CHAPTER 1

[3 + 2] DIPOLAR CYCLOADDITIONS OF CYCLIC NITRONES WITH ALKENES

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INTRODUCTION

This review covers [3 + 2] dipolar cycloadditions of endocyclic nitrones with alkenes, including conjugated polyenes and cumulenes, from 1985 to 2014, thereby updating the survey published by Confalone and Huie[1] in their pioneering *Organic Reactions* review (Scheme 1).



n = 0, 1, 2, 3, etc.

Scheme 1

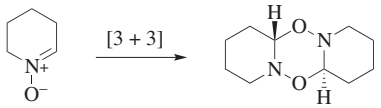
For the sake of conciseness, this contribution is limited to cyclic nitrones and alkenes. Although the earlier chapter included acyclic nitrones and other types of dipolarophiles, this reaction has developed significantly over the last thirty years, and inclusion of these classes of reactants would now be too broad for a single *Organic Reactions* volume. Nevertheless, reactions employing cyclic nitrones and alkenes provide a good representation of the potential of the method, as evidenced by the fact that most applications of nitrones in total syntheses of natural products rely on the use of cyclic nitrones (mainly five- and six-membered) in a key cycloaddition step. Several of these syntheses are described in the "Applications to Synthesis" section.

The reactions of nitrones and alkenes are by far the most widely studied type of 1,3-dipolar cycloadditions. The success of this chemistry is demonstrated by the numerous reviews and book chapters that have appeared on the theme of 1,3-dipolar cycloadditions of nitrones over the last thirty years.[1−14]

Nitrones can be obtained by a variety of simple methods[3,15−18] and are generally stable, usually crystalline compounds that can often be prepared on a large scale. Several nitrones are also commercially available. Their cycloadditions are very practical, thermal processes that usually take place under mild conditions and do not require sophisticated experimental techniques. Moreover, the chemistry allows installation of two or three contiguous or non-contiguous stereogenic centers in the

final isoxazolidine product in a single operation and in a controlled manner. Finally, and probably most importantly, the adducts can undergo several useful, reliable, and chemoselective transformations, the most common of which is reductive cleavage of the nitrogen–oxygen bond. Reductive ring opening of isoxazolidines is easily achievable by a number of simple methods (Zn/H^+,[19] Raney Ni,[20] $Pd/C/H_2$,[21] $Mo(CO)_6$,[22] SmI_2,[23–25] $Zn/Cu(OAc)_2$,[26] In[27]) and affords γ-amino alcohols, the starting points for diverse synthetic applications.

The cyclic nitrone subclass of dipoles provides some interesting and useful features to the 1,3-dipolar cycloaddition process. Cyclic nitrones are generally more stable than their acyclic counterparts, and five-membered systems are usually more stable than their six-membered homologs. For example, six-membered ring nitrones tend to dimerize through a [3 + 3] cycloaddition process (Scheme 2).[28–34]



Scheme 2

Finally, most common cyclic nitrones have a defined geometric structure, without the problem of (*E*)/(*Z*) isomerization, which allows a more reliable prediction of the stereochemical outcome of the reaction.

MECHANISM AND STEREOCHEMISTRY

1,3-Dipolar cycloadditions of cyclic nitrones are, in general, concerted pericyclic processes[35] that follow the rules of conservation of orbital symmetry.[36–39] A distinction has never been made between acyclic and cyclic nitrones in an analysis of their reactivity. Although computational studies typically employ simple acyclic nitrones as their model compounds (for the sake of reducing the computational complexity), conclusions from these studies can be easily extended to cyclic nitrones. Density Functional Theory (DFT) calculations support the concerted albeit asynchronous nature of this process,[40–42] with respect to formation of the carbon–carbon and carbon–oxygen bonds, as hypothesized by Huisgen.[43,44] Computational studies indicate that Firestone's proposed stepwise, diradical pathway[45] can compete only when special dipolarophiles, such as cyclobutadienes, are employed.[35]

Computational Studies

By means of a simple analysis of the electronic properties of the reactants, frontier molecular orbital (FMO) theory allows a qualitative understanding of reactivity and regioselectivity in 1,3-dipolar cycloadditions.[46,47] According to Sustmann's classification of 1,3-dipolar cycloadditions,[48–50] nitrone cycloadditions are classified as Type II cycloadditions, which means that when simple alkenes are used as dipolarophiles, both $HOMO_{dipole}$–$LUMO_{dipolarophile}$ and $LUMO_{dipole}$–$HOMO_{dipolarophile}$ interactions are meaningful because their energy

gaps are comparable. Therefore, substituents on both the dipolarophile and the nitrone play important roles in controlling which of the two interactions dominates. The electronic properties of substituents on the nitrone, either electron-donating or electron-withdrawing, can impart nucleophilic or electrophilic character to the cyclic nitrone, respectively, as is observed with acyclic nitrones.

Hard and Soft Acid and Base (HSAB) theory, formulated together with DFT, has also been used as a qualitative and quantitative treatment to predict reactivity and regioselectivity based upon ground-state properties of the dipole and dipolarophiles.[41,51] More modern distortion/interaction analysis, which considers the correlation between activation barriers in the cycloadditions and the distortion energies of the dipoles, appears superior in explaining the reactivity of nitrone 1,3-dipolar cycloadditions.[42,52] It is interesting that in this analysis, the distortion energy of the 1,3-dipole has considerable importance, whereas the frontier orbital theory emphasizes only the significance of the interaction between the two cycloaddends. It is possible to reconcile these differences by noting that distortion of the dipole is one way of maximizing the interaction between the two cycloaddends.[53] On the other hand, the relevance of this distortion/interaction analysis to the cycloadditions of cyclic nitrones is unclear: in a study of the possible cycloaddition of 1,3-dipoles to carbon nanotubes, nitrones were computed to be unreactive because of the high distortion energy,[54,55] but this calculation was contradicted by experiments with cyclic five-membered nitrones.[56]

Regioselectivity

On the basis of simple classical FMO considerations, the regioselectivity of the cyclic nitrone [3 + 2] cycloadditions to alkenes can be explained by the preferred overlap of the largest coefficients of the two interacting frontier orbitals.[57] More recent analyses do not contradict these results.

