	2	Gr II	0.1	60	4	(>95)	(0)
n-C_4F_9	HO_2C	2	Hov II	0.1	45	3	(59)	(41)
n-C_4F_9	HO_2C	2	Gr II	0.1	60	4	(42)	(56)
n-C_4F_9	HO	3	Hov II	0.1	45	3	(7)	(79)
n-C_4F_9	HO	3	Gr II	0.1	60	4	(21)	(73)



10 eq



Catalyst (x eq), $C_6F_5CF_3$



+



137

I (*E*)/(*Z*) > 95:5 **II**

R	*n*	Catalyst	*x*	Temp (°)	Time (h)	**I**	**II**
CF_3	1	Hov II	0.05	45	3	(50)	(0)
CF_3	1	Gr II	0.05	60	4	(16)	(19)
CF_3	7	Hov II	0.05	45	3	(>95)	(0)
CF_3	7	Gr II	0.05	60	4	(>95)	(0)
n-C_4F_9	1	Hov II	0.1	45	3	(57)	(0)
n-C_4F_9	1	Gr II	0.1	60	4	(13)	(47)
n-C_4F_9	7	Hov II	0.1	45	3	(>95)	(0)
n-C_4F_9	7	Gr II	0.1	60	4	(24)	(35)

TABLE 29. CROSS-METATHESIS OF VINYLIC COMPOUNDS WITH A PERFLUORINATED CARBON CHAIN (*Continued*)

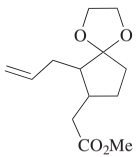
Perfluorinated Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

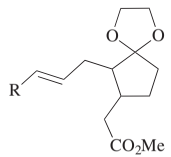
C_{3-6}



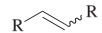
10 eq



Catalyst (*x* eq), $C_6F_5CF_3$



+

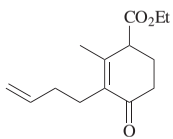


137

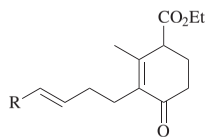
I (*E*)/(*Z*) > 95:5 **II**

R	Catalyst	*x*	Temp (°)	Time (h)	**I**	**II**
CF_3	Hov II	0.05	45	3	(>95)	(0)
CF_3	Gr II	0.05	60	4	(77)	(10)
n-C_4F_9	Hov II	0.1	45	3	(79)	(21)
n-C_4F_9	Gr II	0.1	60	4	(38)	(42)

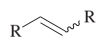
10 eq



Catalyst (*x* eq), $C_6F_5CF_3$



+



137

I (*E*)/(*Z*) > 95:5 **II**

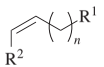
R	Catalyst	*x*	Temp (°)	Time (h)	**I**	**II**
CF_3	Hov II	0.05	45	3	(>95)	(0)
CF_3	Gr II	0.05	60	4	(41)	(33)
n-C_4F_9	Hov II	0.1	45	3	(90)	(10)
n-C_4F_9	Gr II	0.1	60	4	(40)	(45)

C_4

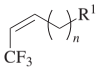


5 eq

$(Z)/(E) > 98:2$



Mo cat **31** (x eq), benzene, 22°

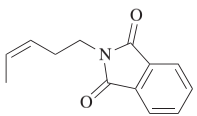


R^1	R^2	n	x	Time (h)		$(Z)/(E)$
PMBO	Et	1	0.05	4	(77)	>98:2
TsO	Et	2	0.02	2	(77)	>98:2
Bn_2N	Et	2	0.03	2	(92)	>98:2
PhS	Et	2	0.03	2	(69)	95:5
B(pin)	Me	1	0.05	2	(70)	97:3
TES	Me	1	0.03	2	(62)	94:6

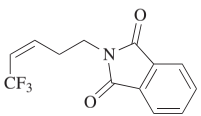
1180

5 eq

$(Z)/(E) > 98:2$



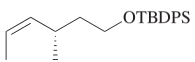
Mo cat **31** (0.03 eq), benzene, 22°, 2 h



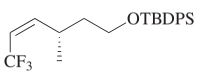
(80) $(Z)/(E) > 98:2$ 1180

10 eq

$(Z)/(E) > 98:2$

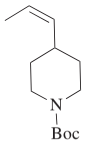
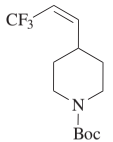
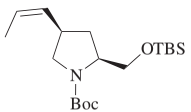
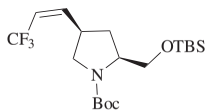
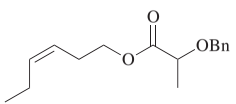
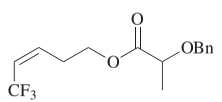
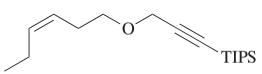
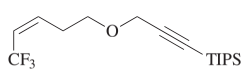


Mo cat **31** (0.05 eq), benzene, 22°, 4 h

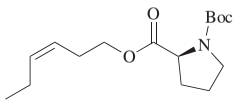


(85) $(Z)/(E) > 98:2$ 1180

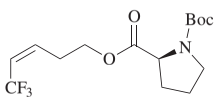
TABLE 29. CROSS-METATHESIS OF VINYLIC COMPOUNDS WITH A PERFLUORINATED CARBON CHAIN (*Continued*)

Perfluorinated Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 10 eq (*Z*)/(*E*) > 98:2		Mo cat **31** (0.05 eq), benzene, 22°, 4 h	 (88) (*Z*)/(*E*) > 98:2	1180
10 eq (*Z*)/(*E*) > 98:2		Mo cat **31** (0.05 eq), benzene, 22°, 4 h	 (84) (*Z*)/(*E*) > 98:2	1180
5 eq (*Z*)/(*E*) > 98:2		Mo cat **31** (0.02 eq), benzene, 22°, 2 h	 (70) (*Z*)/(*E*) = 97:3	1180
5 eq (*Z*)/(*E*) > 98:2		Mo cat **31** (0.05 eq), benzene, 22°, 2 h	 (82) (*Z*)/(*E*) > 98:2	1180

5 eq
(*Z*)/(*E*) > 98:2

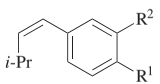


Mo cat **31** (0.03 eq),
benzene, 22°, 2 h

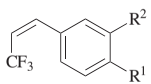


(80) (*Z*)/(*E*) > 98:2 1180

10 eq
(*Z*)/(*E*) > 98:2



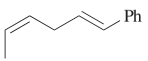
Mo cat **31** (*x* eq),
benzene, 22°, 12 h



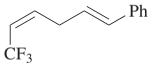
(*Z*)/(*E*) > 98:2 1180

R^1	R^2	*x*	
MeO	H	0.05	(59)
MeO_2C	MeO	0.1	(53)

5 eq
(*Z*)/(*E*) > 98:2

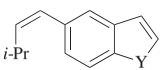


Mo cat **31** (0.03 eq),
benzene, 22°, 2 h

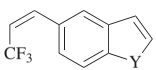


(62) (*Z*)/(*E*) = 97:3 1180

10 eq
(*Z*)/(*E*) > 98:2



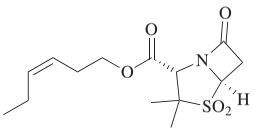
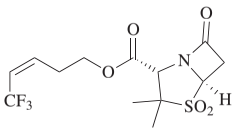
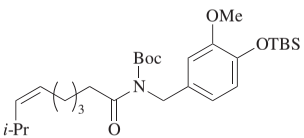
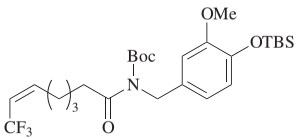
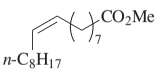
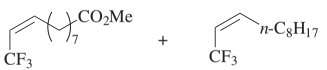
Mo cat **31** (0.05 eq),
benzene, 22°, 12 h



Y		
S	(64)	1180
BocN	(61)	

(*Z*)/(*E*) > 98:2

TABLE 29. CROSS-METATHESIS OF VINYLIC COMPOUNDS WITH A PERFLUORINATED CARBON CHAIN (*Continued*)

Perfluorinated Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
 5 eq (*Z*)/(*E*) > 98:2		Mo cat **31** (0.05 eq), benzene, 22°, 2 h	 (83) (*Z*)/(*E*) > 98:2	1180
10 eq (*Z*)/(*E*) > 98:2		Mo cat **31** (0.05 eq), benzene, 22°, 4 h	 (86) (*Z*)/(*E*) > 98:2	1180
x eq (*Z*)/(*E*) > 98:2		Catalyst (*y* eq), benzene, 22°	 **I** **II**	1180

x	Catalyst	*y*	Time (h)	**I**	(*Z*)/(*E*) **I**	**II**	(*Z*)/(*E*) **II**
20	Mo cat **28**	0.05	4	(66)	91:9	(36)	91:9
20	Mo cat **30**	0.05	4	(64)	81:19	(36)	81:19
20	Mo cat **31**	0.05	4	(90)	98:2	(65)	98:2
5	Mo cat **31**	0.02	0.25	(95)	>98:2	(67)	>98:2

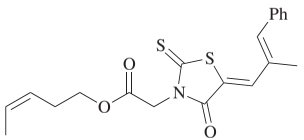
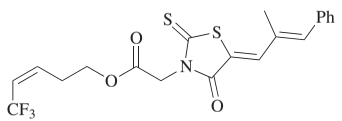
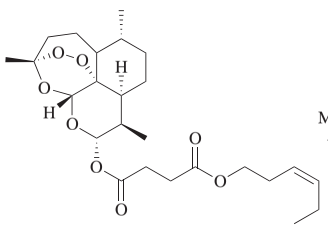
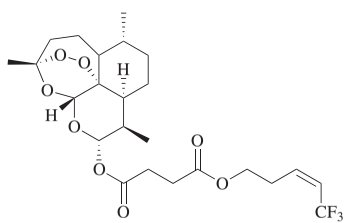
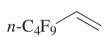
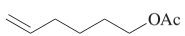
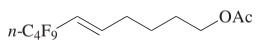
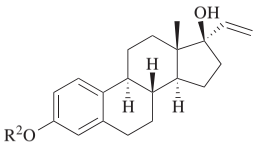
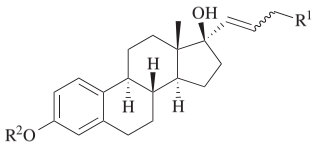
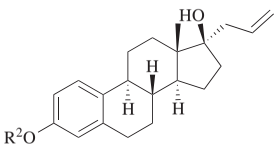
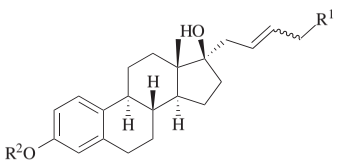
5 eq (Z)/(E) > 98:2		Mo cat **31** (0.05 eq), benzene, 22°, 4 h	 (92) (Z)/(E) > 98:2	1180
5 eq (Z)/(E) > 98:2		Mo cat **31** (0.05 eq), benzene, 22°, 4 h	 (81) (Z)/(E) > 98:2	1180
C_6				
 2 eq		Ru cat **11** (0.042 eq), DCM, reflux, 12 h	 (34) (E)/(Z) = 70:30	139

TABLE 29. CROSS-METATHESIS OF VINYLIC COMPOUNDS WITH A PERFLUORINATED CARBON CHAIN (*Continued*)

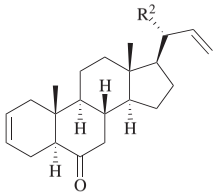
Perfluorinated Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{6-9}				
 2 eq		Hov II (0.1 eq), DCM, 40°, 4 h		134

R^1	R^2	
n-C_3F_7	H	(25)
n-C_3F_7	Me	(29)
i-C_3F_7	H	(12)
n-C_6F_{13}	H	(39)
n-C_6F_{13}	Me	(36)

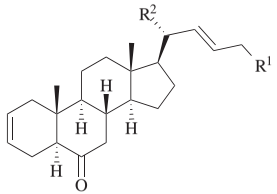
2 eq		Hov II (0.1 eq), DCM, 40°, 4 h		134

R^1	R^2	
n-C_3F_7	H	(58)
n-C_3F_7	Me	(68)
i-C_3F_7	H	(67)
n-C_6F_{13}	H	(53)
n-C_6F_{13}	Me	(62)

2 eq



Hov II (0.1 eq),
DCM, reflux, 4 h



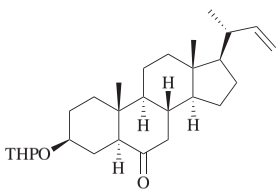
136

R^1	R^2		$(E)/(Z)$
i-C_3F_7	H	(59)	95:5
n-C_3F_7	Me	(71)	(*E*) only
n-C_6F_{13}	Me	(67)	(*E*) only

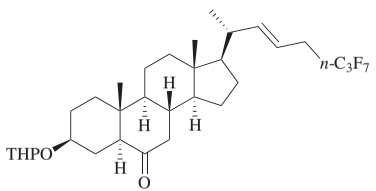
C_6

n-C_3F_7

2 eq



Hov II (0.1 eq),
DCM, reflux, 4 h



136

(81) (*E*) only

TABLE 29. CROSS-METATHESIS OF VINYLIC COMPOUNDS WITH A PERFLUORINATED CARBON CHAIN (*Continued*)

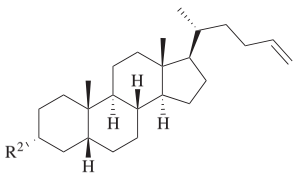
Perfluorinated Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

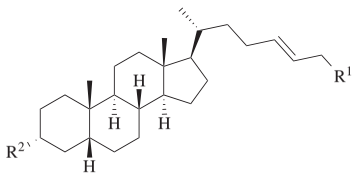
C_{6-9}



2 eq



Catalyst (0.1 eq), DCM, reflux, 3 h

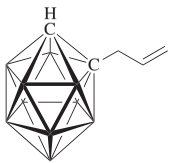


135

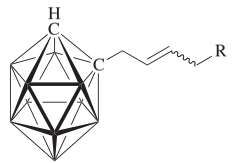
R^1	R^2	Catalyst		(*E*)/(*Z*)
n-C_3F_7	H	Hov II	(75)	60:40
n-C_3F_7	THPO	Hov II	(81)	88:12
i-C_3F_7	HO	Hov II	(75)	60:40
i-C_3F_7	TBSO	Hov II	(63)	88:12
n-C_6F_{13}	H	Hov II	(64)	80:20
n-C_6F_{13}	HO	Hov II	(70)	67:33
n-C_6F_{13}	TBSO	Hov II	(75)	(*E*) only
n-C_6F_{13}	TBSO	Gr II	(59)	(*E*) only



2 eq

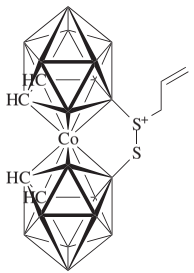


Hov II (0.1 eq), DCM, reflux, 6 h

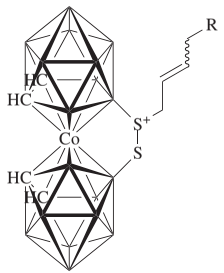


R		
n-C_3F_7	(34)	612
i-C_3F_7	(32)	
n-C_6F_{13}	(34)	

2 eq

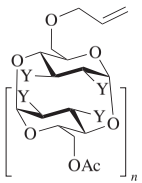


Hov II (0.1 eq),
DCM, reflux, 6 h



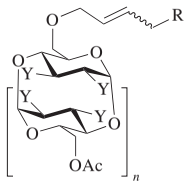
R		
n-C_3F_7	(41)	612
n-C_6F_{13}	(44)	

5 eq



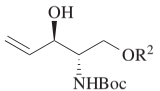
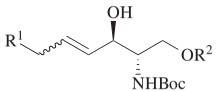
Y = OAc

Hov II (0.1 eq),
DCM, 40°



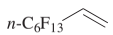
R	n		
n-C_3F_7	5	(32)	
i-C_3F_7	5	(37)	133
n-C_6F_{13}	5	(43)	
n-C_3F_7	6	(43)	
i-C_3F_7	6	(34)	
n-C_6F_{13}	6	(48)	
n-C_3F_7	7	(24)	
i-C_3F_7	7	(29)	
n-C_6F_{13}	7	(38)	

TABLE 29. CROSS-METATHESIS OF VINYLIC COMPOUNDS WITH A PERFLUORINATED CARBON CHAIN (*Continued*)

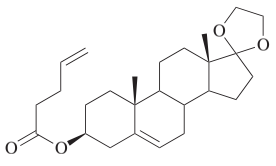
Perfluorinated Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{8-10}  *x* eq		Hov II (2 x 0.05 eq), DCM, 42° (MW), 25 min		138

R^1	*x*	R^2	
n-C_5F_{11}	2 + 1	H	(34)
n-C_6F_{13}	2 + 1	H	(36)
n-C_7F_{15}	2 + 1	H	(32)
n-C_5F_{11}	2	H	(50)
n-C_6F_{13}	2	H	(60)
n-C_7F_{15}	2	H	(50)
n-C_5F_{11}	2 + 1	TBS	(38)
n-C_6F_{13}	2 + 1	TBS	(46)
n-C_7F_{15}	2 + 1	TBS	(47)
n-C_5F_{11}	2	TBS	(58)
n-C_6F_{13}	2	TBS	(65)
n-C_7F_{15}	2	TBS	(50)

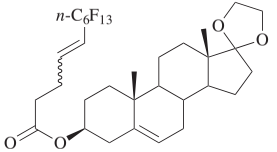
C_8



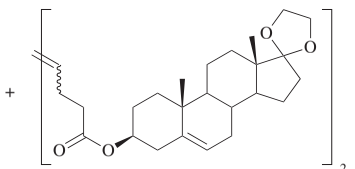
5 eq



Ind II (0.05 eq),
solvent, 60°, 20 h



I

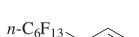


II

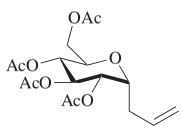
Solvent	**I**	**II**
DCE	(12)	(23)
C_6F_6	(90)	(6)

141

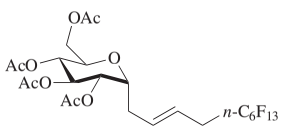
C_9



2 eq

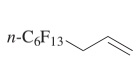
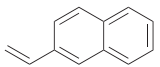
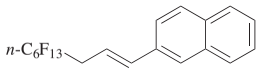
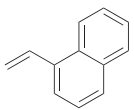
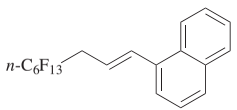
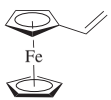
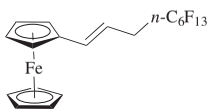
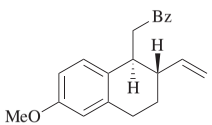
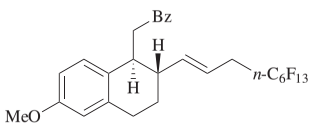


Hov II (0.1 eq),
DCM, reflux, 3 h



(64) (*E*) only 135

TABLE 29. CROSS-METATHESIS OF VINYLIC COMPOUNDS WITH A PERFLUORINATED CARBON CHAIN (*Continued*)

Perfluorinated Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
 2 eq		Hov II (0.1 eq), DCM, reflux, 3 h	 (17) (*E*) only	135
2 eq		Hov II (0.1 eq), DCM, reflux, 3 h	 (15) (*E*) only	135
2 eq		Hov II (0.1 eq), DCM, reflux, 3 h	 (48) (*E*) only	135
	 2 eq	Hov II (0.1 eq), DCM, reflux, 3 h	 (66) (*E*) only	135

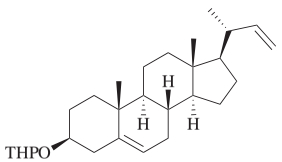
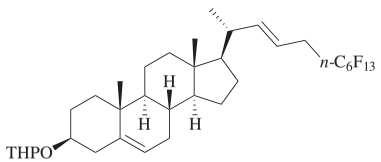
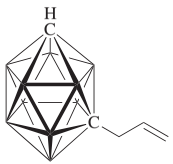
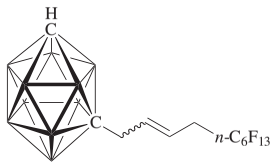
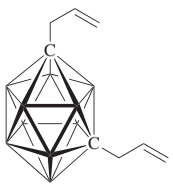
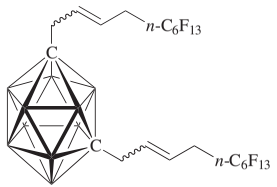
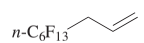
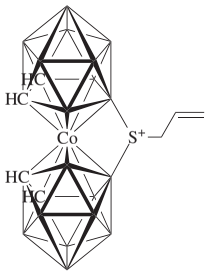
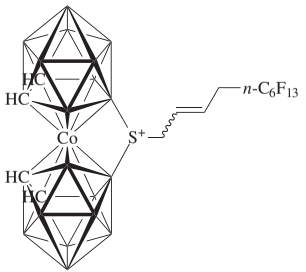
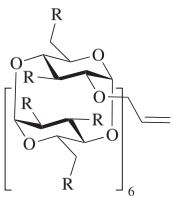
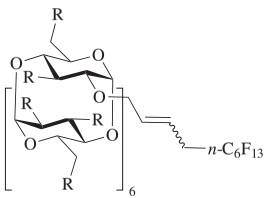
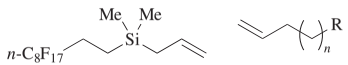
2 eq		Hov II (0.1 eq), DCM, reflux, 3 h	 (79) (*E*) only		135
2 eq		Hov II (0.1 eq), DCM, reflux, 6 h		(31)	612
2 eq		Hov II (0.1 eq), DCM, reflux, 6 h		(38)	612

TABLE 29. CROSS-METATHESIS OF VINYLIC COMPOUNDS WITH A PERFLUORINATED CARBON CHAIN (*Continued*)

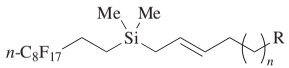
Perfluorinated Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
 2 eq		Hov II (0.1 eq), DCM, reflux, 6 h		(53) 612
5 eq	 R = OAc	Hov II (0.1 eq), DCM, 40°		(50) 133

C_{13}



3 eq

Catalyst (0.05 eq),
BQ (0.5 eq),
DCM, reflux, 12 h

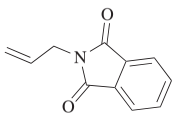


1181

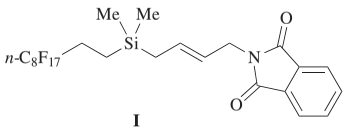
R	*n*	Catalyst		(*E*)/(*Z*)
BnO	0	Gr II	(42)	83:17
BzO	0	Hov II	(36)	83:17
BzO	3	Gr II	(40)	—
BnO_2C	0	Gr II	(39)	75:25

1047

3 eq

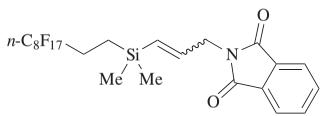


Gr II (0.05 eq),
BQ (*x* eq),
DCM, reflux



I

\+

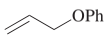
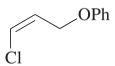
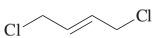
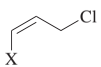


II

1181

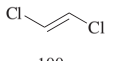
x	Time (h)	**I**	**I/II**	(*E*)/(*Z*) **I**
—	48	(60)	80:20	75:25
0.5	12	(45)	**I** only	80:20
0.5	48	(43)	89:11	80:20

TABLE 30. CROSS-METATHESIS OF VINYL HALIDES

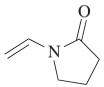
Vinyl Halide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 1.06 eq		Hov II (0.05 eq), C_6D_6/CD_2Cl_2 (10:1), 50°, 16 h	 (20) $(Z)/(E)$ = 56:44	104
5 eq		Mo cat **26** (x eq), benzene, 22°, 4 h		106
 x eq		Hov II (y eq), C_6D_6		104

R	x	Conv. (%)[a]		$(Z)/(E)$
B(pin)	0.05	90	(66)	>98:2
TIPS	0.05	90	(84)	96:4
Ph_3Sn	0.03	97	(89)	>98:2
$MeO_2C(CH_2)_2$	0.03	90	(65)	>98:2

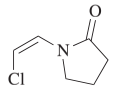
X	R	x	y	Temp (°)	Time (h)		$(Z)/(E)$
F	H	2.5	0.05	50	24	(11)	56:44
Cl	Cl	5.6	0.1	50	3	(78)	50:50
Cl	Cl	6.4	0.05	45	3	(53)	56:44



100 eq



Ru cat **88** (0.1 eq), 50°, 20 h



(32) (*Z*) only

105



x eq

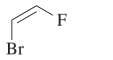


Catalyst (0.05 eq),
solvent, 3 h

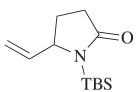


104

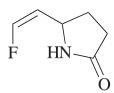
X	*x*	Catalyst	Solvent	Temp (°)		(*Z*)/(*E*)
Cl	5	Hov II	C_6D_6	50	(>90)	60:40
Cl	2.7	Hov II	C_6D_6	45	(60)	56:44
Cl	5	Ru cat **71**	C_6D_6/CD_2Cl_2 (10:1)	50	(43)	62:38
Br	1	Ru cat **71**	C_6D_6/CD_2Cl_2 (10:1)	50	(16)	33:67



5 eq



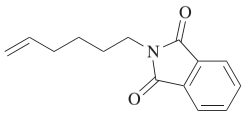
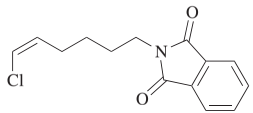
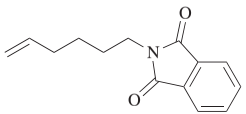
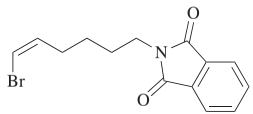
1. Mo cat **26** (0.05 eq),
benzene, 22°, 4 h
2. HCl, MeOH, 22°, 2 h



60% conv.[a], (55) (*Z*)/(*E*) > 98:2

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TABLE 30. CROSS-METATHESIS OF VINYL HALIDES (*Continued*)

Vinyl Halide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 5 eq		Mo cat **26** (0.03 eq), benzene, 22°, 4 h	 81% conv.[a] (65) (*Z*)/(E) > 98:2	106
 8 eq (*Z*)/(*E*) = 64:36		Mo cat **26** (0.05 eq), benzene, 22°, 4 h	 92% conv.[a] (67) (*Z*)/(*E*) = 87:13	106
 100 eq		Ru cat **88** (*x* eq), 20 h		105

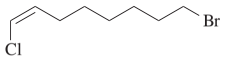
X	R	*n*	*x*	Temp (°)		(*Z*)/(*E*)
Cl	TBSO	4	0.15	50	(76)	60:40
Cl	Br	8	0.05	50	(41)	58:42
Cl	Br	8	0.1	50	(87)	58:42
Br	Br	8	0.15	80	(34)	36:64



5 eq



Catalyst (*x* eq)



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Catalyst	*x*	Temp (°)	Time (h)	Conv. (%)[a]		(*Z*)/(*E*)
Hov II	0.05	50	4	82	(59)	58:42
Ru cat **215**	0.05	50	4	10	(<5)	—
Ru cat **152**	0.05	50	4	<10	(<5)	—
Mo cat **1**	0.05	22	4	67	(<5)	—
W cat **4**	0.05	22	4	45	(<10)	—
Mo cat **5**	0.05	22	4	43	(<5)	—
Mo cat **18**	0.05	22	4	60	(27)	>98:2
Mo cat **24**	0.05	22	4	87	(60)	>98:2
Mo cat **25**	0.05	22	4	62	(40)	98:2
Mo cat **25**	0.05	22	12	95	(84)	93:7
Mo cat **26**	0.03	22	4	90	(75)	>98:2

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TABLE 30. CROSS-METATHESIS OF VINYL HALIDES (*Continued*)

Vinyl Halide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

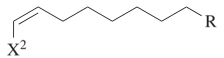
C_2



5 eq



Mo cat **26** (*x* eq), benzene, 22°, 4 h



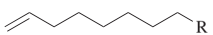
(*Z*)/(*E*) > 98:2 106

X^1	X^2	R	*x*	Conv. (%)[a]	
Cl	Cl	TBSO	0.03	88	(80)
Cl	Cl	BnS	0.05	94	(71)
Cl	Cl	TIPS—≡–	0.03	97	(89)
Br	F	TIPS—≡–	0.05	>98	(64)
Cl	Cl		0.05	91	(68)

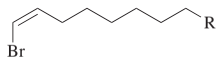


8 eq

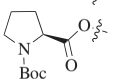
(*Z*)/(*E*) = 64:36



Mo cat **26** (0.05 eq), benzene, 22°, 4 h

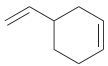


106

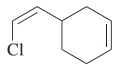
R	Conv. (%)[a]		(*Z*)/(*E*)
TBSO	95	(63)	88:12
$Bn_2N(CH_2)_3$	90	(66)	88:12
TIPS—≡–	98	(83)	87:13
	84	(66)	87:13



5 eq



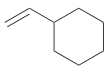
Mo cat **26** (0.03 eq), benzene, 22°, 4 h



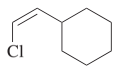
96% conv.[a] (75) (*Z*)/(*E*) > 98:2

106

5 eq



Mo cat **26** (0.03 eq), benzene, 22°, 4 h



>98% conv.[a] (78) (*Z*)/(*E*) = 96:4

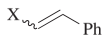
106



x eq



Hov II (0.05 eq), solvent, 50°



104

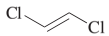
X	R	*x*	Solvent	Time (h)	
F	H	2.7	C_6D_6	24	(0)
Cl	Cl	5.5	C_6D_6/CD_2Cl_2 (10:1)	3	(5)
Cl	H	12	C_6D_6/CD_2Cl_2 (10:1)	3	(5)

TABLE 30. CROSS-METATHESIS OF VINYL HALIDES (*Continued*)

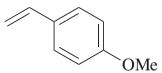
Vinyl Halide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

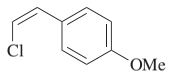
C_2



100 eq



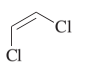
Catalyst (*x* eq), CuCl (*y* eq), reflux



(*Z*)/(*E*) = 83:17

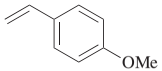
105

Catalyst	*x*	*y*	Time (h)	
Gr II	0.05	—	20	(15)
Gr II	0.05	0.05	20	(32)
Hov II	0.05	—	20	(24)
Ru cat **88**	0.05	—	20	(54)
Ru cat **88**	0.01	—	20	(21)
Ru cat **115**	0.05	—	20	(24)
Ru cat **115**	0.15	—	6	(91)

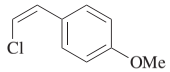


10 eq

(*Z*)/(*E*) > 98:2

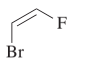


Catalyst (0.05 eq), benzene, 22°, 4 h

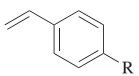


1180

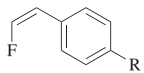
Catalyst		(*Z*)/(*E*)
Mo cat **27**	(34)	52:48
Mo cat **29**	(80)	>98:2



5 eq

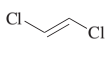


Mo cat **26** (0.05 eq), benzene, 22°, 4 h

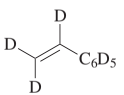


106

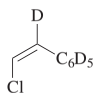
R	Conv. (%)[a]		(*Z*)/(*E*)
MeO	>98	(71)	95:5
AcO	84	(72)	94:6
Cl	78	(64)	97:3
Br	88	(66)	93:7



100 eq



Ru cat **88** (0.1 eq), 50°, 20 h



(52) (*Z*)/(*E*) = 72:28

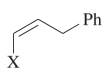
105



x eq

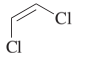


Catalyst (*y* eq), solvent

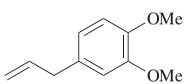


104

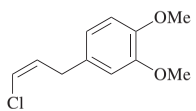
X	R	*x*	Catalyst	*y*	Solvent	Temp (°)	Time (h)		(*Z*)/(*E*)
F	H	0.31	Hov II	0.1	C_6D_6/CD_2Cl_2 (10:1)	50	24	(<10)	—
Cl	Cl	2.5	Ru cat **71**	0.1	C_6D_6/CD_2Cl_2 (10:1)	50	3	(58)	50:50
Cl	Cl	3.4	Hov II	0.1	C_6D_6	50	3	(50)	50:50
Cl	Cl	3.2	Hov II	0.05	C_6D_6	43	3	(50)	50:50
Cl	H	7.5	Hov II	0.1	C_6D_6/CD_2Cl_2 (10:1)	50	24	(20)	75:25



5 eq



Mo cat **26** (0.03 eq), benzene, 22°, 4 h



86% conv.[a]
(50) (*Z*)/(*E*) = 95:5

106

TABLE 30. CROSS-METATHESIS OF VINYL HALIDES (*Continued*)

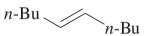
Vinyl Halide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

C_2



x eq



Catalyst (*y* eq), solvent



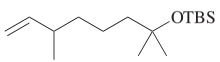
104

X	R	*x*	Catalyst	*y*	Solvent	Temp (°)	Time (h)		(*Z*)/(*E*)
F	H	8.5	Hov II	0.05	CD_2Cl_2	23/50	0.5/3	(9)	79:21
Cl	Cl	5	Hov II	0.05	C_6D_6	23	16	(100)	71:29
Cl	Cl	3	Hov II	0.04	C_6D_6	23	40	(>98)	69:31
Cl	Cl	4.1	Hov II	0.05	C_6D_6	45	3	(85)	67:33
Cl	Cl	1.6	Ru cat **67**	0.05	C_6D_6/CD_2Cl_2 (10:1)	50	3	(<5)	—
Cl	Cl	0.93	Ru cat **71**	0.05	C_6D_6/CD_2Cl_2 (10:1)	50	24	(0)	—
Cl	H	8	Hov II	0.05	C_6D_6/CD_2Cl_2 (10:1)	23	24	(29)	(*Z*) only
Cl	H	8	Ru cat **71**	0.05	C_6D_6/CD_2Cl_2 (10:1)	50	3	(25)	88:12
Cl	H	5.8	Ru cat **67**	0.05	C_6D_6/CD_2Cl_2 (10:1)	50	3	(0)	—
Br	Br	2	Hov II	0.05	C_6D_6/CD_2Cl_2 (10:1)	50	24	(22)	—
Br	H	8	Hov II	0.05	C_6D_6/CD_2Cl_2 (10:1)	50	3	(5)	—

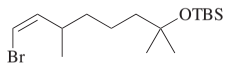


8 eq

(*Z*)/(*E*) = 64:36



Mo cat **26** (0.05 eq), benzene, 22°, 4 h



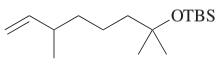
74% conv.[a]

(57) (*Z*)/(*E*) = 91:9

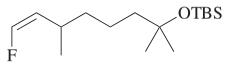
106



5 eq



Mo cat **26** (0.05 eq), benzene, 22°, 4 h

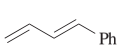


>98% conv.[a]
(70) (*Z*)/(*E*) > 98:2

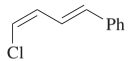
106



10 eq
(*Z*)/(*E*) > 98:2



Catalyst (0.05 eq), benzene, 22°, 4 h

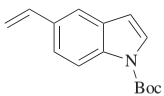


Catalyst		(*Z*)/(*E*)
Mo cat **27**	(31)	—
Mo cat **29**	(83)	>98:2

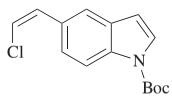
1180



10 eq
(*Z*)/(*E*) > 98:2



Catalyst (0.05 eq), benzene, 22°, 4 h

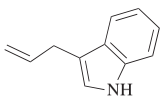


Catalyst		(*Z*)/(*E*)
Mo cat **27**	(73)	28:72
Mo cat **29**	(83)	>98:2

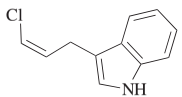
1180



5 eq



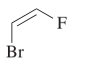
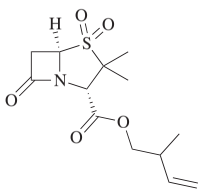
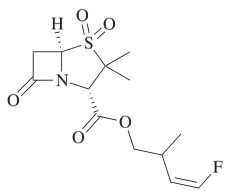
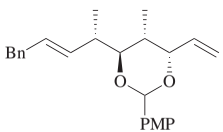
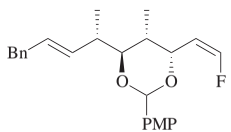
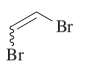
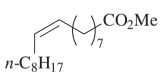
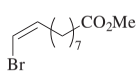
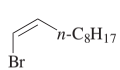
Mo cat **26** (0.03 eq), benzene, 22°, 4 h



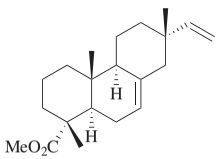
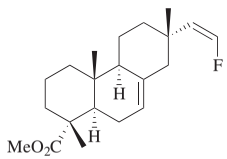
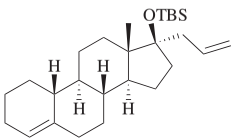
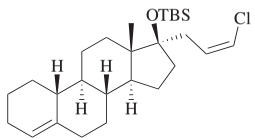
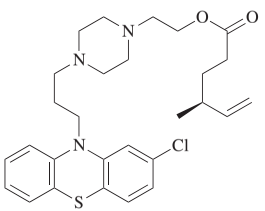
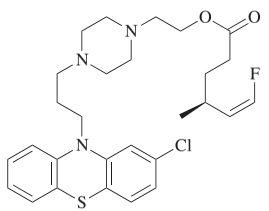
86% conv.[a]
(50) (*Z*)/(*E*) = 95:5

106

TABLE 30. CROSS-METATHESIS OF VINYL HALIDES (*Continued*)

Vinyl Halide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 5 eq		Mo cat **26** (0.05 eq), benzene, 22°, 4 h	 86% conv.[a] (80) (*Z*)/(*E*) > 98:2	106
5 eq		Mo cat **26** (0.05 eq), benzene, 22°, 4 h	 80% conv.[a] (63) (*Z*)/(*E*) > 98:2	106
 8 eq (*Z*)/(*E*) = 64:36		Catalyst (*x* eq), benzene, 22°, 4 h	 +  **I** **II**	1180

Catalyst	*x*	**I**	(*Z*)/(*E*) **I**	**II**	(*Z*)/(*E*) **II**
Mo cat **27**	0.05	(45)	89:11	(45)	89:11
Mo cat **29**	0.03	(90)	>98:2	(85)	>98:2

 5 eq		Mo cat **26** (0.05 eq), benzene, 22°, 4 h		83% conv.[a] (70) (*Z*)/(*E*) = 96:4 106
 5 eq		Mo cat **26** (0.05 eq), benzene, 22°, 4 h		75% conv.[a] (70) (*Z*)/(*E*) = 95:5 106
 5 eq		Mo cat **26** (0.05 eq), benzene, 22°, 4 h		88% conv.[a] (78) (*Z*)/(*E*) > 98:2 106

[a] The conversion was determined by ^{1}H NMR analysis.

TABLE 31. CROSS-METATHESIS OF VINYL SILANES AND SILOXANES

A. VINYL SILANES

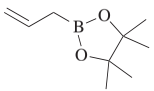
Vinyl Silane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

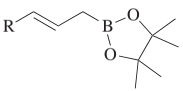
C_2



x eq



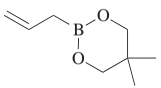
Catalyst (0.05 eq), DCM, 40°, 3 h



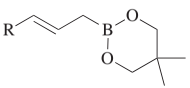
699

R	*x*	Catalyst		(*E*)/(*Z*)
TMS	5	Hov II	(0)	—
$PhMe_2Si$	5	Hov II	(0)	—
Cl_3Si	3	Gr II	(92)	(*E*) only
Cl_2PhSi	3	Hov II	(83)	(*E*) only

x eq



Catalyst (0.05 eq), DCM, 40°, 3 h



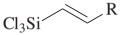
699

R	*x*	Catalyst		(*E*)/(*Z*)
TMS	5	Hov II	(0)	—
$PhMe_2Si$	5	Hov II	(0)	—
Cl_3Si	3	Gr II	(95)	(*E*) only
Cl_2PhSi	3	Hov II	(93)	(*E*) only



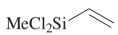
x eq

Catalyst (*y* eq), DCM, reflux



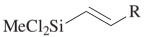
200

R	*x*	Catalyst	*y*	Time (h)	Conv. (%)[a]	[b]	(*E*)/(*Z*)
n-BuOCH$_2$	1	Gr II	0.05	1	100	(92)	89:11
TMSCH$_2$	0.2	Gr II	0.005	1	100	(100)	96:4
n-Bu	0.2	Gr I	0.05	3	0	(—)	—
n-Bu	0.2	Gr II	0.05	3	100	(100)	95:5
n-Bu	1	Hov II	0.05	1	99	(97)	95:5
Ph	0.07	Gr I	0.005	1	0	(—)	—
Ph	0.07	Gr II	0.005	1	85	(83)	(*E*) only
Ph	1	Hov II	0.05	1	100	(85)	(*E*) only



x eq

Catalyst (*y* eq), DCM, reflux



200

R	*x*	Catalyst	*y*	Time (h)	Conv. (%)[a]	[b]	(*E*)/(*Z*)
n-BuOCH$_2$	1	Gr II	0.05	1	100	(98)	96:4
TMSCH$_2$	0.2	Gr II	0.005	1	100	(100)	95:5
n-Bu	0.2	Gr I	0.005	1	0	(—)	—
n-Bu	0.2	Gr II	0.005	1	100	(100)	95:5
n-Bu	1	Gr II	0.05	20	traces	(—)	—
n-Bu	1	Hov II	0.05	6	90	(88)	(*E*) only
Ph	0.07	Gr II	0.005	1	80	(78)	(*E*) only
Ph	1	Hov II	0.02	1	100	(70)	(*E*) only
4-MeC$_6$H$_4$	1	Gr II	0.05	1	100	(95)	(*E*) only
4-ClC$_6$H$_4$	1	Gr II	0.05	1	100	(90)	(*E*) only
4-ClCH$_2$C$_6$H$_4$	1	Gr II	0.05	1	100	(98)	(*E*) only

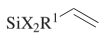
TABLE 31. CROSS-METATHESIS OF VINYL SILANES AND SILOXANES (*Continued*)

A. VINYL SILANES (*Continued*)

Vinyl Silane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

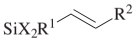
C_2





x eq

Catalyst (0.05 eq), DCM, reflux



200

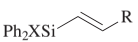
R^1	X	R^2	*x*	Catalyst	Time (h)	Conv. (%)[a]	[b]	(*E*)/(*Z*)
Ph	F	Ph	1	Gr I	20	100	(99)	(*E*) only
Ph	F	Ph	1	Gr II	20	80	(50)	(*E*) only
Ph	Cl	*n*-$BuOCH_2$	1	Gr II	1	100	(90)	(*E*) only
Ph	Cl	*n*-Bu	1	Gr II	1	100	(95)	96:4
Ph	Cl	Ph	1	Gr II	1	100	(98)	(*E*) only
Ph	Cl	4-ClC_6H_4	1	Gr II	1	100	(95)	(*E*) only
4-$CF_3C_6H_4$	Cl	*n*-Bu	0.25	Gr II	3	100	(95)	96:4
4-MeC_6H_4	Cl	*n*-Bu	1	Gr II	1	100	(99)	96:4
4-$CF_3C_6H_4$	Cl	Ph	0.25	Gr II	1	100	(95)	(*E*) only
4-MeC_6H_4	Cl	Ph	1	Gr II	2	100	(95)	(*E*) only





1 eq

Gr II (0.05 eq), DCM, reflux



200

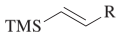
X	R	Time (h)	Conv. (%)[a]	[b]	(*E*)/(*Z*)
Cl	*n*-Bu	2	100	(90)	96:4
F	Ph	20	100	(20)	(*E*) only
Cl	Ph	1	100	(99)	(*E*) only
Cl	4-ClC_6H_4	1	100	(97)	(*E*) only





x eq

Catalyst (*y* eq), solvent



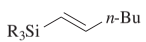
R	*x*	Catalyst	*y*	Solvent	Time (h)	Temp (°)	Conv. (%)[a]	[b]	(*E*)/(*Z*)	
Ph	3	Gr I	0.02	DCM	6	rt	0	(—)	—	200
Ph	0.2	Gr II	0.02	DCM	6	reflux	0	(—)	—	200
Ph	0.2	Hov II	0.02	DCM	6	reflux	90	(85)	(*E*) only	200
n-Bu	0.2	$RuCl_2(PPh_3)_3$	0.1	—	10	105	55	(45)	—	1182
n-C_5H_{11}	0.2	$RuCl_2(PPh_3)_3$	0.1	—	10	105	60	(55)	—	1182
n-C_6H_{13}	0.2	$RuCl_2(PPh_3)_3$	0.1	—	10	105	55	(50)	—	1182
n-C_7H_{15}	0.2	$RuCl_2(PPh_3)_3$	0.1	—	10	105	45	(45)	—	1182
n-C_8H_{17}	0.2	$RuCl_2(PPh_3)_3$	0.1	—	10	105	50	(45)	—	1182
n-$C_{16}H_{33}$	0.5	$RuCl_2(PPh_3)_3$	0.1	—	10	105	40	(40)	—	1182



5 eq



Gr II (0.02 eq), DCM, reflux, 3 h



200

R	Conv. (%)[a]	[b]	(*E*)/(*Z*)
Ph	0	(—)	—
4-MeC_6H_4	0	(—)	—
4-$CF_3C_6H_4$	100	(97)	96:4

TABLE 31. CROSS-METATHESIS OF VINYL SILANES AND SILOXANES (*Continued*)