For an electron-rich monosubstituted alkene, complete regioselectivity in favor of the 5-substituted isoxazolidines (isoxazolidine numbering) is expected because of the perfect matching of the largest coefficients, both in the preferred $LUMO_{dipole}$–$HOMO_{dipolarophile}$ interaction and in the less preferred one (Figure 1, Schemes 3 and 4).[58]

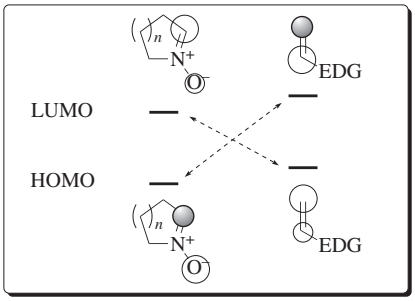
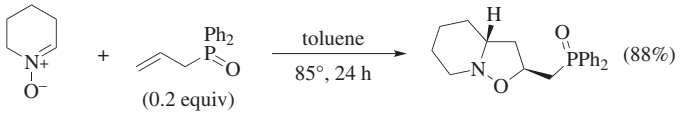


Figure 1. HOMO-LUMO inteactions with electron-rich dipolarophiles.



n = 0, 1, 2, 3, etc.

Scheme 3



Scheme 4

In view of the stronger $HOMO_{dipole}$–$LUMO_{dipolarophile}$ interaction expected for a 1,3-dipole with an electron-poor alkene (Figure 2), a preference for 4-substituted isoxazolidines is anticipated. However, mixtures of constitutional isomers are typically obtained (Scheme 5).

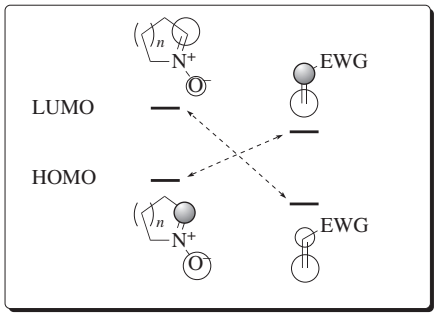
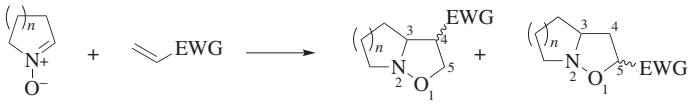


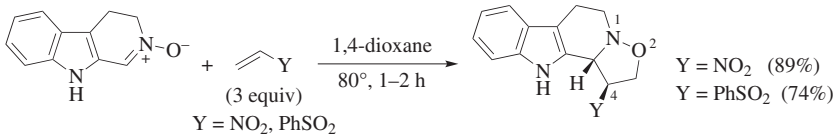
Figure 2. HOMO-LUMO inteactions with electron-poor dipolarophiles.



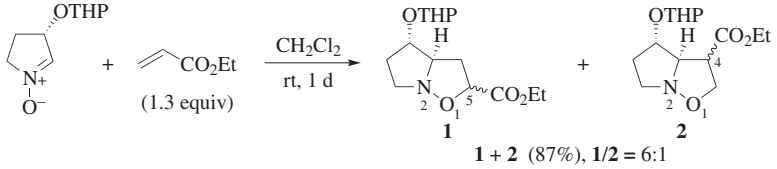
n = 0, 1, 2, 3, etc.

Scheme 5

In fact, the matching of HOMO and LUMO coefficients leads to opposite constitutional isomers for the $HOMO_{dipole}$–$LUMO_{dipolarophile}$ and the less energetically preferred $LUMO_{dipole}$–$HOMO_{dipolarophile}$ interaction. Indeed, apart from nitroalkenes or other very electron-poor alkenes (Scheme 6),[59] in which the $HOMO_{dipole}$–$LUMO_{dipolarophile}$ interaction is largely preferred, mixtures of constitutional isomers are generally obtained, with 5-substituted isoxazolidines usually predominating for less electron-withdrawing groups such as esters (Scheme 7).[60]



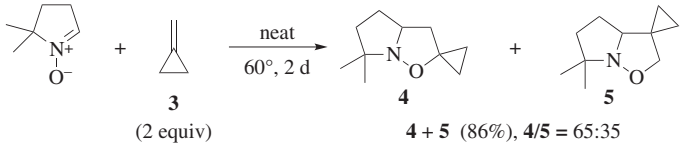
Scheme 6



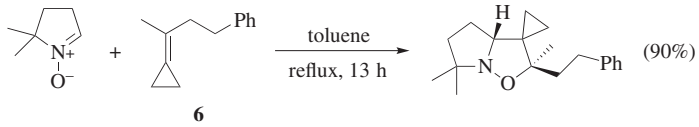
Scheme 7

The carbon and oxygen coefficients in the LUMO orbital of the nitrone are more differentiated than those of the HOMO (Figure 2), and it has been suggested that this may control the regioselectivity of the reaction. In fact, the higher energy $LUMO_{dipole}$–$HOMO_{dipolarophile}$ interaction favors 5-substituted isoxazolidines like **1** (Scheme 7) with moderately electron-deficient alkenes.[47] Steric effects may also play a prominent role in determining this preference, because steric repulsions of the two approaching components are more severe in the transition state (TS) leading to 4-substituted constitutional isomers like **2** than in the one that leads to 5-substituted adducts.

The influence of steric effects on the regioselectivity of the cycloaddition has been documented. One striking example is the different regioselectivity observed in the cycloadditions of 3,4-dihydro-2,2-dimethyl-2*H*-pyrrole *N*-oxide (DMPO) with methylenecyclopropane (**3**) (Scheme 8)[61] and alkylidenecyclopropane **6** (Scheme 9).[62]



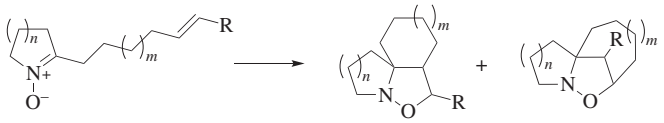
Scheme 8



Scheme 9

The regiochemical course of the cycloaddition of DMPO with **3** is surprising as the reaction produces a mixture of isomers **4** and **5**, whereas simple 1,1-disubstituted alkenes, like isobutene, provide exclusively the 5-substituted constitutional isomer with cyclic nitrones.[63,64] Methylenecyclobutane also generates the 5-substituted adduct selectively.[65] An explanation of these results can be postulated taking into account only steric hindrance. Methylenecyclopropane (**3**), like other non-polarized 1,1-disubstituted alkenes lacking any differentiation of orbital coefficients, should produce a 1:1 mixture of constitutional isomers like **4** and **5** based on FMO arguments (Scheme 8).[66] The low steric demand of the cyclopropane ring in **3** helps to rationalize the formation of both constitutional isomers, in contrast to isobutene and methylenecyclobutane. However, when the competition is between bulky alkyl substituents and a flat cyclopropane ring (as in **6**), the product with a less encumbered cyclopropane ring at the isoxazolidine C(4) position is obtained exclusively (Scheme 9).