A. VINYL SILANES (*Continued*)

Vinyl Silane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

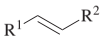
C_2





10 eq

Catalyst (0.01 eq), solvent

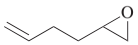


1183

R^1	R^2	Catalyst	Solvent	Temp (°)	Time (h)	[b]	(*E*)/(*Z*)
$PhMe_2Si$	*n*-C_5H_{11}	$RuCl_2(PPh_3)_3$	benzene	reflux	48	(60)	98:2
$PhMe_2Si$	*n*-C_5H_{11}	$RuCl_2(PPh_3)_3$	benzene	130	48	(70)	—
$PhMe_2Si$	*n*-C_5H_{11}	$RuCl_2(PPh_3)_3$	—	130	48	(60)	—
$PhMe_2Si$	*n*-C_6H_{13}	$RuCl_2(PPh_3)_3$	benzene	reflux	4	(70)	95:5
$PhMe_2Si$	*n*-C_6H_{13}	$RuCl_2(PPh_3)_3$	—	130	48	(80)	—
$PhMe_2Si$	*n*-C_8H_{17}	$RuCl_2(PPh_3)_3$	benzene	130	2	(70)	98:2
$PhMe_2Si$	*n*-C_8H_{17}	$RuCl_2(PPh_3)_3$	—	130	48	(85)	—
$PhMe_2Si$	*n*-C_8H_{17}	$[RuCl_2(CO)_3]_2$	—	130	48	(85)	—
$PhMe_2Si$	*n*-C_8H_{17}	$Ru_2(acac)_3$	—	130	48	(50)	—
$PhMe_2Si$	*n*-C_8H_{17}	$RhCl(PPh_3)_3$	—	130	48	(40)	—
$PhMe_2Si$	*n*-$C_{10}H_{21}$	$RuCl_2(PPh_3)_3$	benzene	130	4	(65)	94:6
$PhMe_2Si$	*n*-$C_{10}H_{21}$	$RuCl_2(PPh_3)_3$	—	130	48	(80)	—
$PhMe_2Si$	*n*-$C_{12}H_{25}$	$RuCl_2(PPh_3)_3$	benzene	130	6	(65)	95:5
$PhMe_2Si$	*n*-$C_{12}H_{25}$	$RuCl_2(PPh_3)_3$	—	130	48	(70)	—
$PhMe_2Si$	*n*-$C_{16}H_{33}$	$RuCl_2(PPh_3)_3$	benzene	130	6	(70)	—
$PhMe_2Si$	*n*-$C_{16}H_{33}$	$RuCl_2(PPh_3)_3$	—	130	48	(75)	—
$PhMe_2Si$	Ph	$[RuCl_2(CO)_3]_2$	—	120	0.3	(85)	97:3
$PhMe_2Si$	Ph	$RuCl_2(PPh_3)_3$	benzene	120	0.3	(85)	—
Ph_2MeSi	*n*-C_8H_{17}	$RuCl_2(PPh_3)_3$	benzene	130	6	(70)	98:2
Ph_3Si	*n*-C_8H_{17}	$RuCl_2(PPh_3)_3$	benzene	150	24	(30)	—



1.1 eq

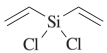


Gr I (0.05 eq), DCM, 40°, 8 h



(17) 1184

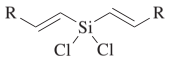
C_4





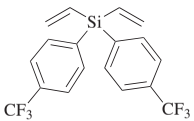
4 eq

Gr II (0.05 eq), DCM, reflux



203

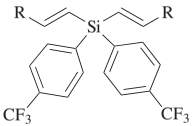
R	Time (h)		(*E*)/(*Z*)
4-ClC_6H_4	3	(98)	(*E*) only
n-C_8H_{17}	1	(99)	94:6





x eq

Catalyst (*y* eq), DCM, reflux



203

R	*x*	Catalyst	*y*	Time (h)		(*E*)/(*Z*)
4-ClC_6H_4	4	Gr I	0.05	5	(0)	—
4-ClC_6H_4	4	Gr II	0.05	5	(14)	(*E*) only
4-ClC_6H_4	10	Gr II	0.1	5	(64)	(*E*) only
4-ClC_6H_4	10	Hov II	0.1	3	(96)	(*E*) only
4-$MeOC_6H_4$	10	Gr II	0.1	5	(70)	(*E*) only
n-C_8H_{17}	4	Gr I	0.05	5	(0)	—
n-C_8H_{17}	4	Gr II	0.05	3	(57)	94:6
n-C_8H_{17}	10	Gr II	0.05	3	(96)	94:6
n-C_8H_{17}	10	Hov II	0.05	3	(56)	94:6

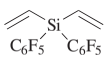
TABLE 31. CROSS-METATHESIS OF VINYL SILANES AND SILOXANES (*Continued*)

A. VINYL SILANES (*Continued*)

Vinyl Silane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

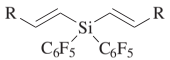
C_4





x eq

Catalyst (*y* eq), DCM, reflux



203

R	*x*	Catalyst	*y*	Time (h)		(*E*)/(*Z*)
4-ClC_6H_4	10	Gr II	0.1	5	(72)	(*E*) only
4-ClC_6H_4	10	Hov II	0.1	3	(98)	(*E*) only
4-$MeOC_6H_4$	10	Gr II	0.1	5	(74)	(*E*) only
n-C_8H_{17}	4	Gr I	0.05	5	(0)	—
n-C_8H_{17}	10	Gr II	0.05	3	(98)	94:6

[a] The conversion was determined by GC analysis.

[b] The yield was determined by GC analysis.

TABLE 31. CROSS-METATHESIS OF VINYL SILANES AND SILOXANES (*Continued*)

B. VINYL SILOXANES

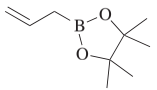
Vinyl Siloxane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

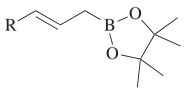
C_2



5 eq



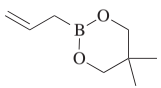
Catalyst (0.05 eq),
DCM, 40°



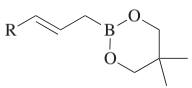
699

R	Catalyst	Time (h)		(*E*)/(*Z*)
$(MeO)_3Si$	Gr I	3	(99)	91:9
$(MeO)_3Si$	Gr II	3	(94)	(*E*) only
$(MeO)_3Si$	Hov II	1	(99)	(*E*) only
$(EtO)_3Si$	Gr I	3	(98)	(*E*) only
$(EtO)_3Si$	Gr II	3	(87)	(*E*) only
$(EtO)_3Si$	Hov II	1	(99)	(*E*) only

5 eq



Catalyst (0.05 eq),
DCM, 40°



699

R	Catalyst	Time (h)		(*E*)/(*Z*)
$(MeO)_3Si$	Gr I	3	(78)	75:25
$(MeO)_3Si$	Gr II	3	(98)	(*E*) only
$(MeO)_3Si$	Hov II	1	(99)	(*E*) only
$(EtO)_3Si$	Gr I	3	(92)	(*E*) only
$(EtO)_3Si$	Gr II	3	(82)	(*E*) only
$(EtO)_3Si$	Hov II	1	(99)	(*E*) only

TABLE 31. CROSS-METATHESIS OF VINYL SILANES AND SILOXANES (*Continued*)

B. VINYL SILOXANES (*Continued*)

Vinyl Siloxane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

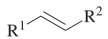
C_2



x eq

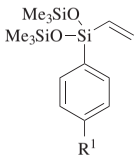


Catalyst (*y* eq), DCM



200

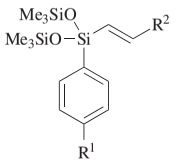
R^1	*x*	R^2	Catalyst	*y*	Temp	Time (h)	Conv. (%)[a]	[b]	(*E*)/(*Z*)
$(AcO)_3Si$	5	$TMSCH_2$	Gr II	0.005	reflux	1	100	(100)	96:4
$(AcO)_3Si$	5	*n*-Bu	Gr II	0.005	reflux	1	100	(100)	95:5
$(AcO)_3Si$	15	Ph	Gr II	0.005	reflux	1	80	(75)	(*E*) only
$(Me_3SiO)Cl_2Si$	1	*n*-$BuOCH_2$	Gr II	0.05	reflux	1	100	(95)	96:4
$(Me_3SiO)Cl_2Si$	1	*n*-Bu	Gr II	0.05	reflux	1	100	(97)	95:5
$(Me_3SiO)Cl_2Si$	1	Ph	Gr II	0.05	reflux	1	100	(95)	(*E*) only
$Ph(EtO)_2Si$	1	*n*-Bu	Gr II	0.05	reflux	1	90	(75)	96:4
$Ph(EtO)_2Si$	1	*n*-Bu	Hov II	0.05	reflux	20	100	(20)	(*E*) only
$Ph(EtO)_2Si$	1	Ph	Gr I	0.05	reflux	20	40	(40)	(*E*) only
$Ph(EtO)_2Si$	1	Ph	Gr II	0.05	reflux	20	90	(88)	(*E*) only
$Ph(EtO)_2Si$	3	4-ClC_6H_4	Gr II	0.05	reflux	20	95	(90)	(*E*) only
$Me(EtO)_2Si$	1	Ph	Gr I	0.02	rt	6	10	(7)	(*E*) only
$Me(EtO)_2Si$	1	Ph	Gr II	0.02	reflux	3	10	(6)	(*E*) only
$Ph_2(EtO)Si$	1	Ph	Gr I	0.05	reflux	3	0	(0)	—
$Ph_2(EtO)Si$	1	Ph	Gr II	0.05	reflux	3	100	(50)	(*E*) only
$Me_2(EtO)Si$	1	Ph	Gr I	0.02	rt	6	3	(0)	—
$Me_2(EtO)Si$	1	Ph	Gr II	0.05	reflux	3	7	(5)	—



x eq



Catalyst (0.05 eq)
DCM, reflux, 5 h



R^1	*x*	R^2	Catalyst	Conv. (%)[a]	[b]	(*E*)/(*Z*)
MeO	5	Ph	Gr II	94	(93)	(*E*) only
MeO	5	4-$MeOC_6H_4$	Gr II	95	(94)	91:9
MeO	5	*n*-C_8H_{17}	Gr II	93	(93)	96:4
MeO	5	$TMSCH_2$	Gr II	80	(80)	(*E*) only
CF_3	1	Ph	Gr I	86	(86)	(*E*) only
CF_3	5	Ph	Gr I	97	(97)	(*E*) only
CF_3	1	4-$MeOC_6H_4$	Gr I	94	(94)	(*E*) only
CF_3	1	4-ClC_6H_4	Gr I	80	(80)	(*E*) only
CF_3	5	*n*-C_8H_{17}	Gr I	100	(95)	91:9
CF_3	2	*n*-$BuOCH_2$	Gr I	100	(100)	89:11
CF_3	5	4-$MeOC_6H_4$	Gr II	99	(95)	(*E*) only
CF_3	5	*n*-C_8H_{17}	Gr II	100	(95)	91:9
CF_3	5	$TMSCH_2$	Gr II	100	(100)	96:4
CF_3	5	*n*-$BuOCH_2$	Gr II	100	(95)	87:13

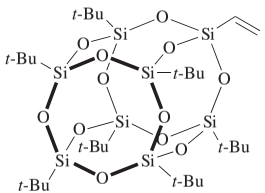
TABLE 31. CROSS-METATHESIS OF VINYL SILANES AND SILOXANES (*Continued*)

B. VINYL SILOXANES (*Continued*)

Vinyl Siloxane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

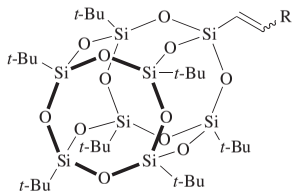
C_2



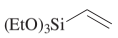


x eq

Gr I (*y* eq), DCM



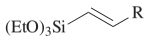
R	*x*	*y*	Temp	Time (h)		
$TMSCH_2$	3	0.01	reflux	18	(85)	1188
$PhCH_2$	2	0.02	reflux	18	(87)	1188
Ph	2	0.01	reflux	6	(97)	1188
4-MeC_6H_4	3	0.01	reflux	6	(94)	1188
4-$MeOC_6H_4$	1.5	0.01	reflux	6	(97)	1188
4-ClC_6H_4	1.5	0.01	reflux	6	(96)	1188
4-BrC_6H_4	1.5	0.01	reflux	6	(95)	1188
4-BrC_6H_4	3	0.03	30°	72	(68)	338



x eq



Catalyst (*y* eq), DCM



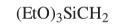
x	R	Catalyst	*y*	Temp	Time (h)	Conv. (%)[a]	[b]	(*E*)/(*Z*)	
1	Ph	Gr I	0.02	rt	6	95	(95)	(*E*) only	200
1	Ph	Gr II	0.02	reflux	1	100	(80)	(*E*) only	200
3	Ph	Gr II	0.02	reflux	3	100	(95)	(*E*) only	200
1	Ph	Hov II	0.05	reflux	2	100	(85)	(*E*) only	200
5	*n*-Bu	Gr I	0.05	reflux	3	100	(75)	90:10	200
5	*n*-Bu	Gr II	0.05	reflux	3	100	(99)	95:5	200
5	$PhOCH_2$	Gr I	0.05	reflux	3	80	(72)	83:17	1185
5	$PhCH_2$	Gr I	0.05	reflux	3	85	(68)	91:9	1185
5	$(EtO)_3SiCH_2$	Gr I	0.05	reflux	3	75	(71)	94:6	1185
5	$TMSCH_2$	Gr I	0.05	reflux	3	100	(95)	(*E*) only	1185
5	*n*-Bu	Gr I	0.05	reflux	3	100	(75)	90:10	1185
5	n-C_8H_{17}	Gr I	0.05	reflux	3	75	(60)	90:10	1185
5	Ph	Gr I	0.05	reflux	3	70	(67)	(*E*) only	1185
0.3	Ph	Gr I	0.05	reflux	3	100	(95)	(*E*) only	1185
5	4-ClC_6H_4	Gr I	0.05	reflux	3	72	(67)	(*E*) only	1185
0.3	4-ClC_6H_4	Gr I	0.05	reflux	3	100	(95)	(*E*) only	1185
5	4-MeC_6H_4	Gr I	0.05	reflux	1	100	(95)	(*E*) only	1185
5	4-$MeOC_6H_4$	Gr I	0.05	reflux	1	100	(95)	(*E*) only	1185
5	$MeCO_2CH_2$	Gr I	0.05	reflux	3	100	(90)	92:8	1186
5	$EtCO_2CH_2$	Gr I	0.05	reflux	3	99	(94)	93:7	1186
5	*n*-$PrCO_2CH_2$	Gr I	0.05	reflux	3	95	(93)	93:7	1186
10	*n*-$PrCO_2CH_2$	Gr I	0.05	reflux	3	75	(75)	89:11	1186
10	*n*-$PrCO_2CH_2$	Gr I	0.05	reflux	4	90	(90)	92:8	1186
5	*n*-$PrCO_2CH_2$	Gr II	0.05	reflux	1	91	(90)	80:20	1186
5	$PhCO_2CH_2$	Gr I	0.05	reflux	3	85	(80)	67:33	1186
5	*c*-$C_6H_{11}(CH_2)_2CO_2CH_2$	Gr I	0.05	reflux	3	95	(90)	(*E*) only	1186
5		Gr I	0.05	reflux	3	92	(90)	75:25	1186

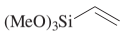
TABLE 31. CROSS-METATHESIS OF VINYL SILANES AND SILOXANES (*Continued*)

B. VINYL SILOXANES (*Continued*)

Vinyl Siloxane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

C_2



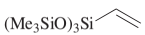
x eq



Gr I (*y* eq),
DCM, reflux



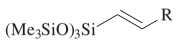
x	R	*y*	Time (h)	Conv. (%)[a]	[b]	(*E*)/(*Z*)	
5	*n*-Bu	0.05	3	80	(60)	86:14	1185
1	Ph	0.02	6	95	(94)	(*E*) only	200
5	$Cy(CH_2)_2CO_2CH_2$	0.05	3	92	(88)	(*E*) only	1186



x eq



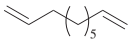
Catalyst (*y* eq),
DCM, reflux



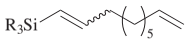
x	R	Catalyst	*y*	Time (h)	Conv. (%)[a]	[b]	(*E*)/(*Z*)	
5	*n*-Bu	Gr I	0.05	3	90	(72)	91:9	200
5	*n*-Bu	Gr II	0.05	3	100	(95)	95:5	1185
1	Ph	Gr I	0.02	6	97	(95)	(*E*) only	1185
5	$Cy(CH_2)_2CO_2CH_2$	Gr I	0.05	3	96	(90)	89:11	1186



6 eq



Gr I (0.05 eq), DCM, reflux



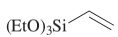
I

\+ 

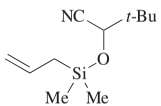
II

R	Time (h)	Conv. (%)[a]	**I**[b]	**II**[b]
MeO	0.17	84	(60)	(11)
MeO	2	100	(7)	(73)
EtO	0.17	88	(50)	(18)
EtO	2	100	(11)	(58)
Me_3SiO	0.17	83	(40)	(13)
Me_3SiO	2	100	(15)	(45)

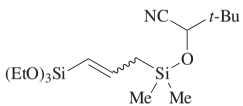
1187



5 eq



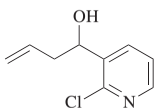
Gr II (0.1 eq), DCM, reflux, 21 h



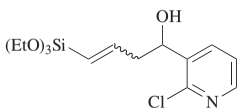
(34)

644

3 eq



Hov II (0.1 eq), DCM, 50°, 24 h

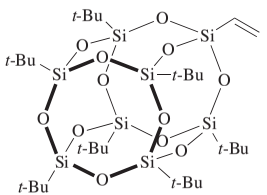
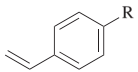
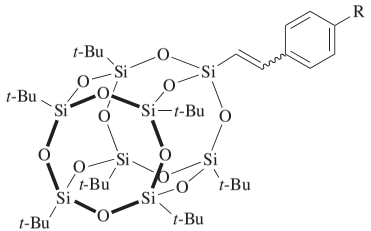


(62)

603

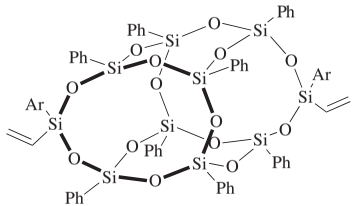
TABLE 31. CROSS-METATHESIS OF VINYL SILANES AND SILOXANES (*Continued*)

B. VINYL SILOXANES (*Continued*)

Vinyl Siloxane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2			Gr I (0.01 eq), DCM, reflux, 24 h		526

R	Conv. (%)[a]	[b]
H	>99	(90)
1-naphthyl	>99	(87)
9-anthracenyl	>99	(88)
2-thienyl	>99	(82)

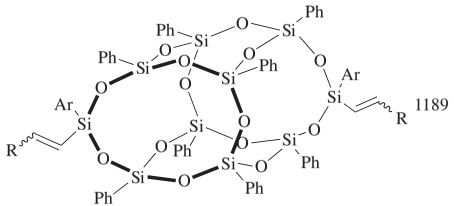
C_4





2 eq

Gr I (x eq), DCM,
reflux, 24 h

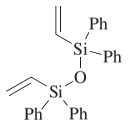
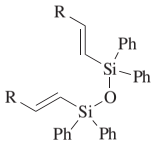


1189

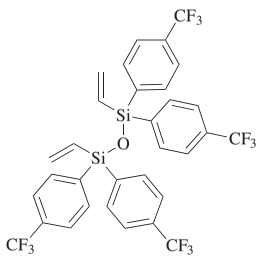
Ar	R	x	Conv. (%)[c]	
Ph	Ph	0.02	—	(94)
Ph	4-BrC_6H_4	0.02	—	(90)
Ph	4-ClC_6H_4	0.02	—	(89)
Ph	4-$MeOC_6H_4$	0.02	99	(—)
Ph	4-$CF_3C_6H_4$	0.02	—	(95)
Ph	4-MeC_6H_4	0.02	—	(92)
4-$MeOC_6H_4$	Ph	0.02	—	(88)
4-$MeOC_6H_4$	4-BrC_6H_4	0.02	—	(89)
4-$MeOC_6H_4$	4-ClC_6H_4	0.02	—	(93)
4-$MeOC_6H_4$	4-$MeOC_6H_4$	0.02	99	(—)
4-$MeOC_6H_4$	4-$CF_3C_6H_4$	0.02	99	(—)
4-$MeOC_6H_4$	4-MeC_6H_4	0.04	58	(—)
4-$MeOC_6H_4$	$TMSCH_2$	0.04	60	(—)
4-$MeOC_6H_4$	$HOCH_2$	0.04	55	(—)

TABLE 31. CROSS-METATHESIS OF VINYL SILANES AND SILOXANES (*Continued*)

B. VINYL SILOXANES (*Continued*)

Vinyl Siloxane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4 	 4 eq	Gr II (0.05 eq), DCM, reflux		203

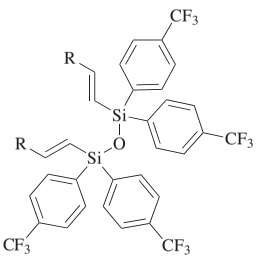
R	Time (h)	[b]	(*E*)/(*Z*)
4-ClC_6H_4	5	(4)	(*E*) only
n-C_8H_{17}	3	(12)	(*E*) only





x eq

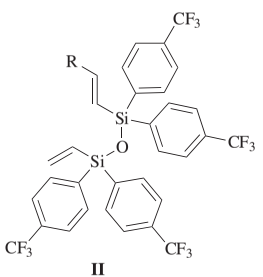
Catalyst (*y* eq), DCM, reflux



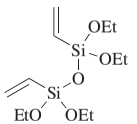
I

203

R	*x*	Catalyst	*y*	Time (h)	**I**[b]	(*E*)/(*Z*) **I**	**II**[b]	(*E*)/(*Z*) **II**
4-ClC_6H_4	10	Gr II	0.1	5	(73)	(*E*) only	(25)	(*E*) only
4-ClC_6H_4	10	Hov II	0.1	5	(83)	(*E*) only	(12)	(*E*) only
4-$MeOC_6H_4$	10	Gr II	0.1	5	(78)	(*E*) only	(20)	(*E*) only
n-C_8H_{17}	4	Gr I	0.05	3	(44)	96:4	(51)	96:4
n-C_8H_{17}	10	Gr I	0.05	3	(66)	96:4	(32)	96:4
n-C_8H_{17}	10	Gr II	0.05	3	(92)	96:4	(8)	96:4
n-C_8H_{17}	10	Hov II	0.05	3	(88)	96:4	(10)	96:4

\+ 

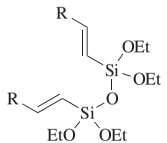
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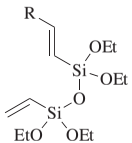


x eq

Catalyst (0.05 eq),
DCM, reflux



+



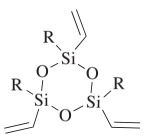
203

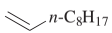
I (*E*) only

II (*E*) only

R	*x*	Catalyst	Time (h)	**I**[b]	**II**[b]
4-ClC_6H_4	4	Gr I	24	(86)	(10)
4-ClC_6H_4	10	Gr II	3	(95)	(2)
4-ClC_6H_4	10	Hov II	5	(66)	(20)
n-C_8H_{17}	4	Gr I	5	(5)	(54)