The inter- or intramolecularity of the cycloaddition is another crucial factor in determining the regiochemical outcome of 1,3-dipolar cycloaddition of nitrones. Although FMO interactions drive the regiochemical outcome in intermolecular cycloadditions, the length of the tether linking the 1,3-dipole and the dipolarophile moieties is the key factor controlling regioselectivity in intramolecular cycloadditions. In the case of nitrones **7** substituted at the C(2) carbon, a mixture of cycloadducts (fused **8** and bridged **9**) can be obtained (Scheme 10). However, when $m = 0$, only fused cycloadduct **8** is obtained. Systems having tethers shorter than three carbon atoms cannot engage in intramolecular cycloadditions.



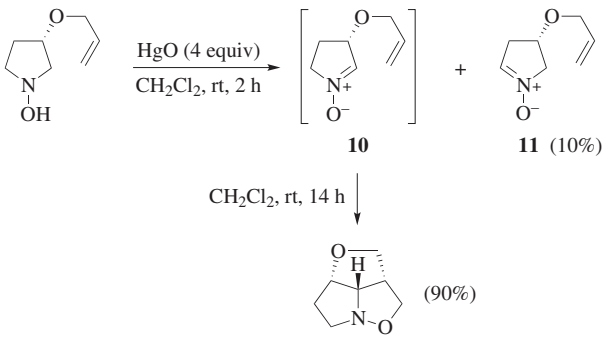
7 **8** **9**

$n = 0, 1, 2, 3\ldots$
$m = 0, 1, 2, 3\ldots$

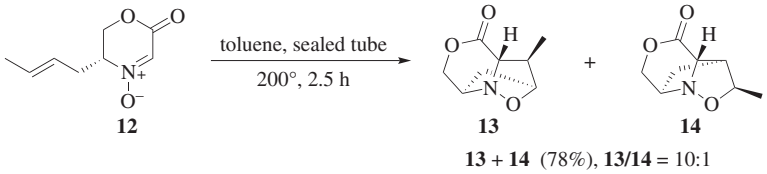
Scheme 10

If the alkene chain is linked to positions on the cyclic nitrone other than C(2), only bridged cycloaddition products can form. The rate of reaction in these cases is dictated by the distances between the combining atoms, as illustrated in the example of Scheme 11.[67] Of the two isomeric nitrones **10** and **11** (formed by oxidation of the hydroxylamine), only **10** undergoes intramolecular cycloaddition, whereas **11** can be isolated unreacted (Scheme 11).

Although two cycloaddition pathways are possible, the reaction of nitrone **12** favors the formation of cycloadduct **13** over cycloadduct **14**, likely because of the lower strain of the tricyclic bridged ring system in the former (Scheme 12).[68]



Scheme 11



Scheme 12

Stereoselectivity

Nitrones have been employed in highly stereoselective 1,3-dipolar cycloaddition processes in both intermolecular and intramolecular modes. The relative facial topicity in a given pairwise combination of a nitrone and a substituted alkene is defined as *endo* when the approach of the alkene substituent R^1 is oriented towards the nitrogen atom in the trigonal nitrone function, and as *exo* when the approach of R^1 is oriented away from the nitrogen atom (Figure 3). An *endo* reaction produces a bicyclic adduct

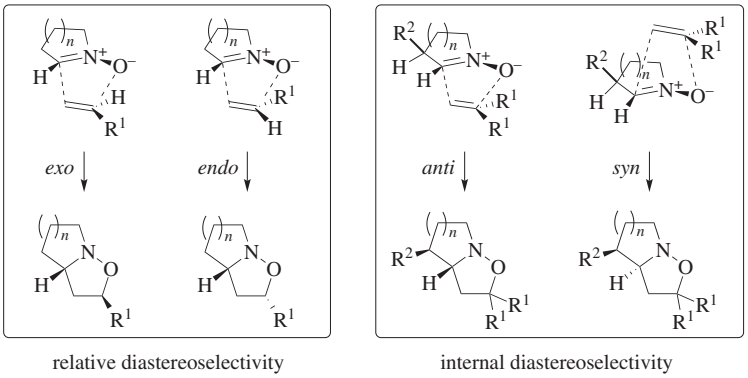


Figure 3. Transition state trajectories for intermolecular cycloadditions leading to stereodifferentiated constitutional isomers.

in which the alkene substituent R^1 and the bridgehead hydrogen are *trans*, whereas an *exo* reaction creates a *cis* relationship between these substituents.

When the nitrone bears a substituent (R^2) and the alkene approaches the nitrone from the face opposite the R^2 substituent (*anti* approach), the resulting bicyclic adducts have a *cis* relationship between R^2 and the bridgehead hydrogen. The approach is defined as *syn* when the alkene approaches the nitrone from the same side as R^2. In this case, the product features a *trans* relationship between R^2 and the bridgehead hydrogen (Figure 3).

The stereochemical outcome of [3 + 2] cycloadditions is influenced by the substituents on both the nitrone and the dipolarophile. The substituent(s) on the dipolarophile determine the *exo* or *endo* mode of approach of the alkene with respect to the nitrone in the transition state (relative diastereoselection); the substituent(s) on the cyclic nitrone determine the *anti* or *syn* approach of the alkene with respect to the nitrone in the transition state (internal diastereoselection). In general, the stereoselectivity of the cycloaddition is primarily controlled by the C(3) and C(5) stereocenters of five-membered (or C(3) and C(6) of six-membered) nitrones. If R^2 and R^3 have a *cis* relationship, the possible transition states and products for the cycloaddition of five-membered cyclic nitrones and monosubstituted alkenes are those shown in Figure 4.

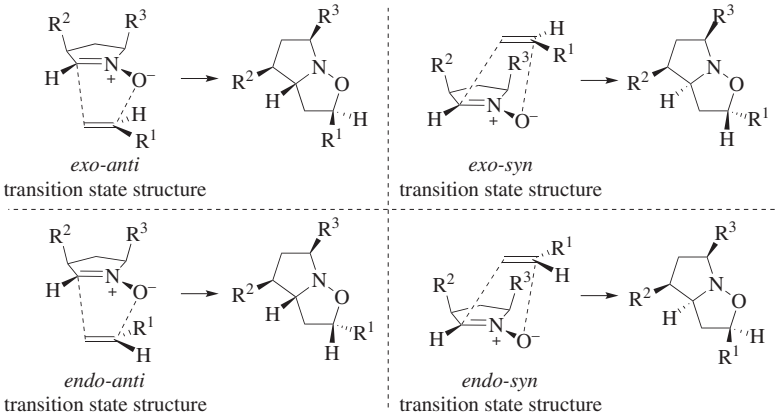
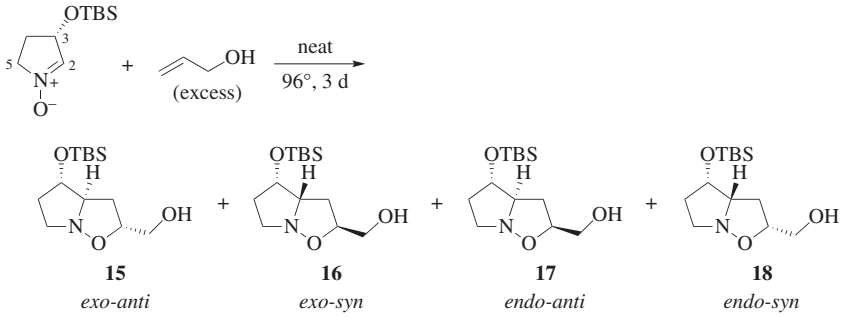