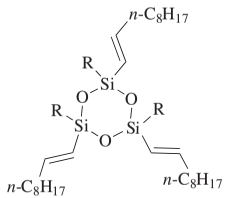
C_6





x eq

Catalyst (0.05 eq),
DCM, 40°



445

R	*x*	Catalyst	Time (h)		(*E*)/(*Z*)
TMSO	3	Gr I	3	(78)	89:11
TMSO	15	Gr II	2	(82)	89:11
Ph	3	Gr II	5	(90)	89:11
4-$MeOC_6H_4$	3	Gr II	5	(91)	91:9

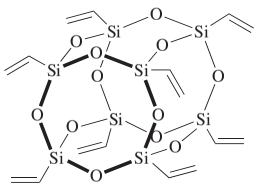
TABLE 31. CROSS-METATHESIS OF VINYL SILANES AND SILOXANES (*Continued*)

B. VINYL SILOXANES (*Continued*)

Vinyl Siloxane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

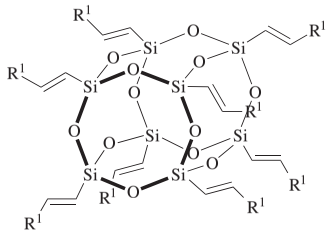
C_{16}





x eq

Catalyst (*y* eq),
solvent

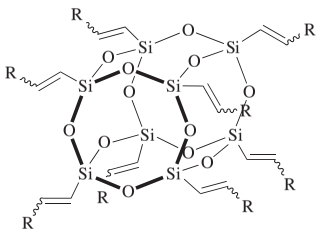


R^1	R^2	*x*	Catalyst	*y*	Solvent	Temp (°)	Time (h)	Conv. (%)[a]		(*E*)/(*Z*)	
Ph	H	1.5	Gr I	0.005	DCM	rt	72	—	(30-40)	—	1213
4-MeC_6H_4	H	1.5	Gr I	0.005	DCM	rt	72	—	(30-40)	—	1213
4-$MeOC_6H_4$	H	1.5	Gr I	0.005	DCM	rt	72	—	(30-40)	—	1213
4-ClC_6H_4	H	1.5	Gr I	0.005	DCM	rt	72	—	(30-40)	—	1213
4-BrC_6H_4	H	1.5	Gr I	0.005	DCM	rt	72	—	(30-40)	—	1213
3-$O_2NC_6H_4$	H	1.5	Gr I	0.005	DCM	rt	72	—	(30-40)	—	1213
n-Pr	*n*-Pr	3	Mo cat **1**	0.016	benzene	25	100	100	(75)	85:15	204
n-Pr	*n*-Pr	3	Mo cat **1**	0.05	C_6D_6	25	4.5	100	(100)	85:15	204
n-Pr	H	2	Mo cat **1**	0.025	—	25	12	100	(100)	85:15	204
Ph	H	5	Mo cat **1**	0.03	C_6D_6	25	12	100	(81)	(*E*) only	204
$TMSCH_2$	H	1.5	Mo cat **1**	0.05	C_6D_6	25	12	100	(100)	88:12	204
$EtO_2C(CH_2)_8$	H	10	Mo cat **1**	0.06	C_6D_6	25	22	100	(100)	80:20	204
$Me_3Si(CH_2)_6$	H	2	Mo cat **1**	0.06	C_6D_6	25	6	100	(100)	84:16	204
$Br(CH_2)_3$	H	12	Mo cat **1**	0.06	C_6D_6	25	6	100	(76)	94:6	204
$Br(CH_2)_3$	H	3	Gr I	0.06	CD_2Cl_2	38	24	25	—	80:20	204
$HO(CH_2)_3$	H	3	Gr I	0.06	CD_2Cl_2	38	48	10	—	80:20	204



x eq

Gr I (*y* eq), DCM, reflux



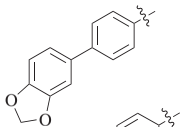
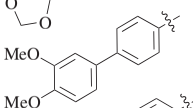
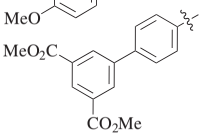
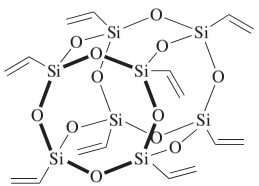
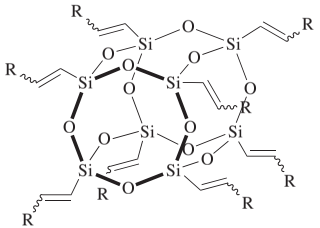
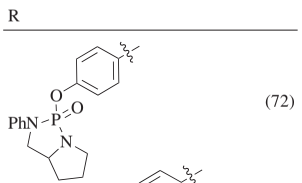
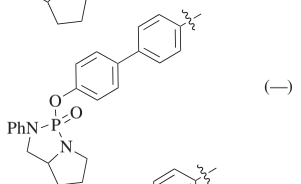
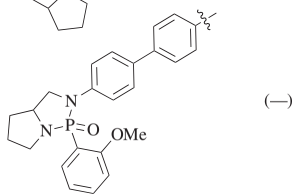
R	*x*	*y*	Time (h)	Conv. (%)[a]	[b]	
Ph	8	0.01	24	>99	(86)	205
4-ClC_6H_4	8	0.01	24	>99	(92)	205
4-BrC_6H_4	8	0.01	24	>99	(93)	205
4-$CF_3C_6H_4$	8	0.01	24	>99	(92)	205
4-(1-naphthyl)C_6H_4	8	0.01	24	>99	(94)	205
4-(9-anthracenyl)C_6H_4	8	0.01	24	>99	(89)	205
4-(2-thienyl)C_6H_4	8	0.01	24	>99	(92)	205
	17	0.035	96	—	(67)	206
	17	0.035	96	—	(53)	206
	17	0.035	96	—	(62)	206

TABLE 31. CROSS-METATHESIS OF VINYL SILANES AND SILOXANES (*Continued*)

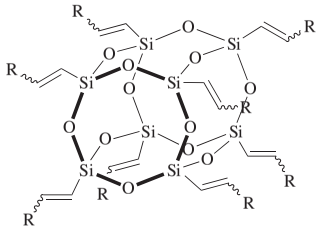
B. VINYL SILOXANES (*Continued*)

Vinyl Siloxane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{16} 	 12.5 eq	Gr I (0.45 eq), DCM, reflux, 90 h	 R  (72)  (—)  (—)	207



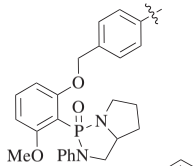
12.5 eq

Gr I (0.45 eq),
DCM, reflux, 90 h

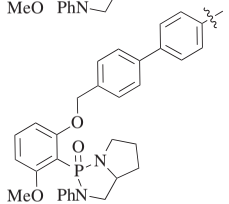


207

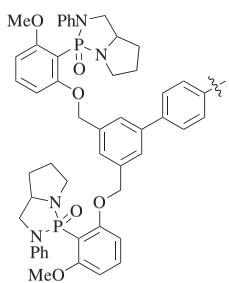
R



(—)



(—)



(—)

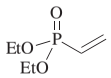
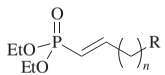
[a] The conversion was determined by GC analysis.

[b] The yield was determined by GC analysis.

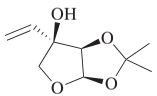
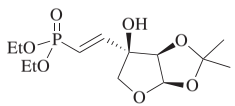
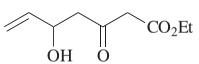
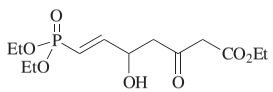
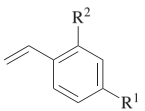
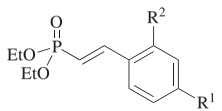
[c] The conversion was determined by ^{1}H NMR analysis.

TABLE 32. CROSS-METATHESIS OF VINYLIC ORGANOPHOSPHORUS COMPOUNDS

A. VINYL PHOSPHONATES

Vinylphosphonate	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
	 *x* eq	Gr II (0.05 eq), DCM, reflux		

R	*n*	*x*	Time (h)		(*E*)/(*Z*)	
BnTsN	1	—	20	(61)	—	1190
Br	2	1.5	12	(82)	>95:5	144
AcO	4	1.5	12	(95)	>95:5	144
OHC	8	1.5	12	(77)	>95:5	144

6 eq		Gr II (0.05 eq), DCM, reflux, overnight		(100)	(*E*) only	907
5 eq		Gr II (0.05 eq), DCM, 40°, 48 h		(47)	(*E*) only	745
 1.5 eq		Gr II (0.05 eq), DCM, 40°, 12 h	 (*E*)/(*Z*) > 95:5			144

R^1	R^2	
H	H	(97)
MeO	H	(97)
Br	H	(93)
Me	Me	(77)

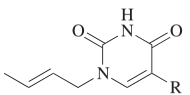
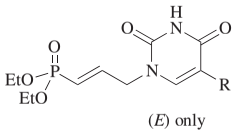
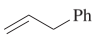
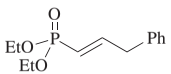
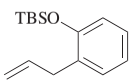
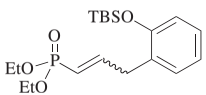
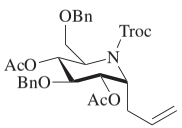
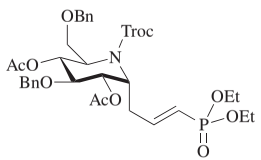
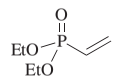
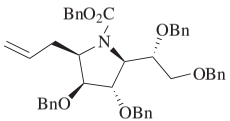
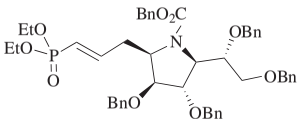
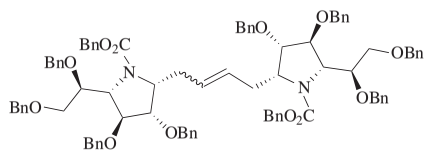
4 eq		Gr II (0.05 eq), DCM, reflux, 22 h	 (*E*) only	R: H (67), PhS (42), Cl (63), Br (37)	669
1.5 eq		Gr II (0.05 eq), DCM, 40°, 12 h		(90) (*E*)/(*Z*) > 95:5	144
3 eq		Gr II (0.02 eq), solvent, 22° (MW), 4 h		Solvent: PTS (51), $PTS/KHSO_4$ (65), DCM (39)	931
2 eq		Gr II (0.1 eq), DCM, reflux, 16–24 h		(71) (*E*)/(*Z*) > 95:5	666

TABLE 32. CROSS-METATHESIS OF VINYLIC ORGANOPHOSPHORUS COMPOUNDS (*Continued*)

A. VINYL PHOSPHONATES (*Continued*)

Vinylphosphonate	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 2 eq		Catalyst (0.1 eq), DCM, 40°	 **I** (*E*) only +  **II**	1191, 1192

Catalyst	Time (h)	I	II
Ru cat **35**	24	(68)	(8)
Gr II	12	(—)	(—)
Ru cat **35**	12	(68)	(8)
Hov II	12	(75)	(10)

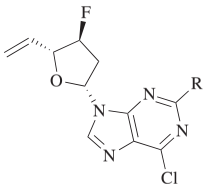
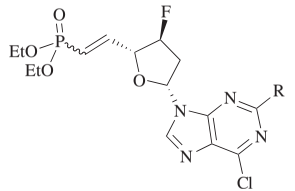
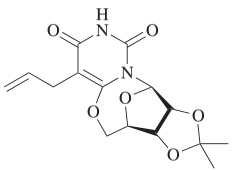
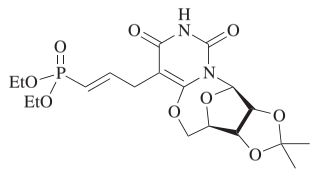
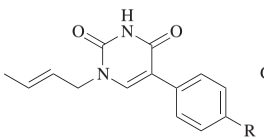
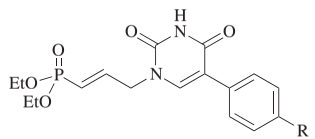
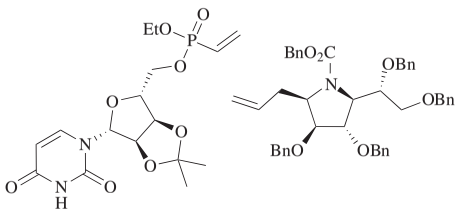
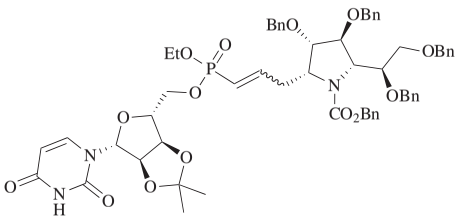
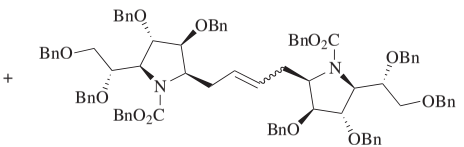
4 eq		Gr II (0.04 eq), DCM, reflux, 26 h		R H (57) F (60)	1193
5 eq		Ru cat **35** (0.06 eq), DCM, reflux, 7 h		(60) (*E*) only	631
4 eq		Gr II (0.05 eq), DCM, reflux, 22 h	 (*E*) only	R H (67) F (71) MeO (52)	629

TABLE 32. CROSS-METATHESIS OF VINYLIC ORGANOPHOSPHORUS COMPOUNDS (*Continued*)

A. VINYL PHOSPHONATES (*Continued*)

Vinylphosphonate	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2	 2 eq	Catalyst (0.1 eq), DCM, 40°	 **I** +  **II**	1191, 1192

Catalyst	Time (h)	**I**	**II**
Ru cat **35**	44	(51)	(8)
Hov II	24	(61)	(—)

TABLE 32. CROSS-METATHESIS OF VINYLIC ORGANOPHOSPHORUS COMPOUNDS (*Continued*)

B. VINYL PHOSPHINE OXIDES

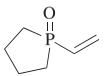
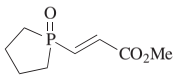
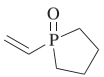
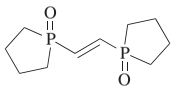
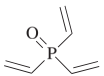
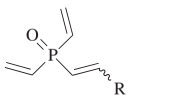
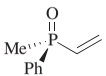
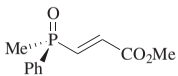
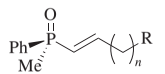
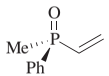
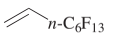
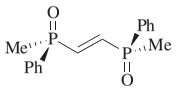
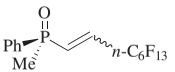
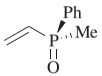
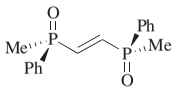
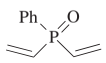
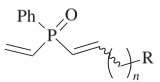
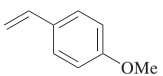
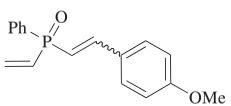
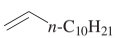
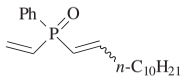
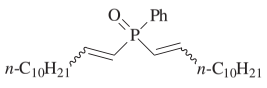
Vinylphosphine Oxide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_6				
	 30 eq	Ru cat **88** (0.05 eq), DCM, reflux, 24 h	 (54) (*E*) only	215
		Ru cat **88** (0.05 eq), DCM, reflux, 24 h	 (62) (*E*) only	215
 3 eq		Gr II (0.04 eq), DCM, reflux, 24 h	 R: Ph (68); *n*-$C_{10}H_{21}$ (75)	217
C_9				
	 30 eq	Ru cat **88** (0.05 eq), DCM, reflux, 24 h	 (62) (*E*) only	215
	 2.5 eq	Catalyst (0.05 eq), DCM, reflux, 16 h	 (*E*) only	
			n R Catalyst: 2 Ac Ru cat **114** (85)	164
			8 MeO_2C Gr II (74)	164
			4 Br Ru cat **88** (86)	171

TABLE 32. CROSS-METATHESIS OF VINYLIC ORGANOPHOSPHORUS COMPOUNDS (*Continued*)

B. VINYL PHOSPHINE OXIDES (*Continued*)

Vinylphosphine Oxide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
	 2.5 eq	Ru cat **88** (0.05 eq), DCM, reflux, 16 h	 (85) (*E*) only +  (0)	164
		Catalyst (0.05 eq), DCM, reflux	 (*E*) only	Catalyst / Time (h): Gr II 16 (18); Hov II 16 (44); Ru cat **88** 16 (95); Ru cat **88** 24 (80)	171, 215, 164
C_{10}				
 3 eq		Gr II (0.02 eq), DCM, reflux, 24 h		*n* / R: 1 TMS (72); 4 Br (86)	217
3 eq		Gr II (0.02 eq), DCM, reflux, 24 h	 (56)	217

x eq		Gr II (0.02 eq), DCM, reflux, 24 h	 **I** +  **II**		217

x	**I**	**II**
1	(47)	(23)
3	(79)	(14)

C_{12}

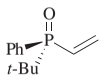
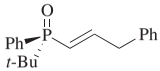
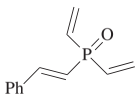
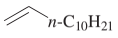
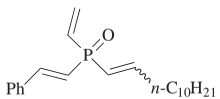
	 2.5 eq	Ru cat **114** (0.05 eq), DCM, reflux, 16 h		(72) (*E*) only	164
 3 eq		Gr II (0.04 eq), DCM, reflux, 48 h		(71)	217

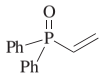
TABLE 32. CROSS-METATHESIS OF VINYLIC ORGANOPHOSPHORUS COMPOUNDS (*Continued*)

B. VINYL PHOSPHINE OXIDES (*Continued*)

Vinylphosphine Oxide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

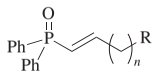
C_{14}





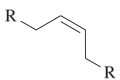
x eq

Catalyst (*y* eq),
DCM, 40°



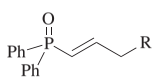
(*E*) only

n	R	*x*	Catalyst	*y*	Time (h)		
0	Ac	3	Gr II	0.02–0.06	20–48	(0)	214
1	TMS	3	Gr II	0.02–0.06	20–48	(97)	214
3	Ph_2OP	—	Gr II	0.02–0.06	20–48	(93)	214
4	AcO	3	Gr II	0.02–0.06	20–48	(94)	214
4	TBSO	0.5	Gr II	0.05	16	(82)	216
4	TBSO	0.5	Ru cat **88**	0.05	16	(82)	171
4	TBSO	0.5	Ru cat **114**	0.05	16	(78)	164
4	TBSO	0.5	Ru cat **106**	0.05	16	(87)	164
4	Br	2.5	Ru cat **114**	0.05	16	(99)	164
4	Br	3	Gr II	0.02–0.06	20–48	(92)	164
9	Me	3	Gr II	0.02–0.06	20–48	(100)	164



2.5 eq

Catalyst (0.05 eq),
DCM, reflux, 16 h



(*E*) only

R	Catalyst		
AcO	Ru cat **88**	(52)	164
Cl	Ru cat **114**	(65)	



excess

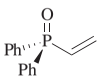
Ru cat **88** (0.05 eq), solvent, reflux, 16 h

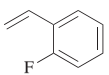


I + **II**

164

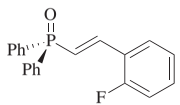
Solvent	**I**	**II**
neat	(98)	(2)
DCM	(70)	(30)





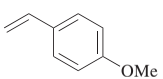
3 eq

Ru cat **88** (0.05 eq), DCM, reflux, 24 h



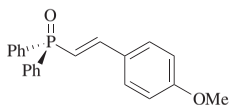
(32) (*E*) only

215



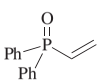
3 eq

Catalyst (0.05 eq), DCM, reflux, 24 h

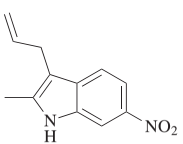


(*E*) only

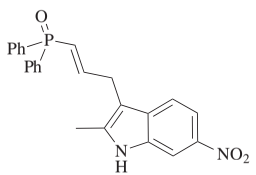
Catalyst		
Gr II	(78)	214, 216, 215
Ru cat **88**	(81)	
Ru cat **106**	(83)	



2 eq



Ru cat **88** (0.05 eq), DCM, reflux, 16 h

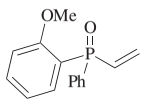
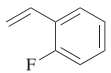
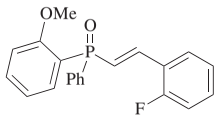
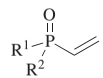
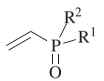
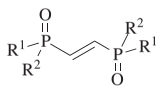


(76) (*E*) only

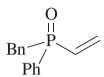
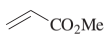
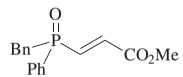
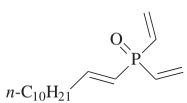
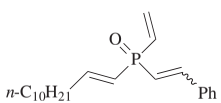
171, 164

TABLE 32. CROSS-METATHESIS OF VINYLIC ORGANOPHOSPHORUS COMPOUNDS (*Continued*)

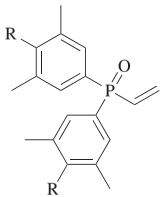
B. VINYL PHOSPHINE OXIDES (*Continued*)

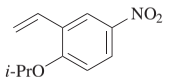
Vinylphosphine Oxide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{14}				
	 3 eq	Ru cat **88** (0.05 eq), DCM, reflux, 24 h	 (29) (*E*) only	215
		Ru cat **88** (0.05 eq), DCM, reflux, 24 h	 (*E*) only	215

R^1	R^2	
n-C_6H_{13}	n-C_6H_{13}	(65)
Bn	Ph	(40)
Bn	Bn	(46)

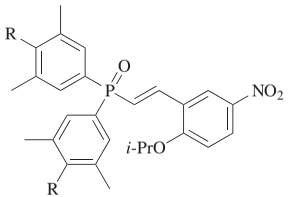
C_{15}				
 30 eq		Ru cat **88** (0.05 eq), DCM, reflux, 24 h	 (34) (*E*) only	215
C_{16}				
 3 eq		Gr II (0.04 eq), DCM, reflux, 48 h	 (87)	217

C_{18}





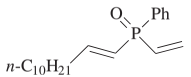
Ru cat **88** (0.05 eq),
DCM, reflux, 24 h



(*E*) only

R		
H	(6)	215
MeO	(6)	

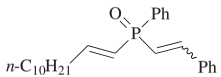
C_{20}



3 eq

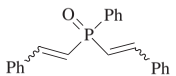


Gr II (0.02 eq),
DCM, reflux, 48 h



I (69)

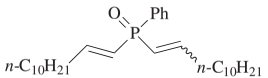
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II (—)

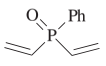
217

\+



III (—)

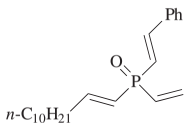
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IV (—)

I/II/III/IV = 8:1:5:4

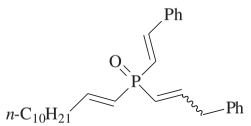
C_{22}



3 eq



Gr II (0.04 eq),
DCM, reflux, 24 h



(65)

217

TABLE 32. CROSS-METATHESIS OF VINYLIC ORGANOPHOSPHORUS COMPOUNDS (*Continued*)

C. VINYL PHOSPHINE BORANES

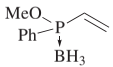
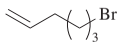
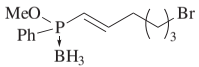
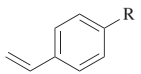
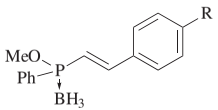
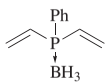
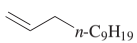
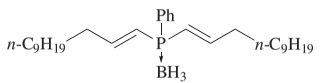
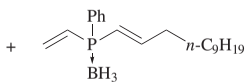
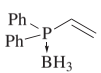
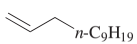
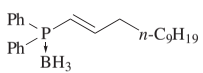
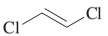
Vinyl Phosphine Borane	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
	 3 eq	Gr II (0.06 eq), DCM, reflux, 36 h	 (55) (*E*) only	213
	 3 eq	Gr II (*x* eq), DCM, reflux	 (*E*) only	213
			R / *x* / Time (h): H 0.08 48 (66); MeO 0.06 36 (46)	
C_{10}				
	 3 eq	Gr II (0.08 eq), DCM, reflux, 48 h	 (22) (*E*) only	213
			+  (17) (*E*) only	
C_{14}				
	 3 eq	Gr II (0.08 eq), DCM, reflux, 48 h	 (35) (*E*) only	213

TABLE 33. CROSS-METATHESIS OF VINYLIC ORGANOSULFUR COMPOUNDS
A. VINYL THIOETHERS

Vinyl Thioether	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{4-8}				
	 *x* eq	Hov II (0.05 eq), solvent, 23°		104

R^1	R^2	R^3	*x*	Solvent	Time (h)		(*Z*)/(*E*)
Et	F	H	—	C_6D_6/CD_2Cl_2 10:1	24	(0)	—
Et	Cl	Cl	5.6	C_6D_6	24	(5)	(*Z*) only
Ph	F	H	—	C_6D_6/CD_2Cl_2 (10:1)	24	(0)	—
Ph	Cl	Cl	6	C_6D_6	24	(50)	88:12
Ph	Cl	Cl	3.8	C_6D_6	40	(70)	81:19

C_{8-9}

	 100 eq	Catalyst (*x* eq), 50°	 (*Z*) only	105

R	Catalyst	*x*	Time (h)	
Ph	Ru cat **115**	0.1	20	(85)
Bn	Ru cat **88**	0.05	24	(35)

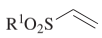
TABLE 33. CROSS-METATHESIS OF VINYLIC ORGANOSULFUR COMPOUNDS (*Continued*)

B. VINYL SULFONES

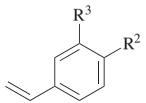
Vinyl Sulphone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

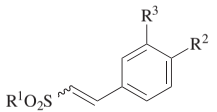
C_{3-8}



5 eq



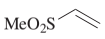
Ru cat **88** (5 x 0.024 eq), $C_6F_5CF_3$, 120° (MW), 50 min



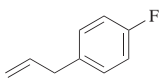
R^1	R^2	R^3	
Me	H	H	(50)
Me	MeO	EtO	(57)
CH_2=CH	MeO	EtO	(45)
Et	$CF_3CH_2OCH_2$	H	(43)
Ph	MeO	EtO	(80)

929

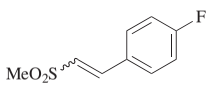
C_3



I



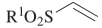
1. Ru cat **352** (0.02 eq), acetone-d_6, rt, 10 min
2. Ru cat **88** (5 x 0.024 eq), **I** (5 eq), $C_6F_5CF_3$, 120° (MW), 50 min



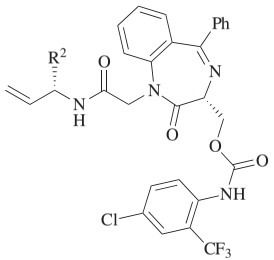
(35)

929

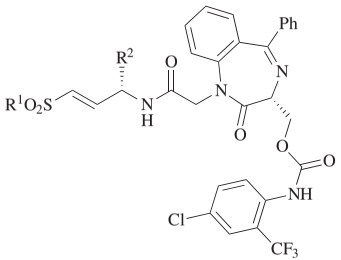
$C_{3–8}$



10 eq



Hov II (0.1 eq),
DCM, 100° (MW), 2 h



(*E*) only 238

R^1	R^2	
Me	H	(47)
Et	H	(53)
Ph	H	(49)
4-$MeOC_6H_4$	H	(51)
Me	$Ph(CH_2)_2$	(47)
Et	$Ph(CH_2)_2$	(49)
Ph	$Ph(CH_2)_2$	(48)
4-$MeOC_6H_4$	$Ph(CH_2)_2$	(46)

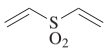
TABLE 33. CROSS-METATHESIS OF VINYLIC ORGANOSULFUR COMPOUNDS (*Continued*)

B. VINYL SULFONES (*Continued*)

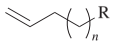
Vinyl Sulphone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

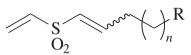
C_4



3 eq

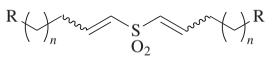


Catalyst (0.05 eq),
DCM, reflux



I

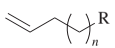
+



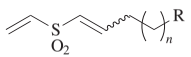
II

R	*n*	Catalyst	Time (h)	**I**	**II**	
Ph	0	Gr II	24	(84)	(9)	228
TMS	0	Gr II	24	(66)	(31)	233
TBSO	3	Gr II	16	(69)	(13)	233
Br	7	Ru cat **88**	22	(72)	(19)	233
HO	8	Gr II	24	(71)	(12)	233

3 eq

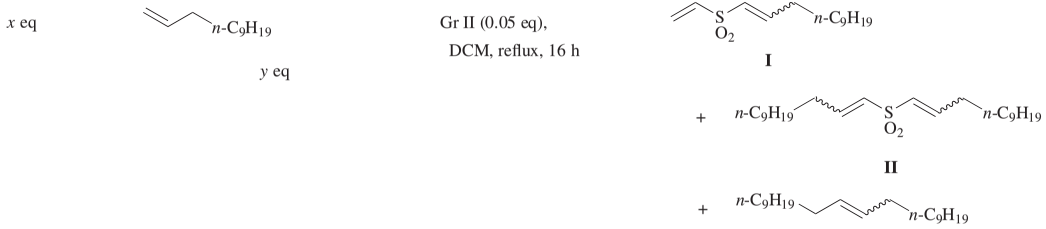


Catalyst (0.05 eq),
DCM, reflux



228, 233

R	*n*	Catalyst	Time (h)	
Br	3	Ru cat **88**	20	(36)
Me	3	Gr II	20	(42)
Me	3	Ru cat **88**	20	(51)
Me	15	Gr II	21	(59)
Me	15	Ru cat **88**	18	(70)



x	*y*	**I/II/III**[a]
1	1	74:20:6
1	3	41:22:37
3	1	82:7:11

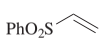
TABLE 33. CROSS-METATHESIS OF VINYLIC ORGANOSULFUR COMPOUNDS (*Continued*)

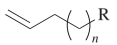
B. VINYL SULFONES (*Continued*)

Vinyl Sulphone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

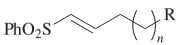
Please refer to the charts preceding the tables for the catalyst structures.

C_8



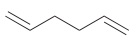


Catalyst (*y* eq), DCM



x eq

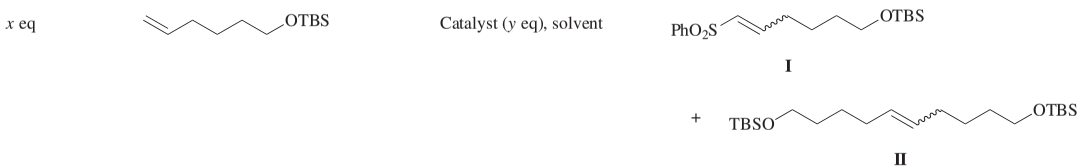
R	*n*	*x*	Catalyst	*y*	Temp (°)	Time (h)		(*E*)/(*Z*)	
TMS	0	3	Gr II	0.05	reflux	3–24	(26)	—	171
TMS	0	3	Ru cat **88**	0.05	reflux	3–24	(33)	—	146
Ph	0	0.5	Gr II	0.05	25	16	(68)	—	216
Ph	0	0.5	Ru cat **88**	0.05	25	16	(86)	—	160
Ph	0	2.5	Gr II	0.025	reflux	12	(43)	(*E*) only	971
Ph	0	2.5	Hov II	0.025	reflux	12	(71)	(*E*) only	1173
Ph	0	2.5	Ru cat **86**	0.025	reflux	12	(62)	(*E*) only	232
HO	3	0.5	Gr II	0.1	reflux	3–24	(81)	—	228
TBSO	3	0.5	Gr II	0.05	45	3–24	(85)	—	228
TBSO	3	0.5	Ru cat **88**	0.025	25	16	(90)	—	228
TBSO	3	0.5	Ru cat **106**	0.025	20	16	(89)	—	228
TBSO	3	0.5	Ru cat **114**	0.05	40	16	(80)	—	228
O_2N	3	0.25	Gr II	0.045	reflux	18	(50)	(*E*) only	228
MeO_2C	7	—	Gr II	0.05	reflux	3–24	(76)	—	228
HO	8	0.5	Ru cat **88**	0.05	reflux	16	(96)	—	228

3 eq 

Ru cat **93** (3 x 0.025 eq), $CDCl_3$, 100° (MW), 2.5 h



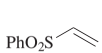
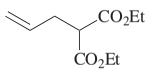
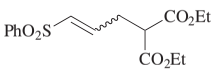
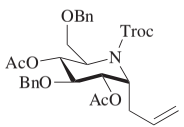
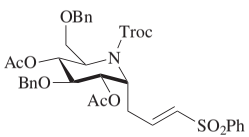
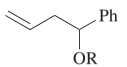
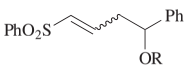
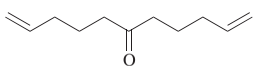
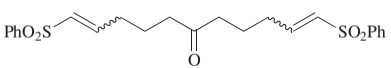
(55) 926



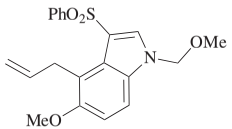
x	Catalyst	*y*	Solvent	Temp (°)	Time (h)	**I**	**II**	
2	Gr II	0.1	toluene	50	3	(86)	(5)	232
2	Gr II	0.1	Et_2O	reflux	3	(80)	(20)	232
2	Gr II	0.1	DCM	reflux	3	(92)	(8)	232
3	Gr II	0.05	DCM	reflux	3	(82)	(0)	232
1	Gr II	0.05	DCM	reflux	3	(57)	(17)	232
0	Gr II	0.05	DCM	reflux	3	(0)	(>95)	232
2	Gr I	0.1	DCM	45	3	(0)	(82)	228
2	Mo cat **1**	0.1	DCM	45	3	(0)	(0)	228
2	Ru cat **35**	0.1	DCM	45	3	(98)	(2)	228
2	Hov II	0.1	DCM	45	3	(87)	(13)	228
2	Ru cat **87**	0.1	DCM	45	3	(80)	(16)	228
2	Ru cat **88**	0.1	DCM	45	3	(95)	(5)	228
2	Ru cat **167**	0.05	toluene	80	0.5	(78)	(—)	1060

TABLE 33. CROSS-METATHESIS OF VINYLIC ORGANOSULFUR COMPOUNDS (*Continued*)

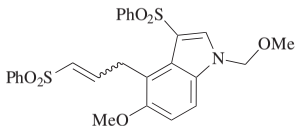
B. VINYL SULFONES (*Continued*)

Vinyl Sulphone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
 2 eq		Gr II (0.05 eq), DCM, reflux, 3–24 h	 (74)	232, 228
3 eq		Gr II (0.1 eq), DCM, reflux, 16–24 h	 (50) $(E)/(Z) > 95:5$	666
2 eq		Catalyst (*x* eq), DCM, reflux, 3–24 h		232, 228
		R: H; Catalyst: Ru cat **87**; *x*: 0.05; (71)		
		R: TBS; Catalyst: Gr II; *x*: 0.1; (55)		
		R: TBS; Catalyst: Ru cat **35**; *x*: 0.05; (53)		
		R: TBS; Catalyst: Ru cat **87**; *x*: 0.05; (30)		
		R: TBS; Catalyst: Ru cat **88**; *x*: 0.05; (48)		
6 eq		Ru cat **190** (0.025 eq), DCM, 50°, 96 h	 (73)	231

2 eq



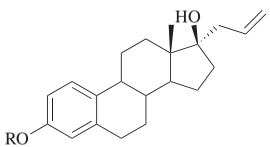
Catalyst (*x* eq),
DCM, reflux, 3–24 h



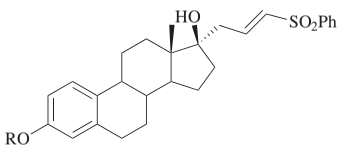
232, 228, 171

Catalyst	*x*	
Gr II	0.1	(33)
Ru cat **35**	0.05	(44)
Ru cat **35**	0.1	(54)
Ru cat **87**	0.05	(41)
Ru cat **88**	0.05	(53)
Ru cat **122**	0.05	(54)

x eq



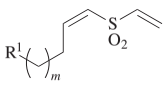
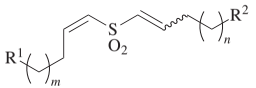
Gr II (0.05 eq), solvent, 6 h



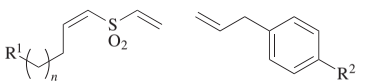
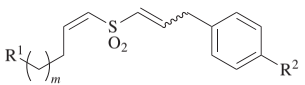
x	R	Solvent	Temp (°)		(*E*)/(*Z*)	
—	H	DCE/$C_6F_5CF_3$ (1:4)	70	(55)	(*E*) only	229
3	H	DCM	40	(29)	—	140
3	*n*-$C_8F_{17}(CH_2)_2$(*i*-Pr)$_2$Si	$C_6F_5CF_3$	70	(69)	—	140

TABLE 33. CROSS-METATHESIS OF VINYLIC ORGANOSULFUR COMPOUNDS (*Continued*)

B. VINYL SULFONES (*Continued*)

Vinyl Sulphone	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
$C_{8–13}$	 4 eq	Gr II (*x* eq), DCM, reflux		233

R^1	*m*	R^2	*n*	*x*	Time (h)	
TBSO	3	Me	3	0.1	23	(85)
HO	8	Br	7	0.08	16	(74)

$C_{11–21}$	 4 eq	Catalyst (*x* eq), DCM, reflux		233

R^1	*n*	R^2	Catalyst	*x*	Time (h)	
Ph	0	H	Ru cat **88**	0.1	16	(68)
Ph	0	Br	Ru cat **88**	0.08	44	(74)
Me	15	H	Gr II	0.2	24	(54)

[a] The ratio of products was determined by GC analysis.

TABLE 33. CROSS-METATHESIS OF VINYLIC ORGANOSULFUR COMPOUNDS (*Continued*)

C. VINYL SULFONAMIDES

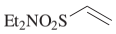
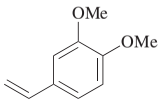
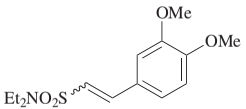
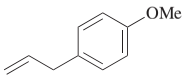
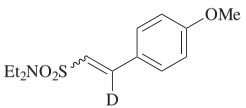
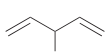
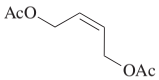
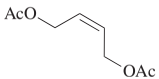
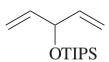
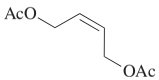
Vinyl Sulfonamide	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_2				
 5 eq		Ru cat **88** (5 x 0.024 eq), $C_6F_5CF_3$, 120° (MW), 50 min	 (89)	929
5 eq		1. Ru cat **352** (0.02 eq), acetone-d_6, D_2O, rt, 10 min 2. Ru cat **88** (5 × 0.02 eq), **I** (5 eq), $C_6F_5CF_3$, 120° (MW), 50 min	 (41)	929

TABLE 34. ASYMMETRIC CROSS-METATHESIS

Prochiral Diene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_5				
	 5 eq	Catalyst (0.05 eq), DCM, 40°		97

Catalyst		er
Ru cat **16**	(15)	61.0:39.0
Ru cat **18**	(20)	72.0:28.0
Ru cat **20**	(28)	72.0:28.0
Ru cat **22**	(20)	67.0:33.0
Ru cat **24**	(12)	68.5:31.5

	 5 eq	Ru cat **215** (0.05 eq), THF, 35°, 19 h		(35) er 75.0:25.0	98
 5 eq		Ru cat **20** (0.05 eq), 40°, 6 h		(52) er 76.0:24.0	97

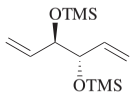
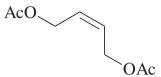
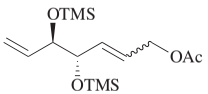
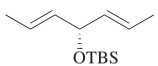
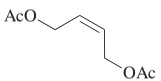
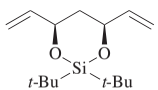
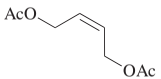
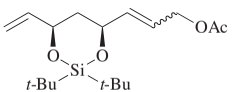
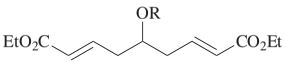
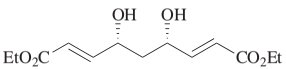
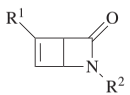
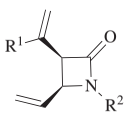
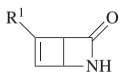
C_6		 5 eq	Ru cat **20** (0.05 eq), DCM, 40°, 6 h		(17) er 70.0:30.0	97
C_7		 5 eq	Ru cat **20** (0.05 eq), DCM, 40°, 6 h		(23) er 52.0:48.0	97
		 5 eq	Ru cat **20** (0.05 eq), DCM, 40°, 6 h		(48) er 68.5:31.5	97

TABLE 35. RING-OPENING CROSS-METATHESIS

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)		Refs.
Please refer to the charts preceding the tables for the catalyst structures.					
C_5					
	 6 eq	Hov II (2 x 0.025 eq), DCM, rt		(*E*) only	1194
			R / Time (h): H 72 (20); TBS 48 (66)		
	 6 eq	Hov II (2 x 0.025 eq), DCM, rt, 89 h		(52) (*E*) only	1194
C_{5-6}					
	 excess	Gr I (0.1 eq), DCM, rt			119

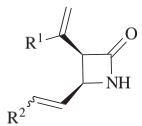
R^1	R^2	
H	H	(50)
H	TMS	(0)
H	TBDPS	(60)
H	TBS	(89)
Me	H	(28)
Me	TMS	(0)
Me	TBDPS	(53)
Me	TBS	(90)



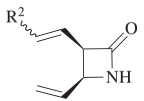


5 eq

Gr I (0.1 eq), DCM, rt



+



119

I **II**

R^1	R^2	**I**	**II**
H	*n*-Bu	(9)	(3)
H	Ph	(7)	(5)
Me	*n*-Bu	(10)	(—)
Me	Ph	(15)	(—)

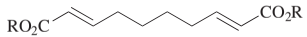
C_6





x eq

Gr II (*y* eq), solvent



(*E*) only

R	*x*	*y*	Solvent	Temp	Time (h)		
H	0.33	0.05	DCM	reflux	3	(94)	170
t-Bu	2	0.05	DCM	rt	3	(88)	170
t-Bu	0.25	0.005	2.5 % aq. PTS	rt	15	(80)	976

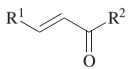
TABLE 35. RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

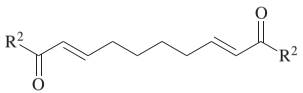
C_6





x eq

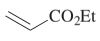
Gr II (*y* eq), solvent



(*E*) only

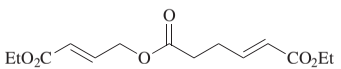
R^1	R^2	*x*	*y*	Solvent	Temp	Time (h)		Refs.
H	Me	2.5	0.02	2 % aq. PTS	rt	15	(68)	976
Me	Et	0.33	0.05	DCM	reflux	3	(72)	170





6 eq

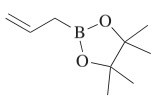
Hov II (2 x 0.025 eq), DCM, rt, 72 h



(50) (*E*) only 1194

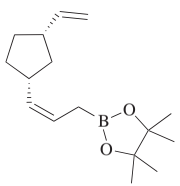
C_7





10 eq

Ru cat **151** (0.05 eq), DCM, 22°, 2 h

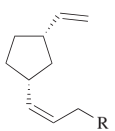


(64) (*Z*)/(*E*) = 90:10 83

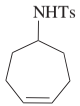


10 eq

Ru cat **151** (0.05 eq), DCM, 22°, 2 h



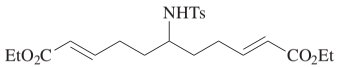
R		(*Z*)/(*E*)	Refs.
HO	(68)	88:12	83
$HOCH_2$	(84)	87:13	
n-$BuOCH_2$	(66)	87:13	





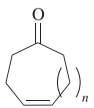
6 eq

Hov II (2 x 0.025 eq),
DCM, rt, 48 h



(79) (*E*) only 1194

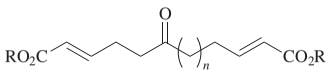
C_{7-8}





6 eq

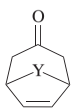
Hov II (2 x 0.025 eq),
DCM, rt, 48 h



(*E*) only 1194

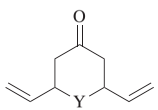
R	*n*	
Et	1	(63)
Et	2	(77)
Bn	2	(72)
t-Bu	2	(60)

C_7





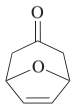
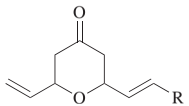
Gr I (0.01 eq),
DCM, rt, 26 h



Y	
O	(43)
CH_2	(50)

345

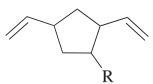
TABLE 35. RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_7 	 bubbled	Gr I (0.01 eq), DCM, rt		345

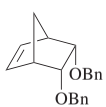
R	Time (h)		(*E*)/(*Z*)
Me	4	(40)	78:22
Et	1	(42)	89:11

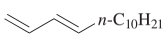
$C_{7\text{-}10}$ 

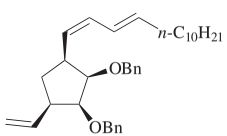
 *x* bar

Catalyst (*y* eq), toluene, rt 

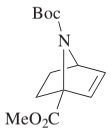
R	*x*	Catalyst	*y*	Time (h)		Refs.
$(EtO)_3Si$	4	Ru cat **73**	0.00025	24	(99)	346
Me_3SiOMe_2Si	4	Ru cat **73**	0.001	24	(99)	346
$(EtO)_3Si$	3	Gr I	0.00025	24	(97)	347
$CH_2{=}CHCH_2$	2	Gr I	0.0014	24	(88)	347
Ac	2	Gr I	0.001	48	(92)	347

C_7 

 1.5 eq

Ru cat **216** (0.02 eq) 50°, 24 h 

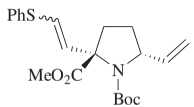
(>95) (*Z*)/(*E*) > 95:5 — 538





4 eq

Gr II (0.08 eq),
$CHCl_3$, 55°, 16 h



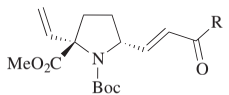
(89)

710



2 eq

Hov II (0.04 + 0.04 eq),
toluene, 80°, 24 h



(*E*) only

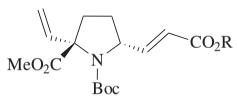
R	
H	(76)
Me	(87)
Et	(89)