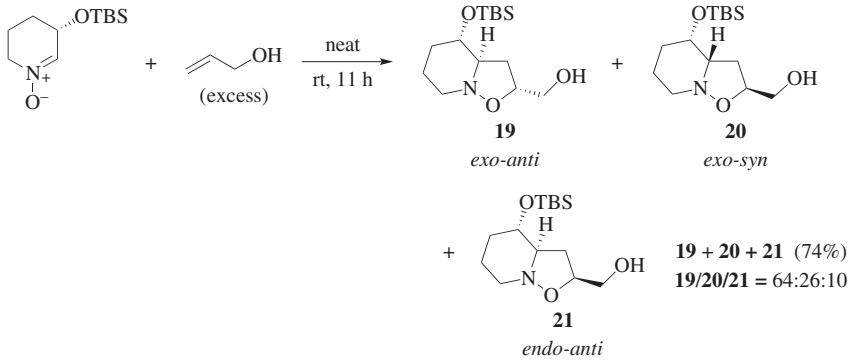
Figure 4. Possible transition states and products for the cycloaddtion of 5-membered cyclic nitrones and monosubstituted alkenes.

Of the four possibilities, the *exo-anti* TS is by far the most highly favored, followed by either the *endo-anti* TS or the *exo-syn* TS depending on the particular substitution pattern of the nitrone and the alkene. The *endo-syn* approach is the most disfavored, and generally is not observed. For example, the reaction between a C(3)-substituted nitrone and allyl alcohol results in a mixture of compounds such as **15–18**, favoring *exo-anti* isomer **15** (Scheme 13).[67] If R^2 and R^3 are *trans*, the stereoselectivity varies and depends on the particular nature of the substituents on the dipole and/or

the dipolarophile, with a tendency for the C(5) nitrone substituent R^3 to have the greatest effect on the stereochemical outcome. The analysis of cycloadditions of six-membered ring nitrones is similar, but their larger conformational flexibility can play an important role. In the reaction depicted in Scheme 14,[69] cycloadducts **19–21** are formed as a mixture, and the *endo-syn* product is not observed.

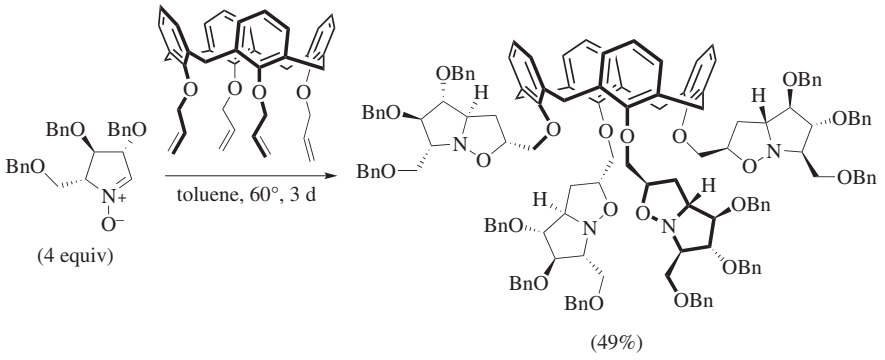


Scheme 13



Scheme 14

An uncommonly high level of stereoselectivity is observed in the 1,3-dipolar cycloadditions of *trans*,*trans*-3,4,5-trisubstituted five-membered cyclic nitrones: substituents at C(3) and C(5) hamper the *syn* approaches of the dienophile, and the substituent at C(4) disfavors the *endo* mode of addition.[70–77] The result is a highly selective *exo-anti* cycloaddition, which is nicely illustrated by the four-fold cycloadditions of a D-arabinose-derived nitrone with a calix[4]arene tetraallylated at the lower rim (Scheme 15).[78] Out of 70 possible stereoisomeric cycloadducts, only the product of *exo-anti* addition to all C=C double bonds is isolated, and it is obtained in 49% yield.



Scheme 15

In intramolecular cycloadditions, diastereoselectivity and regioselectivity are primarily dictated by the connecting tether. For 2-substituted nitrones that lead mainly to fused bicyclic cycloadducts, an *exo* approach of the substituent on the alkene is preferred. For the other substituted nitrones, the alkene on the tether attacks the nitrone from the same face and in an *endo* fashion (with regard to the tethering substituent) when the tether is short enough, as exemplified in Schemes 11 and 12.

The use of metal catalysis is among the most recent developments of 1,3-dipolar cycloaddition chemistry. Although this modification has mainly been applied to acyclic nitrones, examples involving cyclic nitrones have also been reported (see below).[8,10,79–86] High levels of asymmetric induction can be achieved in these cycloadditions by the use of an appropriate chiral ligand. More recently, examples of organocatalyzed cycloadditions have also been described and thoroughly reviewed.[87,88]

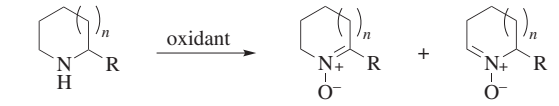
SCOPE AND LIMITATIONS

Preparation of Cyclic Nitrones

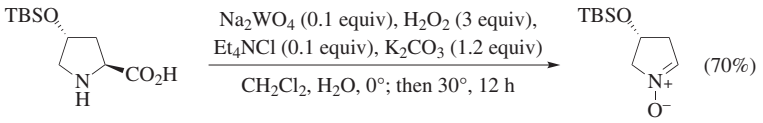
Most of the methods currently known for the synthesis of acyclic nitrones,[15,17,18,89] (mainly oxidations and condensations of nitrogen derivatives) can be also applied to the synthesis of cyclic nitrones.[16] There are, however, several other methods that are specific for forming cyclic nitrones.

The metal-catalyzed oxidation of secondary amines with hydrogen peroxide, or urea hydrogen peroxide (UHP), is a simple and effective method (Scheme 16). Among the catalysts used, selenium dioxide,[90] sodium tungstate decahydrate,[91–93] sodium molybdate or other molybdenum catalysts,[91,92] and methyltrioxorhenium (MTO)[94–97] are the most efficient. (Trialkanolaminato) titanium(IV) complexes[98,99] and molybdenum oxide/bipyridine hybrid material $\{[MoO_3(bipy)][MoO_3(H_2O)]\}_n$[100] have been added to the list of effective catalysts. Both inorganic oxidants (e.g., Oxone[101]) and organic oxidants (such as 2-(phenylsulfonyl)-3-phenyloxaziridine,[102] 3-chloroperoxybenzoic acid (*m*-CPBA),[103] or dimethyldioxirane[104]) have been used with success. 2-Substituted cyclic amines

in principle might afford mixtures of constitutional isomers, depending on the nature of the R substituent (Scheme 16). In general, however, the oxidation of the carbon bearing the R substituent is the major or the sole process observed. With 3-substituted amines, the oxidation typically occurs with little or moderate regioselectivity. A regioselective method carried out by oxidation/decarboxylation of α-amino acids under phase-transfer conditions has been reported; Scheme 17 illustrates transformation of proline-derivative **22** into *N*-oxide **23**.[105,106]



Scheme 16

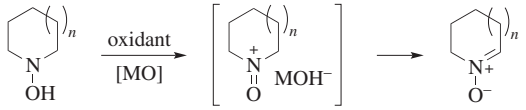


22 **23**

Scheme 17

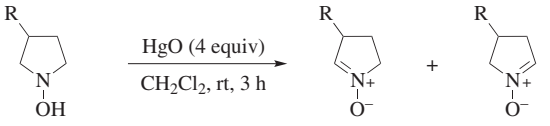
Cyclic hydroxylamines may also be oxidized to nitrones; in fact, such species are generally intermediates in the oxidation of cyclic amines to nitrones (Scheme 18). Depending on the oxidant, the conversion of hydroxylamines to nitrones may occur via nitrosonium ion **24** or via a radical species. Oxidation of hydroxylamines occurs under much milder conditions than that of amines, affording excellent yields of nitrones. A vast number of methods has been used for this transformation, including stoichiometric inorganic and organic oxidants, catalytic methods, and electrochemical oxidation.[107] Examples of stoichiometric oxidants include NaOCl,[108] H_2O_2,[1,109] 4-benzoquinone,[110] 2,2,6,6-tetramethyl-1-piperidinyloxy (TEMPO),[111] yellow HgO,[112,113] PbO_2,[114,115] 2-iodoxybenzoic acid (IBX),[116] and MnO_2.[96,114,117] The last oxidant is usually preferred for its selectivity and low toxicity compared to HgO. Many catalytic methods have also been developed that employ milder and more environmentally compatible oxidants, such as *N*-methylmorpholine *N*-oxide (with tetrapropylammonium perruthenate [TPAP] as the catalyst),[118] H_2O_2 (with MTO[119] or Jacobsen[120] catalysts), or even molecular oxygen (with TPAP,[121] copper(II) acetate,[122] or metallic gold[123] as the catalyst). The formation of mixtures of isomeric nitrones from 2-substituted cyclic hydroxylamines is more typical than in amine oxidations, once again depending on the nature of the substituent. In non-symmetrical cyclic hydroxylamines with methylene groups adjacent to the nitrogen, the regioselectivity is generally poor. For example, the mercury(II) oxide oxidation of 3-substituted *N*-hydroxypyrrolidines **25** generally results in mixtures of nitrones **26** and **27** (Scheme 19). However, it was found that the presence of an

inductively electron-withdrawing OR substituent resulted in the preferential removal of the proton vicinal and antiperiplanar to the substituent by the $[MOH]^-$ base, favoring formation of nitrone **26**. [67,124]



24

Scheme 18

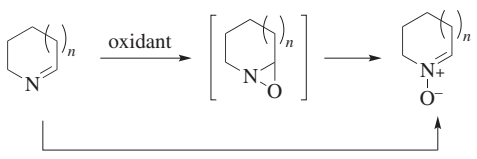


25 **26** **27**

R	Yield (%)	**26/27**
Me	90	1.8:1
Ph	94	2:1
Bn_2N	12	2:1
HO	24	5:1
t-BuO	80	9:1
allylO	90	9:1
TBSO	54	12:1
PhOCO	56	>20:1

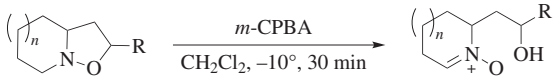
Scheme 19

Oxidation of cyclic imines to nitrones is a less common process that can be carried out with permanganate under phase transfer conditions,[125] with dioxirane,[126] or more selectively and efficiently, with UHP/MTO (Scheme 20).[127–129] The oxidation of a cyclic imine may occur directly, as it does with UHP/MTO, or it may proceed via an intermediate oxaziridine. Indeed, the isomerization of an oxaziridine to the corresponding nitrone is a smooth process that has been reported on some occasions to proceed during purification on silica gel,[130–133] but can be more efficiently induced by acids such as trifluoroacetic acid.[134,135] In contrast to the oxidation of amines or hydroxylamines, the oxidation of imines has the advantage of generating a single nitrone when an unsymmetrical substrate is used.



Scheme 20

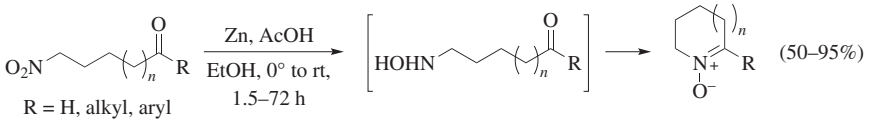
The oxidation of isoxazolidines **28** (Scheme 21) is an excellent method for the selective synthesis of functionalized nitrones **29** that are not easily obtained by oxidation of a free amine. 3-Chloroperoxybenzoic acid is the oxidant of choice, and this reagent promotes the opening of the isoxazolidine ring with formation of a nitrone in high yield and with good regioselectivity.[136–139] When nonpolar solvents (e.g., CH_2Cl_2) are used, this oxidation occurs at the less substituted carbon adjacent to nitrogen. The regioselectivity may depend on the ring size and the solvent used, and with more polar solvents (e.g., MeOH, AcOH), it is typically reversed to form the keto nitrone preferentially.[139,140] Since the starting isoxazolidines are in turn produced by cycloadditions of alkenes to nitrones, this method is often employed in iterative processes.[141] A unique example of an analogous oxidation/opening of a 1,2-oxazine to furnish a cyclic nitrone has also been reported.[142]



28 **29**

Scheme 21

The intramolecular condensation of hydroxylamino-substituted aldehydes or ketones is a common method of synthesis of cyclic nitrones (Scheme 22).[143–152] Usually the hydroxylamine is produced in situ from the corresponding nitro aldehyde or nitro ketone by reduction with zinc dust and acetic acid, or by zinc dust in aqueous ammonium chloride. Other methods include the reduction of an oxime with sodium cyanoborohydride followed by acid treatment,[153] or the fragmentation of an oxaziridine by acid hydrolysis.[154] In these cases, the aldehyde group must be protected by acetal formation, which can later be removed under the acid catalysis in the last step to promote the condensation. In a recent example, cyclic nitrones are obtained by aluminum amalgam reduction of nitro nitriles and nitro ketones.[155]