1195



x eq

Catalyst (*y* eq), solvent



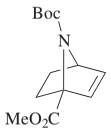
R	*x*	Catalyst	*y*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)	
H	10	Hov II	0.04 + 0.04	toluene	80	48	(23)	100:0	710
Me	4	Hov II	0.08	toluene	80	—	(98)	—	1195
Me	10	Gr II	0.08	DCM	rt	144	(15)	100:0	1195
Me	10	Gr II	0.08	$CHCl_3$	55	48	(50)	100:0	1195
Me	10	Gr II	0.04	toluene	80	24	(76)	100:0	1195
Me	10	Hov II	0.04	toluene	80	4	(92)	100:0	1195
Et	10	Hov II	0.04	toluene	80	4	(93)	100:0	1195
i-Bu	10	Hov II	0.04	toluene	80	4	(89)	100:0	1195
t-Bu	10	Hov II	0.04	toluene	80	4	(90)	100:0	1195

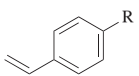
TABLE 35. RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

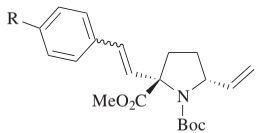
C_7





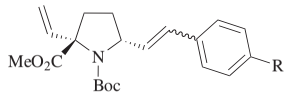
4 eq

Gr II (0.08 eq), $CHCl_3$, 55°



I

\+



II

R	**I + II**	**I/II**
H	(82)	64:36
F	(81)	33:67
MeO	(79)	78:22
MeO_2C	(71)	52:48

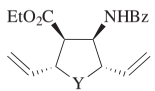
710

C_{7-8}



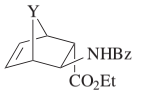


Catalyst (0.05 eq), DCM, 20°, 2 h



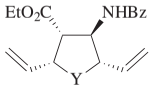
Y	Catalyst	
O	Hov I	(79)
CH_2	Gr I	(37)
CH_2	Gr II	(33)
CH_2	Hov I	(38)
CH_2	Hov II	(41)

348



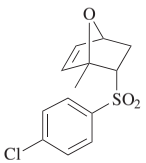


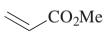
Catalyst (0.05 eq), DCM, 20°, 2 h



Y	Catalyst		
O	Hov I	(68)	348
CH_2	Gr I	(46)	
CH_2	Gr II	(20)	
CH_2	Hov I	(80)	
CH_2	Hov II	(28)	

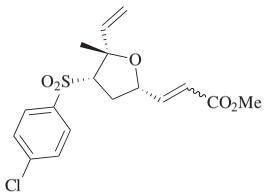
C_7





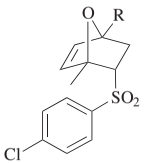
50 eq

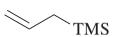
Hov II (0.05 eq), DCE, 70°, 12 h



(67) 909

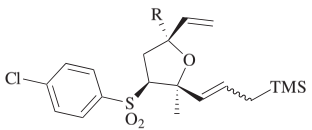
C_{7-8}





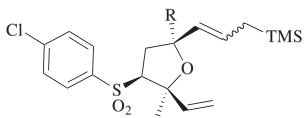
x eq

Hov II (*y* eq), DCE, 12 h



I

\+

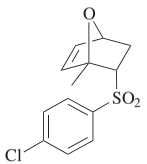
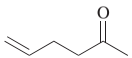
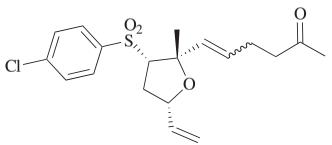
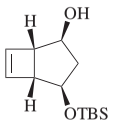
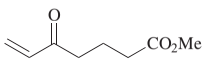
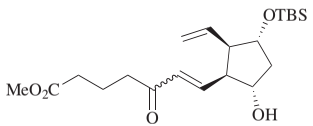
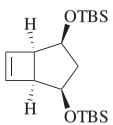
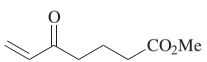
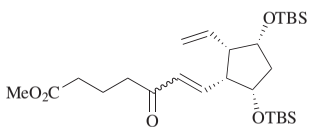


II

909

R	*x*	*y*	Temp (°)	**I** + **II**	**I**/**II**
H	10	0.01	70	(76)	92:8
Me	15	0.025	25	(94)	**I** only

TABLE 35. RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_7				
	 6 eq	Hov II (0.01 eq), DCE, 84°		(59)	909
	 2 eq	1. Gr I (0.05 eq), ethylene, benzene, rt, 12 h 2. Hov II (0.1 eq), reflux, 18 h		(77)	1196
	 2 eq	1. Gr I (0.05 eq), ethylene, benzene, rt, 12 h 2. Hov II (0.1 eq), reflux, 18 h		(68)	1196

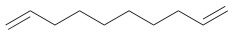
C_8





x bar

Mo cat **6** (*y* eq), neat, rt



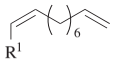
350

x	*y*	Time (h)	Conv. (%)[a]	
10	0.0002	16	98	(90)
10	0.0001	20	98	(80)
20	0.0002	20	93	(93)
20	0.0001	16	88	(88)
20	0.0006	20	75	(75)



x eq

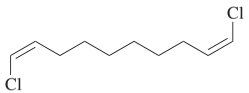
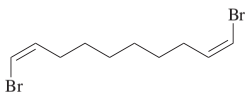
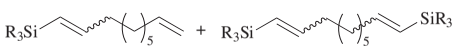
Hov II (*y* eq), C_6D_6



104

R^1	R^2	*x*	*y*	Temp (°)	Time (h)		(*Z*)/(*E*)
F	H	3	0.05	23	48	(55)[b]	72:28
F	H	18	0.05	50	24	(0)	—
Cl	H	10.6	0.05	23	24	(93)	—
Cl	Cl	5.5	0.05	23	24	(>95)	68:32
Cl	Cl	5.5	0.05	45	1	(>95)	68:32
Cl	Cl	4	0.03	23	44	(97)	—

TABLE 35. RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
	 5 eq	Mo cat **26** (0.05 eq), benzene, 22°, 2 h	 >98% conv.[a], (75) (*Z,Z*)/(*E,E*) > 98:2	106
	 8 eq (*Z*)/(*E*) = 64:36	Mo cat **26** (0.05 eq), benzene, 22°, 4 h	 >98% conv.[a], (88) (*Z,Z*)/(*E,E*) > 98:2	106
	 3 eq	Gr I (0.05 eq), DCM, reflux	 **I** **II**	1187

R	Time (h)	Conv. (%)[c]	**I**[d]	**II**[d]
MeO	0.17	96	(43)	(35)
MeO	2	100	(8)	(72)
EtO	0.17	81	(47)	(8)
EtO	2	100	(10)	(60)
Me_3SiO	0.17	94	(29)	(35)
Me_3SiO	2	100	(2)	(60)

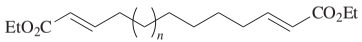
C_{8-10}





6 eq

Hov II (2 x 0.025 eq), DCM, rt



(*E*) only 1194

n	Time (h)	
1	89	(74)
3	48	(58)

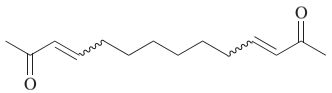
C_8





3 eq

Hov II (0.03 eq), DCE, reflux, 0.5–1 h

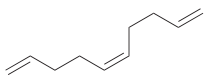


(92) 953



24 eq

1. $MoCl_5/SiO_2$ (0.06 eq), 24 h
2. $SnMe_4$ (8 eq), 24 h

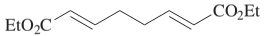


(68) (*Z*)/(*E*) = 99:1 349

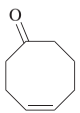


6 eq

Hov II (2 x 0.025 eq), DCM, rt, 89 h



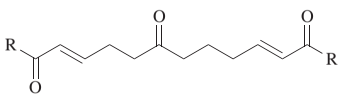
(72) (*E*) only 1194





6 eq

Hov II (2 x 0.025 eq), DCM, rt, 48 h



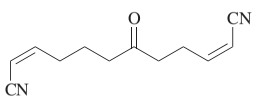
(*E*) only 1194

R	
H	(30)
Et	(89)



6 eq

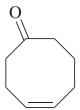
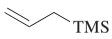
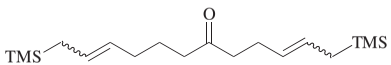
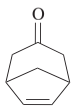
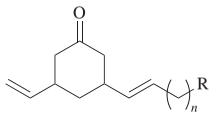
Hov II (2 x 0.025 eq), DCM, 140° (MW), 4 h



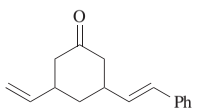
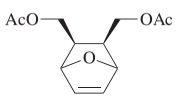
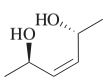
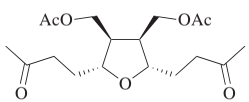
1194

(73) (*Z*,*Z*/*Z*,*E*/*E*,*Z*) = 50:25:25

TABLE 35. RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)		Refs.
Please refer to the charts preceding the tables for the catalyst structures.					
C_8					
	 6 eq	Hov II (2 x 0.025 eq), DCM, rt, 48 h		(14)	1194
		Catalyst (0.01 eq), DCM, rt			345

R	*n*	Catalyst	Time		(*E*)/(*Z*)
H	1	Gr I	75 min	(40)	78:22
H	2	Gr I	1 h	(65)	86:14
H	4	Gr I	20 min	(50)	88:12
Ph	1	Gr II	19 h	(50)	34:66

	 5 eq	Gr I (0.01 eq), DCM, rt, 6 h		(61) (*E*) only	345
	 6 eq	1. Catalyst (*x* eq), DCM, rt, 4 h 2. 200°, 8.5 h			737

Catalyst	*x*	
Gr II	0.1	(72)
Hov II	0.01	(58)

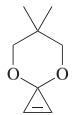
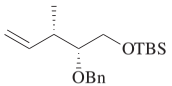
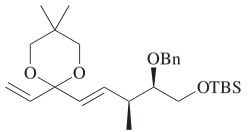
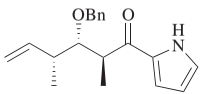
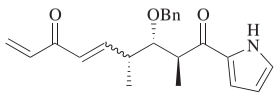
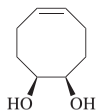
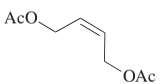
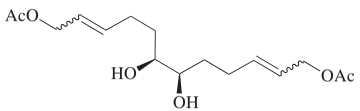
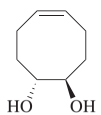
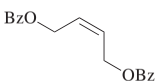
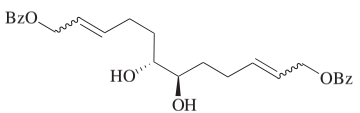
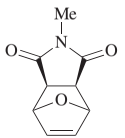
		Gr II (0.1 eq), benzene, 90°, 3.5 h		(72)	$(E)/(Z)$ = 60:40	1123
2 eq		Gr II (0.1 eq), aq $HClO_4$, THF, rt		(50)		340
	 15 eq	Gr II (0.1 eq), DCM, reflux		(99)		1197
	 7.7 eq	Gr II (0.05 eq), DCM, reflux		(74)		1197

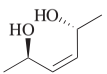
TABLE 35. RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

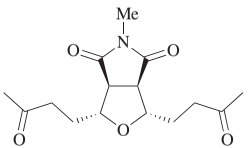
C_8





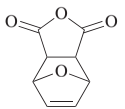
6 eq

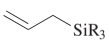
1. Catalyst (*x* eq), DCM, rt, 4 h
2. 200°, 8.5 h



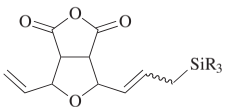
737

Catalyst	*x*	
Gr II	0.1	(72)
Hov II	0.01	(63)





Catalyst (*x* eq), solvent



R	Catalyst	*x*	Solvent	Temp	Time (h)		(*E*)/(*Z*)	
Me	Ru cat **351**	0.02	$CDCl_3$	rt	2	(95)	50:50	1198
Me	Ru cat **347**	0.01	$CHCl_3$	45°	5.5	(>95)	—	1199
Me	Ru cat **348**	0.14	$CHCl_3$	45°	4	(50)	—	1199
Me	Ru cat **349**	0.02	$CDCl_3$	rt	12	(100)	—	1200
Me	Ru cat **350**	0.02	$CDCl_3$	rt	12	(100)	—	1200
Ph	Ru cat **349**	0.02	$CDCl_3$	rt	12	(100)	—	1200
Ph	Ru cat **350**	0.02	$CDCl_3$	rt	12	(100)	—	1200

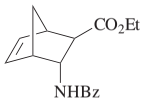
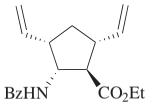
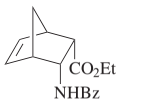
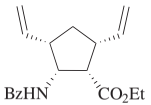
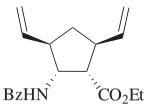
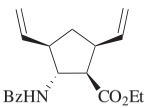
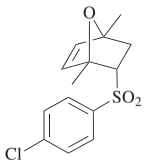
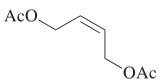
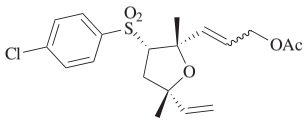
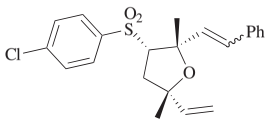
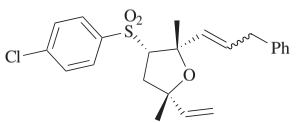
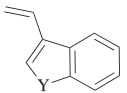
		Catalyst (0.05 eq), DCM, 20°, 2 h		Catalyst Gr I (68) Gr II (29) Hov I (45) Hov II (16)	348
		Catalyst (0.05 eq), DCM, 20°, 2 h		Catalyst Gr I (6) Gr II (26) Hov I (29) Hov II (31)	348
		Hov I (0.05 eq), DCM, 20°, 2 h		(39)	348
		Hov I (0.05 eq), DCM, 20°, 2 h		(64)	348

TABLE 35. RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_8				
	 6 eq	Hov II (0.1 eq), ethylene, DCE, 25°, 12 h		(55) 909
	 10 eq	Hov II (0.05 eq), DCE, 25°, 12 h		(93) 909
	 6 eq	Hov II (0.05 eq), ethylene, DCE, 0°, 12 h,		(89) 909

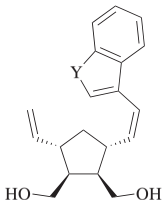
C_9





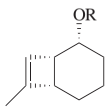
10 eq

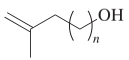
Ru cat **151** (0.05 eq),
DCM, 22°, 2 h



Y		(*Z*)/(*E*)
TsN	(93)	93:7
S	(97)	98:2

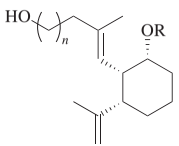
83





5 eq

Hov II (*x* eq),
solvent, 22 h



1201

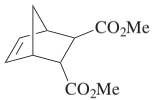
R	*n*	*x*	Solvent	Temp (°)		(E)/(Z)
H	0	0.1	DCM	60	(47)	50:50
H	0	0.1	DCE	90	(40)	67:33
H	0	0.1	DCM	rt	(85)	50:50
TES	0	0.1	DCM	60	(60)	50:50
H	1	0.1	DCM	60	(31)	75:25
H	1	0.1	DCM	rt	(0)	—
TES	1	0.15	DCM	60	(15)	>95:5

TABLE 35. RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

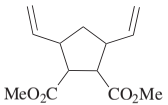
C_9





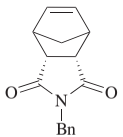
x bar

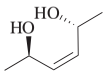
Catalyst (0.01 eq), benzene



353

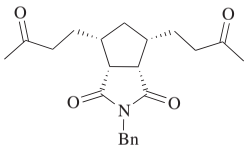
x	Catalyst	Time (h)	Temp (°)	
1	W cat **1**	16	20	(22)
3.7	W cat **1**	16	20	(24)
20	W cat **1**	16	20	(3)
1	W cat **2**	16	20	(25)
3.7	W cat **2**	16	20	(41)
3.7	W cat **2**	22	20	(47)
3.7	W cat **2**	48	20	(53)
20	W cat **2**	16	20	(24)
1	W cat **2**	22	20	(45)
1	W cat **2**	24	20	(63)
1	W cat **2**	21	60	(85)
1	W cat **2**	48	60	(70)
1	W cat **2**	93	60	(>98)
1	W cat **2**	21	80	(52)





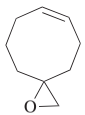
6 eq

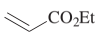
1. Gr II (0.1 eq), DCM, rt, 4 h
2. 200°, 8.5 h



(41)

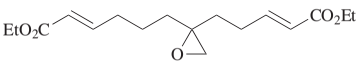
737





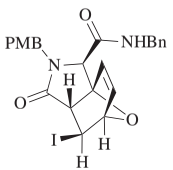
6 eq

Hov II (2 x 0.025 eq), DCM, rt, 48 h



(67) (*E*) only

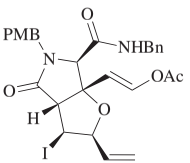
1194





5 eq

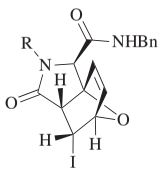
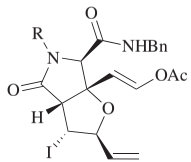
Hov II (0.02 eq), benzene, 60°, 4 h



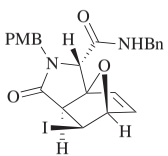
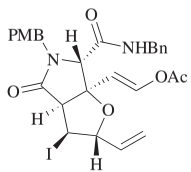
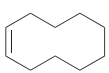
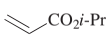
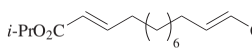
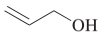
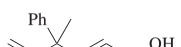
(99) (*E*)/(*Z*) = 80:20

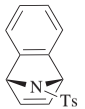
1178

TABLE 35. RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
	 5 eq	Hov II (*x* eq), solvent		1178

R	*x*	Solvent	Temp (°)	Time (h)		(*E*)/(*Z*)
PMB	0.02	benzene	60	4	(87)	93:7
$TBSO(CH_2)_2$	0.15	benzene, DCE	45	9	(74)	84:16

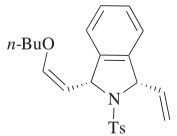
	 5 eq	Hov II (0.01 eq), benzene, rt, 14 h		(87) (*E*)/(*Z*) = 93:7	664, 1179
C_{10}					
	 2 eq	Gr II (0.0013 eq), DCM, 40°, 16 h		(80–85) (*E*) only	1202
 1.5 eq		Hov II (0.005 eq), toluene, 22°, 5 min		>98% conv.[a], (*E*)/(*Z*) = 67:33	624





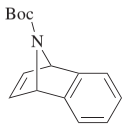
10 eq

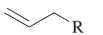
Ru cat **151** (0.02 eq),
DCM, 22°, 2 h



(83) (*Z*)/(*E*) = 98:2

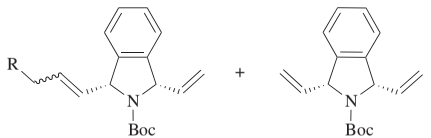
83





x eq

Catalyst (*y* eq),
DCM, rt, 21 h

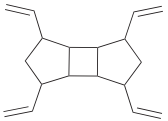
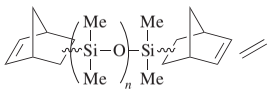
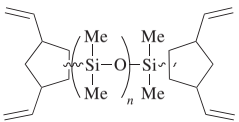
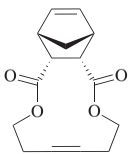
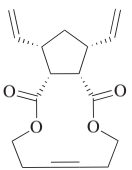


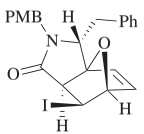
I **II**

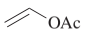
1203

R	*x*	Catalyst	*y*	**I**	**II**
TMS	1.2	Hov II	0.07	(98)	(—)
TMS	1.2	Gr II	0.03	(100)	(—)
TMS	1.2	Hov II	0.03	(97)	(—)
TMS	1.2	Hov II	0.01	(73)	(—)
MeO_2C	2	Gr II	0.05	(61)	(12)
MeO_2C	2	Hov II	0.03	(62)	(9)

TABLE 35. RING-OPENING CROSS-METATHESIS (*Continued*)

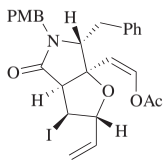
Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{14}				
	 3 bar	Gr I (0.0003 eq), toluene, rt, 24 h	 (99)	347
	4 bar	Gr I (x eq), toluene, rt, 24 h		347
			n x (99) 1 0.0005 (99) 12 0.0007 (99) 13 0.0007 (99)	
C_{15}				
		Gr I (0.05 eq), rt, 20 h	 (76)	385





5 eq

Hov II (*x* eq), benzene, rt



x	Time (h)	Concn (M)		(*Z*)/(*E*)
0.01	3	0.041	(59)	56:44
0.03	5	0.0038	(60)	50:50

[a] The conversion was determined by ^{1}H NMR analysis.

[b] This reaction included the use of ultrasound.

[c] The conversion was determined by GC analysis.

[d] The yield was determined by GC analysis.

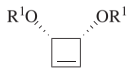
[e] The alkene was bubbled through the reaction mixture every 3 h.