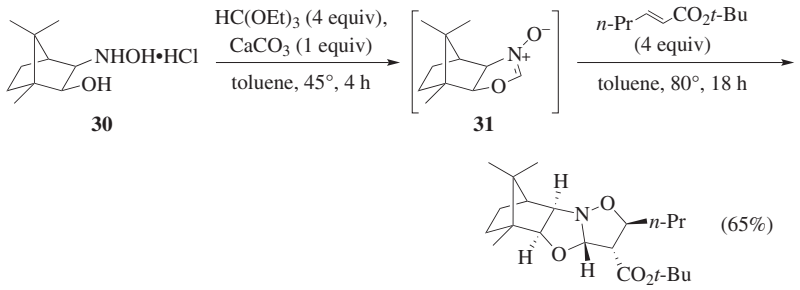


Scheme 22

One example of the condensation of a bis-oxime of a 1,4-dioxo compound has been reported.[156] The intramolecular condensation of γ-, δ-, and ε-nitro nitriles under reductive conditions produces 2-amino-substituted five-,[157,158] six-,[159] and seven-membered[160] cyclic nitrones, respectively, in good yields. The formation of six-, and

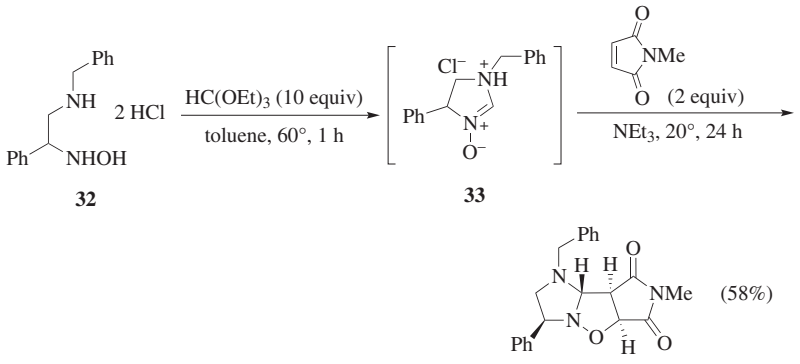
seven-membered nitrones from nitro nitriles can be also carried out by electrochemical reduction.[161−163]

The condensation of amide acetals with β-hydroxy hydroxylamines,[130] or of orthoesters with β-hydroxy hydroxylamines (e.g., **30**)[164−168] (Scheme 23) and β-amino hydroxylamines (e.g., **32**)[169] (Scheme 24) has been widely employed for the synthesis of enantiomerically pure oxazoline *N*-oxides or imidazoline *N*-oxides (e.g., compounds **31** and **33**, respectively) that undergo 1,3-dipolar cycloadditions in situ.



30 **31**

Scheme 23

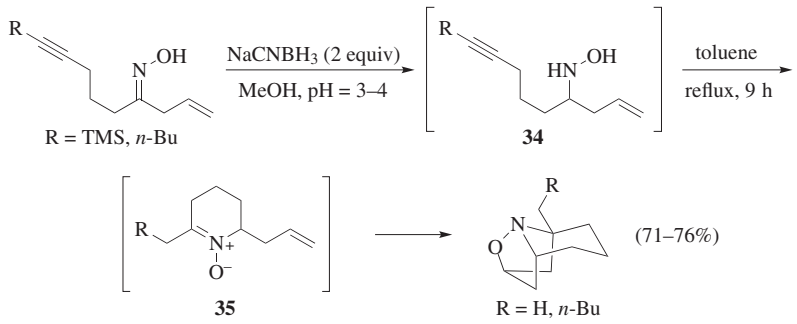


32 **33**

Scheme 24

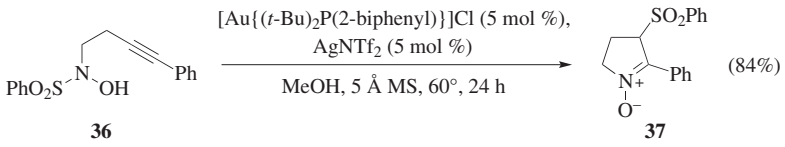
Enantioselective Michael additions of β-keto sulfones to nitroalkenes promoted by C_3-symmetric cinchonine–squaramide catalysts have been reported, and these reactions lead to highly enantioenriched cyclic nitrones.[150] An organocatalytic Michael addition of aldehydes to nitroalkenes, carried out in water and followed by in situ reductive cyclization, produces enantiomerically enriched five-membered cyclic nitrones in a one-pot procedure and with excellent er values (er > 99.0:1.0).[170] Intramolecular hydroxylamine–alkyne cyclizations are also known to furnish cyclic

nitrones. The method has been applied to the synthesis of euphococcinine and adaline alkaloids, and the intermediate hydroxylamine **34** and nitrone **35** can be produced in situ (Scheme 25).[171−174]



Scheme 25

A related gold-catalyzed cyclization of alkynyl *N*-sulfonylhydroxylamines affords five-membered cyclic nitrones in good yields (with migration of the sulfonyl group), as depicted in Scheme 26 for the formation of nitrone **37** from compound **36**.[175]

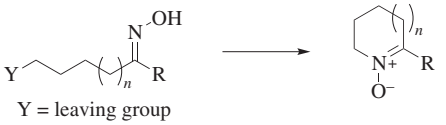


36 **37**

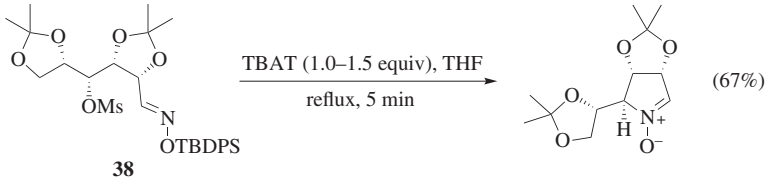
Scheme 26

The nucleophilic displacement of a leaving group by an oxime nitrogen is a general method for the synthesis of nitrones (Scheme 27). The most commonly employed leaving groups in this method are sulfonate esters or iodide. This type of cyclization occurs with high levels of stereoselectivity, and is particularly well-suited for use with carbohydrate-derived substrates, where the numerous hydroxy groups allow easy generation of a leaving group. In addition, a variety of ring sizes and configurations of the nitrone are available.[69,176,177] Another approach is to use an *O*-silylated oxime, which will cyclize when treated with a fluoride source, such as tetrabutylammonium fluoride[72,178] or the non-basic tetrabutylammonium triphenyldifluorosilicate (TBAT), as in case of TBDPS-protected oxime **38** (Scheme 28).[179] This method has also been carried out in one-pot procedures without isolation of the intermediate oximes (or silylated oximes) and sulfonates.[180,181] This process can be performed in a sequential fashion, as in case of the sensitive nitrone **39**

which is synthesized in the presence of a dipolarophile and trapped in a 1,3-dipolar cycloaddition (Scheme 29).[182]