TABLE 36. ASYMMETRIC RING-OPENING CROSS-METATHESIS

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

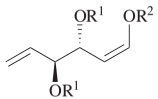
C_4





x eq

Mo cat **18** (0.006 eq), benzene, 0.5 h



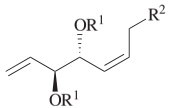
339

R^1	R^2	*x*	Temp (°)	Conv. (%)[a]		(*Z*)/(*E*)	er
Bn	*n*-Bu	1.1	22	60	(52)	97:3	79.5:20.5
Bn	*n*-Bu	2	22	65	(53)	97:3	80.0:20.0
Bn	*n*-Bu	5	22	97	(89)	97:3	82.5:17.5
Bn	*n*-Bu	10	22	>98	(90)	96:4	86.0:14.0
Bn	*n*-Bu	20	60	>98	(61)	84:16	85.0:15.0
TBS	*n*-Bu	1.1	22	60	(52)	97:3	79.5:20.5
TBS	*n*-Bu	10	22	>98	(90)	96:4	86.0:14.0
Bn	PMP	1.1	22	57	(43)	95:5	68.0:32.0
Bn	PMP	2	22	68	(58)	94:6	75.0:25.0
Bn	PMP	5	22	98	(90)	94:6	81.0:19.0
Bn	PMP	10	22	>98	(90)	94:6	85.0:15.0
Bn	PMP	20	60	>98	(73)	98:2	85.0:15.0
TBS	PMP	1.1	22	57	(34)	95:5	68.0:32.0
TBS	PMP	10	22	>98	(90)	94:6	85.0:15.0



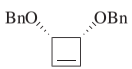
7 eq

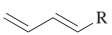
Ru cat **215** (0.01 eq),
THF, 23°



98, 1204

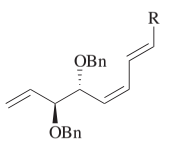
R^1	R^2	Time (h)		$(Z)/(E)$	er (Z)	er (E)
H	BzO	1–1.5	(67)	75:25	95.5:4.5	83.5:16.5
Bz	HO	1–1.5	(69)	75:25	98.0:2.0	91.0:9.0
Bn	HO	1.5	(62)	89:11	96.5:3.5	93.0:7.0
Bn	AcO	1–1.5	(79)	85:15	97.5:2.5	—
Bn	BzO	1.5	(61)	88:12	98.5:1.5	94.0:6.0
Bn	TBSO	1.5	(68)	87:13	94.5:5.5	88.5:11.5
Bn	BnO	1.5	(64)	86:14	95.5:4.5	—
Bn	4-$MeOC_6H_4$	1.5	(76)	90:10	96.5:3.5	89.5:10.5
Bn	$AcCH_2$	1.5	(65)	90:10	96.0:4.0	92.0:8.0
Bn	Bpin	1.5	(50)	—	95.5:4.5	—
TBS	HO	1.5	(66)	88:12	99.5:0.5	—
i-Pr	BzO	1.5	(<5)	—	—	—





10 eq

Ru cat **151** (0.05 eq),
DCM, 40°, 12 h

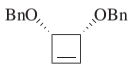
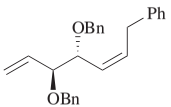
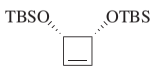
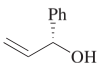
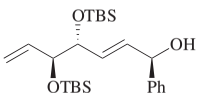
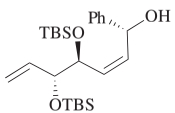
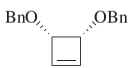
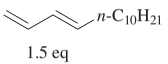
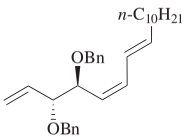
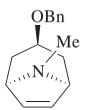
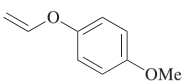
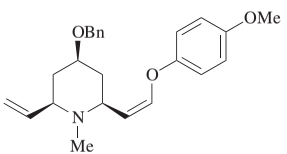


$(Z)/(E)$ = 98:2

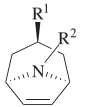
R	
MeO	(88)
n-C_6H_{13}	(60)

83

TABLE 36. ASYMMETRIC RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_4				
	 10 eq	Ru cat **151** (0.05 eq), DCM, 40°, 12 h	 (58) (*Z*)/(*E*) = 98:2	83
	 1.03 eq	Ru cat **187** (0.02 eq), toluene, 22°, 2 h	 (51) dr 98:2 +  (36) dr 98:2	624
	 1.5 eq	Ru cat **216** (0.02 eq) 50°, 24 h	 (89) (*Z*)/(*E*) > 95:5	538
C_7				
	 *x* eq	Mo cat **18** (0.03 eq), benzene, 60°, 3 h		624

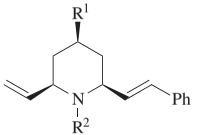
x	Conv. (%)[a]		(*Z*)/(*E*)	er
2	28	(25)	75:25	72.0:28.0
10	69	(50)	80:20	75.0:25.0
20	98	(90)	92:8	91.0:9.0





x eq

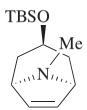
Catalyst (*y* eq),
benzene, 22°, 24 h



(*E*)/(*Z*) > 98:2

R^1	R^2	*x*	Catalyst	*y*		er	
H	EtO_2C	10	Mo cat **12**	0.05	(72)	95.0:5.0	
H	EtO_2C	20	Ru cat **210**	0.1	(66)	3.0:97.0	
TBSO	EtO_2C	10	Mo cat **12**	0.1	(60)	90.0:10.0	
BnO	Me	10	Mo cat **12**	0.05	(86)	98.0:2.0	

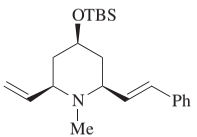
102





x eq

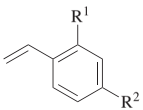
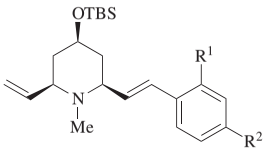
Catalyst (0.05 eq),
solvent, 22°



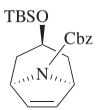
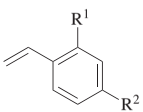
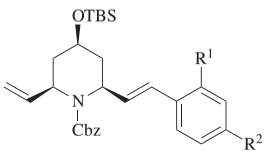
(*E*)/(*Z*) > 98:2

x	Catalyst	Solvent	Time (h)	Conv. (%)[a]		er	
20	Ru cat **210**	—	36	30	(—)	66.5:33.5	91
20	Ru cat **212**	—	36	<5	(—)	—	91
20	Ru cat **213**	—	36	<4	(—)	—	91
10	Mo cat **12**	benzene	1	>98	(95)	97.0:3.0	91
2	Ru cat **210**	benzene	12	<2	(—)	—	102
2	Ru cat **212**	benzene	12	<2	(—)	—	102
2	Ru cat **213**	benzene	12	<2	(—)	—	102
2	Mo cat **8**	benzene	12	<2	(—)	—	102
2	Mo cat **9**	benzene	12	>98	(—)	<51.0:49.0	102
2	Mo cat **10**	benzene	12	<2	(—)	—	102
2	Mo cat **12**	benzene	12	>98	(—)	97.0:3.0	102

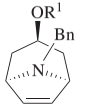
TABLE 36. ASYMMETRIC RING-OPENING CROSS-METATHESIS (*Continued*)

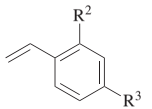
Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_7				
	 10 eq	Mo cat **12** (0.05 eq), benzene, 22°, 12 h	 (*E*)/(*Z*) > 98:2	102

R^1	R^2		er
H	H	(95)	97.0:3.0
H	MeO	(92)	94.5:5.5
H	CF_3	(88)	82.0:18.0
Br	H	(86)	94.0:6.0
Me	H	(91)	99.0:1.0

	 10 eq	Mo cat **12** (0.1 eq), benzene, 22°, 12 h	 (*E*)/(*Z*) > 98:2	102

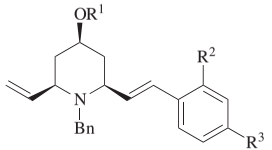
R^1	R^2		er
H	H	(93)	95.0:5.0
H	MeO	(65)	90.0:10.0
Me	H	(92)	93.0:7.0





x eq

Catalyst (0.05 eq),
solvent, 22°

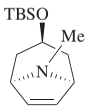
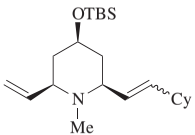
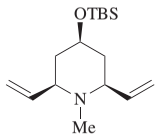
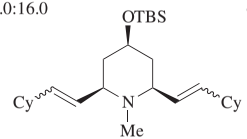
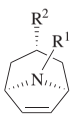
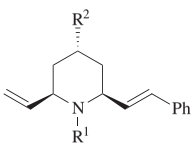


(*E*)/(*Z*) > 98:2

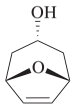
91

R^1	R^2	R^3	*x*	Catalyst	Solvent	Time (h)	Conv. (%)[a]		er
H	H	H	20	Ru cat **210**	—	24	>98	(82)	>99.0:1.0
H	H	H	20	Ru cat **212**	—	24	80	(65)	97.0:3.0
H	Br	H	20	Ru cat **210**	—	24	63	(55)	98.5:1.5
H	Br	H	20	Ru cat **212**	—	24	27	(—)	—
H	Me	H	20	Ru cat **210**	—	24	>98	(81)	99.0:1.0
H	Me	H	20	Ru cat **212**	—	24	95	(60)	99.0:1.0
H	F	H	20	Ru cat **210**	—	24	87	(70)	>99.0:1.0
H	H	MeO	20	Ru cat **210**	—	24	87	(67)	>99.0:1.0
H	H	MeO	20	Ru cat **212**	—	24	50	(38)	98.0:2.0
H	H	CF_3	5	Ru cat **210**	—	24	>98	(78)	98.5:1.5
TBS	H	H	20	Ru cat **210**	—	24	>98	(80)	>99.0:1.0
TBS	H	H	20	Ru cat **212**	—	24	70	(—)	98.0:2.0
TBS	H	H	20	Ru cat **213**	—	24	<5	(—)	—
TBS	H	H	10	Mo cat **12**	benzene	1	>98	(85)	60.5:39.5

TABLE 36. ASYMMETRIC RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_7				
	 10 eq	Mo cat **12** (0.05 eq), benzene, 22°, 12 h	 +  (43) er 84.0:16.0 (25) +  (25)	102
	 *x* eq	Catalyst (*y* eq), benzene, 22°	 (*E*)/(*Z*) > 98:2	102

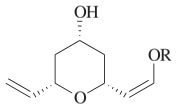
R^1	R^2	*x*	Catalyst	*y*	Time (h)		er
Cbz	H	10	Mo cat **12**	0.1	24	(80)	91.0:9.0
Cbz	H	20	Ru cat **210**	0.1	24	(70)	5.0:95.0
Cbz	TBSO	10	Mo cat **12**	0.1	24	(80)	92.5:7.5
Me	H	2	Mo cat **12**	0.05	1	(64)	90.0:10.0
Me	TBSO	10	Mo cat **12**	0.05	1	(90)	92.5:7.5





x eq

Catalyst (*y* eq),
solvent, 22°



808,
1175

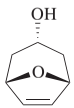
R	*x*	Catalyst	*y*	Solvent	Time (h)	Conv. (%)[a]		(*Z*)/(*E*)	er
n-Bu	20	Ru cat **210**	0.05	benzene	8	>98	(80)	95:5	>98.0:2.0
n-Bu	10	Ru cat **210**	0.005	benzene	8	77	(60)	95:5	>98.0:2.0
n-Bu	20	Ru cat **212**	0.05	benzene	24	85	(58)	92:8	97.0:3.0
n-Bu	20	Hov I	0.05	benzene	24	7	(0)	82:18	—
n-Bu	20	Hov II	0.05	benzene	24	79	(41)	23:77	—
n-C_6H_{13}	20	Ru cat **210**	0.05	benzene	24	>98	(64)	98:2	>98.0:2.0
n-C_6H_{13}	20	Hov II	0.05	benzene	24	>98	(58)	37:63	—
n-C_6H_{13}	20	Ru cat **213**	0.05	THF	2.5	>98	(58)	—	59.0:41.0
Ph	20	Ru cat **213**	0.05	THF	2.5	>98	(68)	—	96.0:4.0
PMP	20	Ru cat **210**	0.05	benzene	24	>98	(67)	95:5	97.0:3.0
PMP	20	Hov II	0.05	benzene	24	>98	(41)	43:57	—
CF_3CH_2	20	Ru cat **210**	0.05	benzene	24	>98	(63)	94:6	96.0:4.0
CF_3CH_2	20	Hov II	0.05	benzene	24	>98	(59)	27:73	—
$Cl(CH_2)_2$	20	Ru cat **210**	0.05	benzene	24	>98	(63)	95:5	>98.0:2.0
$Cl(CH_2)_2$	20	Hov II	0.05	benzene	24	>98	(31)	24:76	—

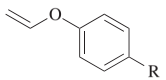
TABLE 36. ASYMMETRIC RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

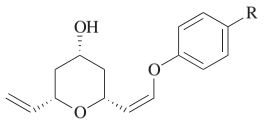
C_7





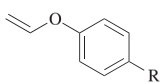
20 eq

Ru cat **213** (0.05 eq)
benzene, 22°, 24 h



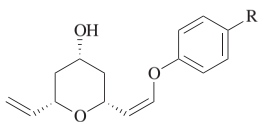
1205

R	Conv. (%)[a]		Efficiency[b]	(*Z*)/(*E*)	er[c]
n-BuO	66	(64)	0.97	92:8	97.0:3.0
Et	74	(69)	0.93	91:9	97.0:3.0
H	82	(74)	0.90	93:7	96.0:4.0
Br	90	(79)	0.88	93:7	96.0:4.0
Cl	93	(75)	0.81	93:7	95.0:5.0
CF_3	95	(73)	0.77	93:7	96.0:4.0



20 eq

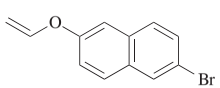
Catalyst (0.05 eq)
benzene, 22°, 24 h



1205

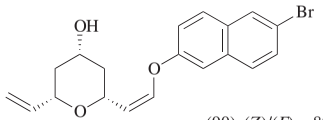
R	Catalyst	Conv. (%)[a]		Efficiency[b]	(*Z*)/(*E*)
n-BuO	Hov I	62	(59)	0.95	83:17
Et	Hov I	72	(66)	0.92	77:23
H	Hov I	81	(70)	0.86	76:24
Br	Hov I	83	(65)	0.78	79:21

Cl	Hov I	86	(66)	0.77	81:19
CF_3	Hov I	94	(70)	0.74	82:18
n-BuO	Hov II	>98	(60)	0.60	40:60
Et	Hov II	>98	(59)	0.59	45:55
H	Hov II	>98	(63)	0.63	45:55
Br	Hov II	>98	(59)	0.59	42:58
Cl	Hov II	>98	(61)	0.61	43:57
CF_3	Hov II	>98	(58)	0.58	43:57



20 eq

Ru cat **213** (0.05 eq), benzene, 22°, 24 h

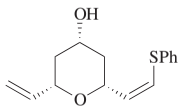


(90) (*Z*)/(*E*) = 89:11, er 96.0:4.0 1175

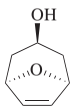


20 eq

Ru cat **213** (0.05 eq), benzene, 22°, 24 h



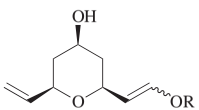
(67) (*Z*)/(*E*) = 91:9, er 96.0:4.0 1175





20 eq

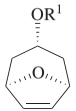
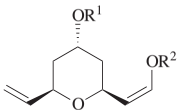
Ru cat **213** (0.05 eq), THF, 22°, 2.5 h



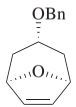
808

R	Conv (%)[a]		er
Ph	>98	(68)	96:4
Cy	>98	(58)	59:41

TABLE 36. ASYMMETRIC RING-OPENING CROSS-METATHESIS (*Continued*)

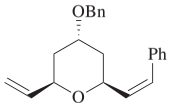
Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_7				
	 *x* eq	Mo cat **18** (0.006 eq), benzene, 22°	 $(Z)/(E) > 98:2$	339

R^1	R^2	*x*	Time (min)	Conv. (%)[a]		er
TBS	*n*-Bu	1.1	30	>98	(53)	52.0:48.0
TBS	*n*-Bu	5	0.5	97	(83)	95.0:5.0
TBS	*n*-Bu	5	1	>98	(89)	90.0:10.0
TBS	*n*-Bu	5	3	>98	(96)	85.5:14.5
TBS	*n*-Bu	5	30	>98	(80)	62.5:37.5
TBS	*n*-Bu	10	30	>98	(80)	73.0:27.0
TBS	*n*-Bu	20	30	>98	(85)	84.5:15.5
TBS	*n*-Bu	30	30	>98	(88)	95.0:5.0
TBS	*n*-Bu	1.1	30	97	(86)	56.5:43.5
TBS	*n*-Bu	5	30	97	(86)	90.0:10.0
TBS	*n*-Bu	5	30	97	(82)	87.0:13.0
Bn	*n*-Bu	1.1	30	96	(54)	57.5:42.5
Bn	*n*-Bu	30	30	>98	(88)	95.0:5.0
TBS	PMP	5	0.5	>98	(83)	86.0:14.0
TBS	PMP	5	1	>98	(87)	84.5:15.5
TBS	PMP	10	3	>98	(90)	91.5:8.5
TBS	PMP	20	30	>98	(87)	92.0:8.0
TBS	PMP	30	30	>98	(82)	91.5:8.5
Bn	PMP	1.1	30	94	(82)	82.0:18.0
Bn	PMP	20	30	>98	(87)	96.5:3.5



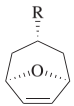


Mo cat **18** (0.02 eq), 22°



(—) (*E*)/(*Z*) = 5:95
er 91.0:9.0

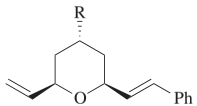
809





x eq

Catalyst (*y* eq), solvent



(*E*)/(*Z*) > 98:2

91

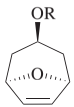
R	*x*	Catalyst	*y*	Solvent	Temp (°)	Time (h)		er
BnO	2	Ru cat **211**	0.02	—	22	36	(85)	95.0:5.0
BnO	2	Ru cat **213**	0.02	—	22	15	(70)	97.0:3.0
BnO	5	Ru cat **213**	0.02	—	–15	15	(84)	>99.0:1.0
BnO	10	Mo cat **12**	0.02	benzene	22	1	(81)	95.0:5.0
I	2	Ru cat **211**	0.02	—	22	5	(65)	96.5:3.5
I	2	Ru cat **213**	0.02	—	22	5	(70)	91.0:9.0
I	10	Mo cat **12**	0.05	benzene	22	1	(76)	98.5:1.5

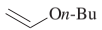
TABLE 36. ASYMMETRIC RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

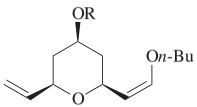
C_7





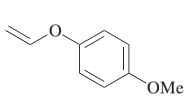
x eq

Catalyst (*y* eq),
benzene, 22°



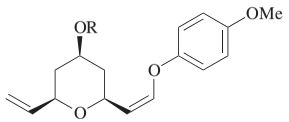
339

R	*x*	Catalyst	*y*	Time (h)	Conv. (%)[a]		(*Z*)/(*E*)	er
TBS	1.1	Hov II	0.01	0.5	69	(32)	25:75	—
TBS	1.1	Mo cat **1**	0.01	0.5	98	(10)	50:50	—
TBS	1.1	Mo cat **8**	0.01	12	<2	(0)	—	—
TBS	1.1	Mo cat **3**	0.01	0.5	>98	(48)	80:20	—
TBS	1.1	Mo cat **5**	0.01	0.5	85	(68)	>98:2	99.0:1.0
TBS	1.1	Mo cat **6**	0.01	0.5	<5	(0)	—	—
TBS	1.1	Mo cat **16**	0.0007	0.5	>98	(87)	>98:2	97.0:3.0
TBS	1.1	Mo cat **17**	0.005	0.5	>98	(87)	>98:2	98.0:2.0
TBS	1.1	Mo cat **18**	0.006	0.5	>98	(89)	>98:2	99.0:1.0
TBS	5	Mo cat **18**	0.05	0.17	>98	(76)	>98:2	99.0:1.0
TBS	1.1	Mo cat **19**	0.007	0.5	>98	(87)	>98:2	98.0:2.0
Bn	1.1	Mo cat **18**	0.006	0.5	>98	(75)	>98:2	99.0:1.0
Bn	5	Mo cat **18**	0.006	0.17	>98	(74)	>98:2	99.0:1.0



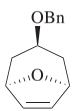
x eq

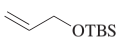
Catalyst (*y* eq),
benzene, 22°



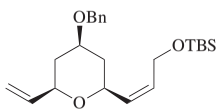
339

R	*x*	Catalyst	*y*	Time (h)	Conv. (%)[a]		(*Z*)/(*E*)	er
TBS	1.1	Hov II	0.01	0.5	95	(<5)	—	—
TBS	1.1	Mo cat **1**	0.01	0.5	98	(14)	80:20	—
TBS	1.1	Mo cat **8**	0.01	12	<2	(0)	—	—
TBS	1.1	Mo cat **3**	0.01	0.5	>98	(75)	82:18	—
TBS	1.1	Mo cat **5**	0.01	0.5	86	(47)	>98:2	99.0:1.0
TBS	1.1	Mo cat **6**	0.01	0.5	<5	(0)	—	—
TBS	1.1	Mo cat **16**	0.0007	0.5	60	(41)	>98:2	86.0:14.0
TBS	1.1	Mo cat **17**	0.005	0.5	>98	(80)	>98:2	92.0:8.0
TBS	1.1	Mo cat **18**	0.006	0.5	>98	(90)	>98:2	99.0:1.0
TBS	5	Mo cat **18**	0.05	0.17	>98	(80)	>98:2	99.0:1.0
TBS	1.1	Mo cat **19**	0.007	0.5	>98	(85)	>98:2	99.0:1.0
Bn	1.1	Mo cat **18**	0.006	0.5	>98	(80)	>98:2	97.0:3.0
Bn	5	Mo cat **18**	0.006	0.17	>98	(77)	>98:2	99.0:1.0





Mo cat **18** (0.05 eq),
22°, 1 h



(45) (*E*)/(*Z*) = 5:95
er 86.0:14.0

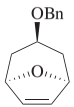
809

TABLE 36. ASYMMETRIC RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

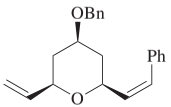
Please refer to the charts preceding the tables for the catalyst structures.