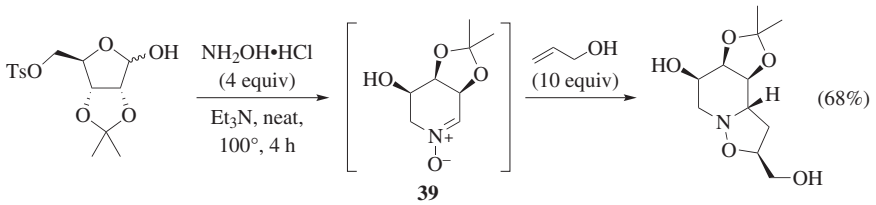
Scheme 27



38

TBAT = tetrabutylammonium triphenyldifluorosilicate

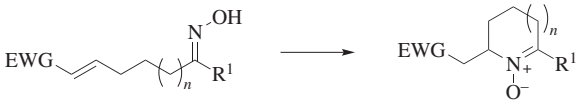
Scheme 28



39

Scheme 29

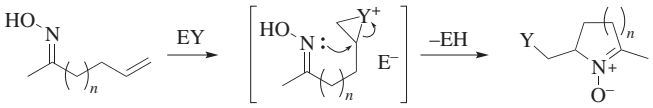
The cyclization by oxime *N*-alkylation can also take place by conjugate addition to an activated double bond (Scheme 30).[183,184]



Scheme 30

The cyclization of simple ω-alkenyl oximes can occur via a concerted 1,3-azaprotio cyclotransfer (APT) mechanism.[183,185−189] An analogous hydroamination of styryl oximes mediated by potassium phosphate at 120° affords cyclic nitrones in high yield.[190]

Several electrophiles are able to promote the cyclization of simple ω-alkenyl oximes (Scheme 31). For example, the cyclization of oximes **40** to products **42** can occur via the corresponding intermediates **41** when induced by electrophiles such as iodine or bromine,[191−195] *N*-halosuccinimides,[191,196] mercuric acetate,[197] palladium(II),[198] or phenylselenylating agents, including phenylselenyl bromide,[196,199−202] arylselenyl triflates,[203] and species produced from the reaction of diphenyl diselenide with ammonium persulfate in the presence of trifluoromethanesulfonic acid[204] (Scheme 31). Related intramolecular *N*-alkylations of oxime epoxides have also been achieved.[177]



40 **41** **42**

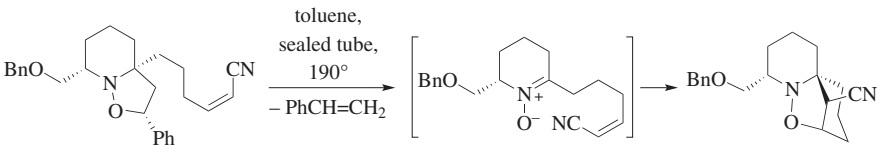
EY = I_2
EY = NBS
EY = PhSeBr
EY = ArSeOTf
EY = $Hg(OAc)_2$

Y = I
Y = Br
Y = PhSe
Y = ArSe
Y = AcOHg

Scheme 31

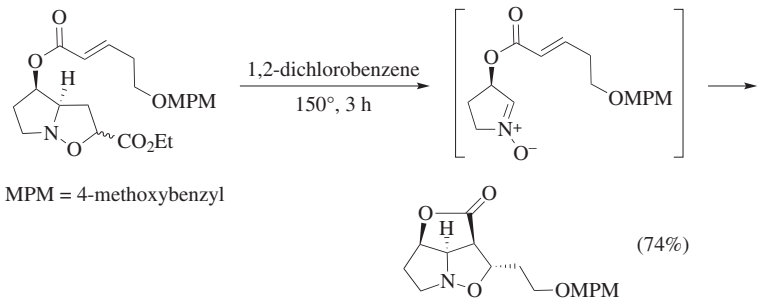
Iminooxyl-radical-promoted cyclization of ω-alkenyl oximes produces cyclic nitrones in high yields and is accompanied by intramolecular aminooximation of the unactivated alkenes.[205] Cyclizations mediated by phenylselenyl bromide have also been carried out on alkynyl oximes.[206] The cyclization of oximes with allenes occurs by catalysis with silver tetrafluoroborate.[207] In a recent report, a mixture of an allenyloxime, an aromatic aldehyde, and an alcohol undergoes a one-pot tandem transformation under simple base catalysis in alcoholic and aqueous solvents to afford five-membered cyclic nitrones in good yields.[208] The cyclization of oximes with imines is also an efficient method of producing quinazoline 3-oxides,[209−211] or tetrahydropyrimidine *N*-oxides.[212−214] The cyclization of an oxime onto an aldonitrone moiety produces an imidazole-1,3-dioxide after oxidation.[114,115,215]

The cycloreversion of isoxazolidines to the precursor nitrones and alkenes occurs at a temperature higher than that necessary to form the isoxazolidine. If the temperature is reasonably low (i.e., below 200°), the process then becomes a convenient method for producing nitrones (Schemes 32 and 33).[138,216,217]



(82%)

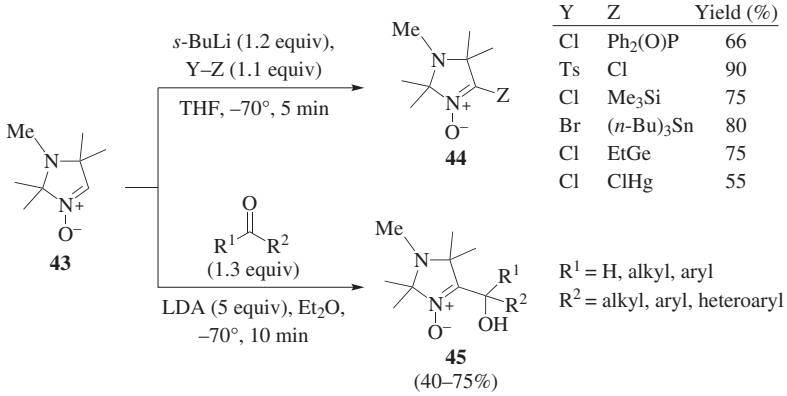
Scheme 32



Scheme 33

This method is particularly convenient when a nitrone can undergo an intramolecular reaction, but needs temporary protection. The protection can be achieved by cycloaddition to a sacrificial alkene, most commonly styrene or an acrylate ester. This method has been applied to several alkaloid syntheses.[60,174,218–221]