C_7





Catalyst (0.01 eq), 22°, 1 h



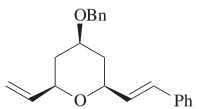
809

Catalyst		(*E*)/(*Z*)	er
Mo cat **12**	(80)	>2:98	95.0:5.0
Ru cat **212**	(85)	>2:98	98.5:1.5
Ru cat **213**	(87)	5:95	98.0:2.0



5 eq

Catalyst (*x* eq), solvent, 1 h

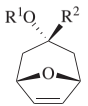


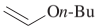
(*E*)/(*Z*) > 98:2

91

Catalyst	*x*	Solvent	Temp (°)		er
Ru cat **210**	0.02	—	22	(70)	98.0:2.0
Ru cat **213**	0.02	—	22	(90)	94.0:6.0
Ru cat **213**	0.02	—	–15	(87)	95.5:4.5
Mo cat **12**	0.05	benzene	22	(—)	—

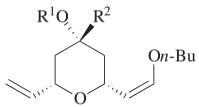
$C_{7–8}$





20 eq

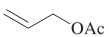
Ru cat **210** (0.05 eq),
benzene, 22°, 24 h



808, 1175

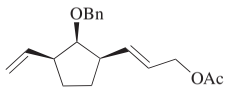
R^1	R^2		$(Z)/(E)$	er
TBS	H	(71)	87:13	93.0:7.0
TBS	Me	(72)	92:8	95.0:5.0
Bn	H	(62)	94:6	91.0:9.0





7 eq

Ru cat **215** (0.01 eq),
THF, 23°, 1–1.5 h



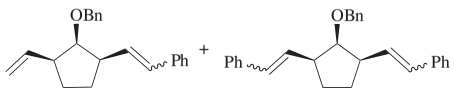
98

(56) $(E)/(Z)$ = 85:15, er (*E*) 96.5:3.5, er (*Z*) 97.0:3.0



1 eq

Catalyst (0.05 eq),
C_6D_6, 40 h

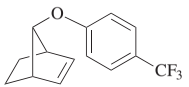
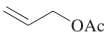
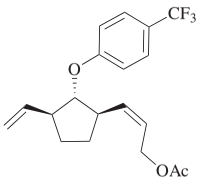
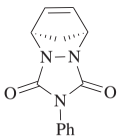
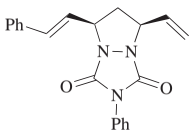


I **II**

1206

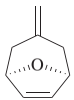
Catalyst	Temp (°)	**I**	**II**	er **I**
Mo cat **12**	25	(56)	(36)	95.5:4.5
Mo cat **20**	25	(36)	(42)	90.0:10.0
Mo cat **22**	25	(<2)	(<2)	—
Mo cat **15**	25	(64)	(24)	2.0:98.0
Mo cat **21**	75	(61)	(14)	1.0:99.0
Mo cat **23**	75	(57)	(14)	1.0:99.0

TABLE 36. ASYMMETRIC RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_7				
	 7 eq	Ru cat **215** (0.01 eq), THF, 23°, 1 h	 (40) (*Z*)/(*E*) = 70:30, er (*Z*) 97.5:2.5, er (*E*) 97.5:2.5	98, 417
	 10 eq	Catalyst (*x* eq), NaI (*y* eq), DCM, rt, 1 h		97

Catalyst	*x*	*y*		(*E*)/(*Z*)	er (*E*)	er (*Z*)
Ru cat **24**	0.01	—	(99)	55:45	84.0:16.0	57.5:42.5
Ru cat **25**	0.03	1	(99)	55:45	84.0:16.0	55.0:45.0

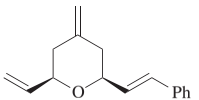
C_8





x eq

Catalyst (*y* eq),
solvent, 22°

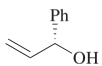


91

x	Catalyst	*y*	Solvent	Time (h)	Conv. (%)[a]		(*E*)/(*Z*)	er
5	Ru cat **211**	0.02	—	36	—	(50-60)	>98:2	97.0:3.0
5	Ru cat **213**	0.02	—	15	—	(50-60)	>98:2	>99.0:1.0
2	Mo cat **8**	0.05	pentane	4	>98	—	—	—
2	Mo cat **9**	0.05	pentane	4	<5	—	—	—
2	Mo cat **10**	0.05	pentane	4	50	—	—	—
2	Mo cat **12**	0.05	pentane	4	>98	—	>98:2	97.0:3.0
5	Mo cat **12**	0.05	benzene	1	—	(50-60)	>98:2	98.5:1.5
2	Mo cat **15**	0.05	pentane	4	<5	—	—	—

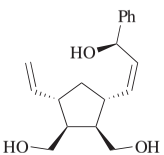


0.2 eq



er 96.0:4.0

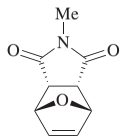
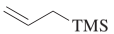
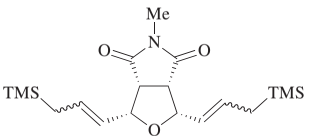
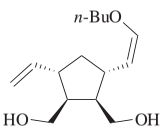
Ru cat **151** (0.05 eq),
DCM, 22°, 8 h



(67) (*Z*)/(*E*) = 98:2, dr 98:2

83

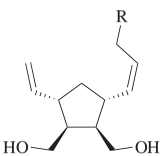
TABLE 36. ASYMMETRIC RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)		Refs.
Please refer to the charts preceding the tables for the catalyst structures.					
C_8					
		Ru cat **149** (0.005 eq), DCM, reflux, 2 h		>99% conv.[a]	853
C_9					
	 20 eq	Catalyst (0.05 eq), 22°, 24 h			1205

Catalyst	Conv. (%)[a]		(*Z*)/(*E*)	er[c]
Ru cat **212**	>98	(86)	94:6	81.0:19.0
Ru cat **213**	>98	(81)	85:15	67.0:33.0

 10 eq

Ru cat **151** (0.05 eq), DCM, 22°, 8 h



(*Z*)/(*E*) = 98:2

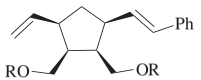
R		Refs.
TMS	(89)	83
4-$MeOC_6H_4$	(83)	
$PhHNOCCH_2$	(65)	
$TBSOCH_2$	(68)	
n-C_7H_{15}	(58)	





5 eq

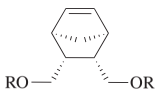
Ru cat **240** (0.01 eq),
DCM, –10°, 12 h



$(E)/(Z)$ = 95:5

95

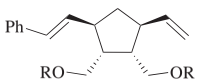
R	Conv. (%)[a]	er
Ac	>98	80.0:20.0
TBS	>98	85.0:15.0





10 eq

Catalyst (x eq),
NaI (y eq), DCM, rt, 1 h



97

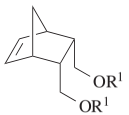
R	Catalyst	x	y		$(E)/(Z)$	er (E)	er (Z)
H	Ru cat **24**	0.01	—	(10)	—	66.5:33.5	64.5:35.5
Ac	Ru cat **24**	0.01	—	(99)	58:42	80.0:20.0	55.0:45.0
Ac	Ru cat **25**	0.03	1	(78)	58:42	86.0:14.0	70.0:30.0

TABLE 36. ASYMMETRIC RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

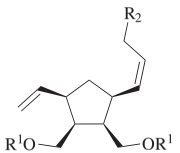
C_9





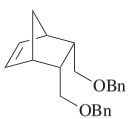
7 eq

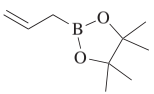
Ru cat **215** (0.01 eq),
THF, 23°, 1 h



R^1	R^2		$(Z)/(E)$	er
Ac	AcO	(45)	97:3	91.0:9.0
Bn	AcO	(64)	95:5	96.5:3.5
Bn	BocHN	(41)	95:5	97.0:3.0
Bn	EtO_2CCH_2	(65)	95:5	95.6:4.5
Bn	*n*-Pr	(62)	95:5	94.5:5.5

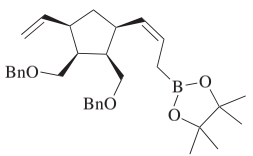
417





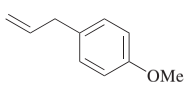
7 eq

Ru cat **215** (0.01 eq),
THF, 23°, 1 h



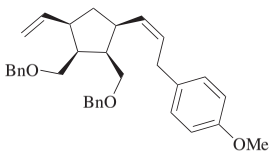
(48) $(Z)/(E)$ = 95:5, er 87.5:12.5

417



7 eq

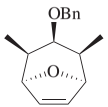
Ru cat **215** (0.01 eq),
THF, 23°, 1 h



(51) (*Z*)/(*E*) = 95:5, er 90.5:9.5

417

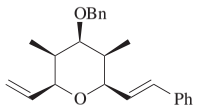
1153





x eq

Catalyst (*y* eq), solvent



(*E*)/(*Z*) > 98:2

91

x	Catalyst	*y*	Solvent	Temp (°)	Time (h)		er
4	Ru cat **211**	0.05	—	22	44	(44)	90.0:10.0
4	Ru cat **213**	0.05	—	22	15	(56)	90.5:9.5
8	Ru cat **213**	0.02	—	–15	20	(64)	94.5:5.5
10	Mo cat **12**	0.05	benzene	22	5	(64)	83.5:16.5

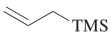
TABLE 36. ASYMMETRIC RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

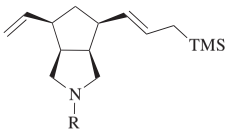
C_9





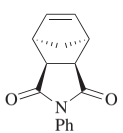
2 eq

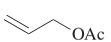
Catalyst (*x* eq), solvent



96

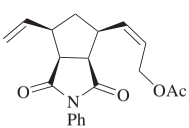
R	Catalyst	*x*	Solvent	Temp (°)	Time (h)	Conv. (%)[a]	(*E*)/(*Z*)	er
CF_3CO	Ru cat **32**	0.025	DCM	rt	2	>99	67:33	90.0:10.0
CF_3CO	Ru cat **32**	0.025	DCM	0	6	>99	67:33	91.0:9.0
Tos	Ru cat **32**	0.03	DCM	rt	12	>99	40:60	87.5:12.5
Tos	Ru cat **32**	0.03	MTBE	rt	12	>99	67:33	79.0:21.0
Tos	Ru cat **32**	0.03	THF	rt	12	>99	50:50	81.5:18.5
Tos	Ru cat **32**	0.03	benzene	rt	12	>99	67:33	76.5:23.5
Tos	Ru cat **32**	0.03	toluene	rt	12	>99	67:33	78.5:21.5
Tos	Ru cat **32**	0.03	trifluorotoluene	rt	12	92	60:40	84.5:15.5
Tos	Ru cat **32**	0.025	DCM	40	1	>99	40:60	87.5:12.5
Tos	Ru cat **32**	0.025	DCM	rt	2	>99	40:60	87.5:12.5
Tos	Ru cat **32**	0.025	DCM	0	2	>99	33:67	89.5:10.5
Tos	Ru cat **32**	0.025	DCM	–10	48	>99	33:67	89.5:10.5
Tos	Ru cat **229**	0.025	DCM	rt	18	>99	50:50	86.5:13.5
Tos	Ru cat **24**	0.025	DCM	rt	2	>99	75:24	67.0:33.0





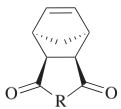
7 eq

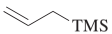
Ru cat **215** (0.01 eq), THF, 23°, 1 h



(63) (*E*)/(*Z*) = 6:94
er 80:20

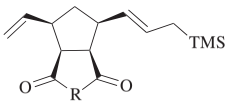
417





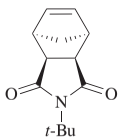
2 eq

Catalyst (*x* eq), DCM, rt



(*E*)/(*Z*) = 67:33 96

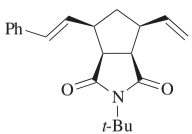
R	Catalyst	*x*	Time (h)	Conv. (%)[a]	er
t-BuN	Ru cat **32**	0.03	96	96	99.0:1.0
t-BuN	Ru cat **229**	0.03	96	>99	97.5:2.5
t-BuN	Ru cat **24**	0.02	18	>99	67.5:32.5
O	Ru cat **32**	0.026	72	87	86.0:14.0





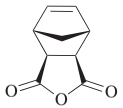
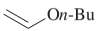
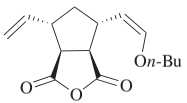
x eq

Catalyst (*y* eq),
NaI (*z* eq), DCM, rt, 1 h

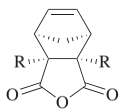
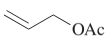
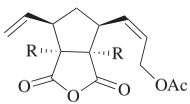


x	Catalyst	*y*	*z*	Temp (°)	Time (h)	Conv. (%)[a]		(*E*)/(*Z*)	er (*E*)	er (*Z*)	
10	Ru cat **24**	0.01	—	rt	1	—	(99)	58:42	78.5:21.5	66.5:33.5	97
10	Ru cat **25**	0.03	1	rt	1	—	(99)	55:45	87.5:12.5	75.0:25.0	97
5	Ru cat **240**	0.01	—	25	20	>98	(—)	96:4	91.0:9.0	—	95
5	Ru cat **240**	0.01	—	–10	72	>98	(—)	93:7	96.0:4.0	—	95
5	Ru cat **24**	0.01	—	25	1	>96	(—)	50:50	78.5:21.5	—	96
5	Ru cat **229**	0.025	—	25	72	98	(—)	92:8	95.5:4.5	—	96
5	Ru cat **32**	0.025	—	40	18	98	(—)	90:10	96.0:4.0	—	96

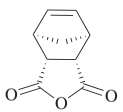
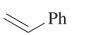
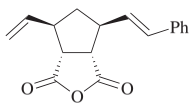
TABLE 36. ASYMMETRIC RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_9				
	 20 eq	Ru cat **213** (0.05 eq) solvent, 22°, 24 h		1205

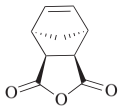
Solvent	Conv. (%)[a]		(*Z*)/(*E*)	er[c]
benzene	>98	(80)	81:19	80:20
THF	>98	(44)	85:15	77:23

	 7 eq	Ru cat **215** (0.01 eq), THF, 23°, 1 h		417

R		(*E*)/(*Z*)	er
H	(58)	2:98	87.5:12.5
Me	(65)	4:96	97.5:2.5

	 20 eq	Catalyst (0.025 eq), THF, 50°, 2 h		655

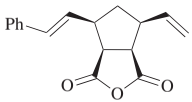
Catalyst		(*E*)/(*Z*)	er
Ru cat **58**	(38)	57:43	52.5:47.5
Ru cat **59**	(78)	50:50	51.0:49.0
Ru cat **60**	(9)	77:23	54.5:45.5





10 eq

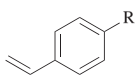
Catalyst (*x* eq),
NaI (*y* eq), DCM, rt, 1 h



(*E*)/(*Z*) = 50:50

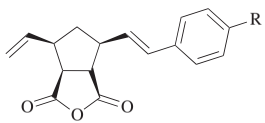
97

Catalyst	*x*	*y*	Conv. (%)[a]	er (*E*)	er (*Z*)
Ru cat **18**	0.01	—	>95	73.5:26.5	—
Ru cat **16**	0.01	—	>95	64.5:35.5	—
Ru cat **20**	0.01	—	>95	81.0:19.0	—
Ru cat **24**	0.01	—	95	88.0:12.0	52.0:48.0
Ru cat **25**	0.03	1	96	90.0:10.0	—



5 eq

Catalyst (*x* eq), DCM



R	Catalyst	*x*	Temp (°)	Time (h)	Conv. (%)[a]	(*E*)/(*Z*)	er	
H	Ru cat **238**	0.01	25	1	>98	95:5	85.5:14.5	95
H	Ru cat **239**	0.01	25	1	>98	95:5	91.5:8.5	95
H	Ru cat **240**	0.01	25	1	>98	>97:3	94.0:6.0	95
H	Ru cat **240**	0.0005	25	15	>98	>97:3	94.0:6.0	95
H	Ru cat **240**	0.01	–10	12	>98	>97:3	96.5:3.5	95
H	Ru cat **24**	0.01	25	1	>98	50:50	88.0:12.0	95
MeO	Ru cat **240**	0.01	25	1	>98	93:7	90.5:9.5	95
CF_3	Ru cat **240**	0.01	25	1	>98	97:3	84.0:16.0	95
O_2N	Ru cat **240**	0.01	25	1	>98	—	86.0:14.0	95
MeO_2C	Ru cat **240**	0.01	25	1	>98	>97:3	89.5:10.5	95
H	Ru cat **32**	0.07	40	16	78	94:6	93.0:7.0	96
H	Ru cat **229**	0.025	25	16	83	93:7	87.5:12.5	96

TABLE 36. ASYMMETRIC RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

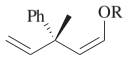
C_{10}



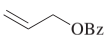


x eq

Catalyst (*y* eq), solvent, 22°

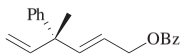


R	*x*	Catalyst	*y*	Solvent	Time (h)	Conv. (%)[a]		(*Z*)/(*E*)	er	
n-Bu	10	Ru cat **151**	0.02	DCM	2	—	(79)	88:12	—	83
n-Bu	10	Mo cat **18**	0.03	benzene	0.5	93	(79)	>98:2	95.0:5.0	339
PMP	2	Mo cat **18**	0.03	benzene	0.5	95	(71)	>98:2	97.0:3.0	339



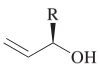
2.05 eq

Ru cat **213** (0.05 eq), THF, 0°, 48 h

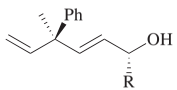


(76) (*E*)/(*Z*) = 75:25, er (*E*) 70.0:30.0 — 1143

1.5 eq

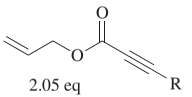


Hov II (0.005 eq), toluene, 22°, 0.25 h



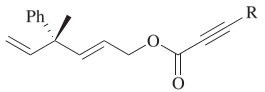
624

R		(*E*)/(*Z*)	dr
Me	(64)	86:14	95:5
$TBSOCH_2$	(71)	92:8	89:11
$Ph(CH_2)_2$	(80)	80:20	91:9



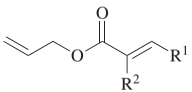
2.05 eq

Ru cat **213** (0.05 eq),
THF, 0°, 48 h



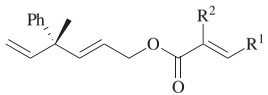
1143

R		(*E*)/(*Z*)	er (*E*)
H	(65)	80:20	93.0:7.0
Me	(72)	67:33	86.0:14.0
TMS	(63)	80:20	69.0:31.0



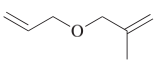
2.05 eq

Ru cat **213** (0.05 eq),
THF, 0°, 48 h



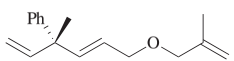
1143

R^1	R^2		(*E*)/(*Z*)	er (*E*)	er (*Z*)
H	H	(71)	82:18	8.0:92.0	—
H	Me	(77)	83:17	8.0:92.0	—
H	CF_3	(63)	86:14	9.0:91.0	65.0:34.0
H	Br	(80)	88:12	1.0:99.0	—
Br	H	(69)	86:14	1.0:99.0	75.0:25.0



2.05 eq

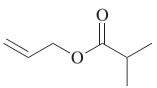
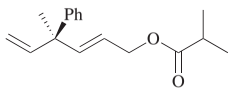
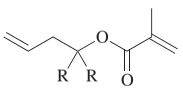
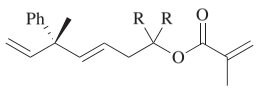
Ru cat **213** (0.05 eq),
THF, 0°, 48 h



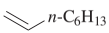
1143

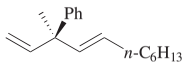
(76) (*E*)/(*Z*) = 67:33, er (*E*) 64.0:36.0

TABLE 36. ASYMMETRIC RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the charts preceding the tables for the catalyst structures.				
C_{10}				
	 2.05 eq	Ru cat **213** (0.05 eq), THF, 0°, 48 h	 (59) (*E*)/(*Z*) = 75:25, er (*E*) 35.0:65.0	1143
	 2.05 eq	Ru cat **213** (0.05 eq), THF, 0°, 48 h		1143

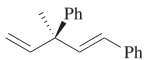
R		(*E*)/(*Z*)	er (*E*)
H	(71)	80:20	80.0:20.0
Me	(60)	83:17	90.0:10.0

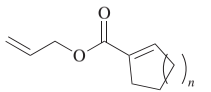
1.5 eq 

Catalyst (*x* eq), solvent 

Catalyst	*x*	Solvent	Temp (°)	Time (h)	Conv. (%)[a]		(*E*)/(*Z*)	er (*E*)	
Ru cat **213**	0.05	THF	0	48	—	(59)	60:40	60.0:40.0	1143
Hov II	0.005	toluene	22	4	83	(—)	75:25	—	624

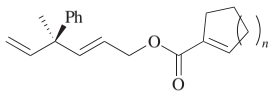
 2.05 eq

Ru cat **213** (0.05 eq), THF, 0°, 48 h  (90) (*E*)/(*Z*) > 95:5, er (*E*) 97.0:3.0 1143



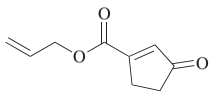
2.05 eq

Ru cat **213** (0.05 eq),
THF, 0°, 48 h



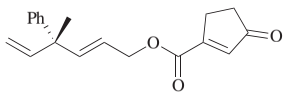
1143

n		(*E*)/(*Z*)	er (*E*)	er (*Z*)
1	(72)	83:17	5.0:95.0	74.0:26.0
2	(83)	75:25	6.0:94.0	70.0:30.0



2.05 eq

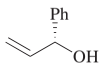
Ru cat **213** (0.05 eq),
THF, 0°, 48 h



1143

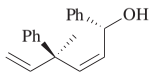
(63) (*E*)/(*Z*) = 67:33, er (*E*) 83.0:17.0

2 eq



er 96.0:4.0

Ru cat **151** (0.05 eq),
DCM, 22°, 8 h



(78) (*Z*)/(*E*) = 91:9, dr 93:7

83

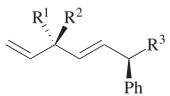
$C_{10–14}$



1 eq



Hov II (0.005 eq),
toluene, 22°



624

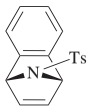
R^1	R^2	R^3	Time	Conv. (%)[a]		(*E*)/(*Z*)	dr
Ph	Me	HO	5 min	—	(87)	91:9	96:4
Ph	Me	MeO	18 h	51	(33)	86:14	79:21
Ph	Me	Me	18 h	56	(55)	90:10	91:9
Ph	$AcOCH_2$	HO	4h	—	(80)	89:11	95:5
2-Naph	Me	HO	5 min	—	(76)	91:9	96:4

TABLE 36. ASYMMETRIC RING-OPENING CROSS-METATHESIS (*Continued*)

Cyclic Alkene	Cross Partner	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the charts preceding the tables for the catalyst structures.

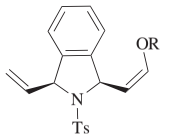
C_{10}





20 eq

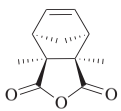
Ru cat **213** (0.05 eq)
solvent, 22°, 24 h



1205

R	Solvent	Conv. (%)[a]		(*Z*)/(*E*)	er[c]
n-Bu	—	>98	(90)	95:5	93.0:7.0
$Cl(CH_2)_2$	—	>98	(89)	>98:2	97.0:3.0
Cy	THF	>98	(93)	95:5	94.0:6.0

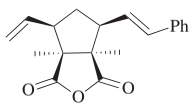
C_{11}





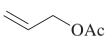
5 eq

Catalyst (*x* eq), DCM



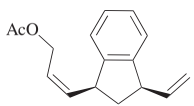
Catalyst	*x*	Temp (°)	Time (h)	Conv (%)[a]	(*E*)/(*Z*)	er	
Ru cat **240**	0.01	25	3.5	>98	95:5	91.0:9.0	95
Ru cat **240**	0.01	–10	48	>98	96:4	95.0:5.0	95
Ru cat **32**	0.05	40	24	97	89:11	90.0:10.0	96
Ru cat **229**	0.05	40	24	96	92:8	85.5:14.5	96





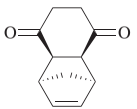
7 eq

Ru cat **215** (0.01 eq),
THF, 23°, 1 h



98

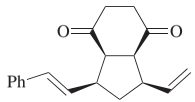
(55) (*Z*)/(*E*) = 76:24, er (*E*) > 99.0:1.0, er (*Z*) > 99.0:1.0



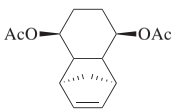


5 eq

Catalyst (x eq), DCM



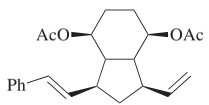
Catalyst	x	Temp (°)	Time (h)	Conv. (%)[a]	(E)/(Z)	er	
Ru cat **240**	0.01	25	120	61	95:5	93.0:7.0	95
Ru cat **32**	0.06	40	16	36	75:25	92.5:7.5	96





5 eq

Ru cat **240** (0.01 eq),
DCM, 25°, 2 h



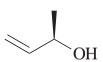
95

Conv. (%)[a] > 98, (E)/(Z) > 97:3, er 88.0:12.0

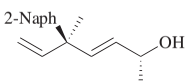
C_{14}



1 eq



Hov II (0.005 eq),
toluene, 22°, 0.25 h



(84) (E)/(Z) = 86:14, dr 97:3

624

[a] The conversion was determined by ^{1}H NMR analysis.

[b] The efficiency was calculated as yield/conversion.

[c] The enantioselectivity was determined by HPLC analysis.

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