Structural modification of preformed cyclic nitrones is a convenient method for the synthesis of new nitrones. 2-Methoxy-substituted imidazole *N*-oxides generate the corresponding 2-amino- or 2-thio substituted imidazole *N*-oxides by nucleophilic substitution with ammonia, methylamine, or potassium sulfide.[222] Lithiation of aldonitrone **43**, followed by addition of various electrophiles or carbonyl electrophiles, affords new nitrones **44** and **45** in good yields (Scheme 34).[223–225]

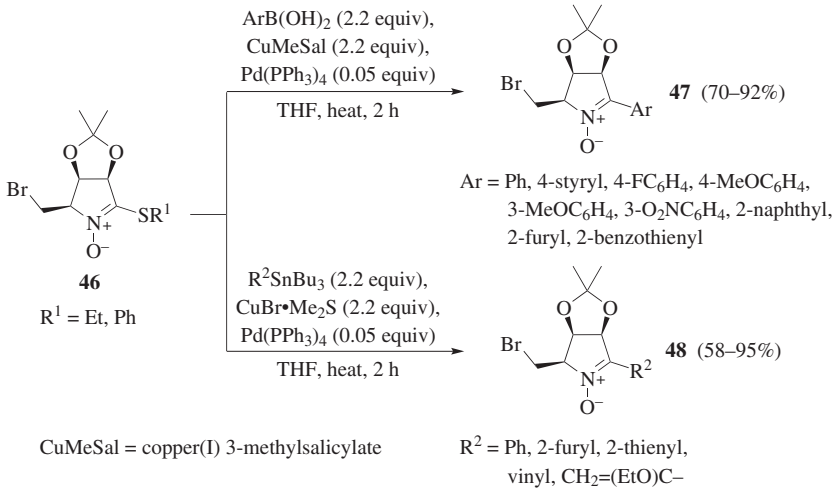


Y	Z	Yield (%)
Cl	$Ph_2(O)P$	66
Ts	Cl	90
Cl	Me_3Si	75
Br	$(n\text{-}Bu)_3Sn$	80
Cl	EtGe	75
Cl	ClHg	55

R^1 = H, alkyl, aryl
R^2 = alkyl, aryl, heteroaryl

Scheme 34

The palladium-catalyzed Liebeskind–Srogl coupling of thioimidate *N*-oxides **46**, obtained by NBS-induced cyclization of the corresponding alkenyl thiohydroxymates represents a new method of generating alkenyl and aryl ketonitrones. Cross-coupling reactions using arylboronic acids or tributyltin-based reagents can be used to access α-alkenyl- and α-aryl-functionalized cyclic nitrones **47** and **48** (Scheme 35).[226]

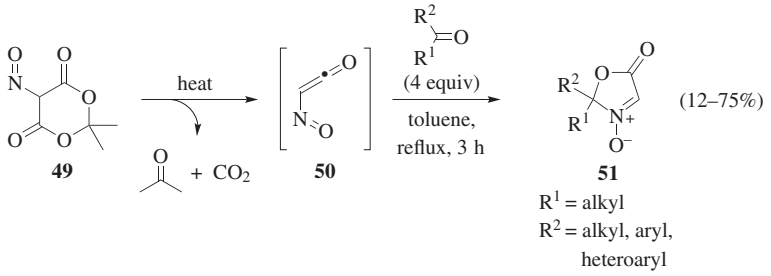


Scheme 35

A similar dehydrogenative coupling of cyclic nitrones catalyzed by Pd, with co-catalysis by pivalic acid or copper bromide, allows a clean and high-yielding synthesis of a large array of 2-substituted aryl, thienyl, and pyridyl cyclic nitrones.[227]

N-Silyloxytetrahydro-1,2-oxazines, efficiently obtained by a formal [3 + 3] cycloaddition of various silyl nitronates with 1,1-cyclopropanediesters with donor substituents under ytterbium(III) trifluoromethanesulfonate catalysis, are transformed into pyrroline *N*-oxides via a novel trifluoromethanesulfonic acid-promoted silanol elimination reaction.[228] The base-promoted elimination of 4-toluensulfonic acid from *N*-hydroxy-*cis,cis*-5-[(4-tolylsulfonyl)oxy]decahydroquinoline, followed by fragmentation, provides a unique example of the synthesis of a 10-membered cyclic nitrone that undergoes inter- and intramolecular cycloadditions (see Schemes 64 and 95).[229]

One straightforward entry into 3-oxazolin-5-one 3-oxides **51** consists of the reaction of nitroso ketene **50**, generated under reflux in toluene from 5-isonitroso-2,2-dimethyl-1,3-dioxane-4,6-dione (**49**), with various ketones (Scheme 36).[230,231]



Scheme 36

The following efficient synthetic methods have afforded nitrones that have not yet been employed in 1,3-dipolar cycloadditions processes.

The addition of ynamines to nitroalkenes produces intermediate oxazines that undergo ring contraction to form four-membered cyclic nitrones in moderate yields.[232] A tandem [2,3]-rearrangement/4π-electrocyclization of *N*-allenylnitrones produces the corresponding four-membered cyclic nitrones in good to excellent yields. The *N*-allenylnitrone intermediates are produced by a copper-catalyzed rearrangement of (*E*)-*O*-propargylic arylaldoximes.[233−235] Azepine *N*-oxides[236] or azocine *N*-oxides[236*a*] are obtained from cyclopropane- or cyclobutane-substituted propargyloximes, respectively. An isoquinoline *N*-oxide is an intermediate in a palladium-catalyzed, four-component cycloaddition of 2-iodobenzaldehyde, allene, and hydroxylamine in the presence of *N*-methylmaleimide.[237]

Quinoxaline *N*-oxides are synthesized in good yields by functionalizing arylethylidene anilines with *tert*-butyl nitrite catalyzed by tetrabutylammonium bromide.[238] Nitroso acetals, produced by tandem [4 + 2]/[3 + 2] cycloadditions of nitroalkenes, rearrange to *C*-alkoxynitrones.[239] The reaction of a nitrosobenzene with benzonitrile oxide produces a benzimidazole *N*-oxide.[240] With aluminum chloride catalysis, a camphor chloro nitroso acetal undergoes NO insertion and ring enlargement to form a seven-membered nitrone.[241] *N*-Hydroxybenzimidamides undergo a cyclization to nitrones by oxidation with mercury(II) oxide and ethylenediaminetetraacetic acid.[242,243] Pyridine or quinolone *N*-oxides behave as 1,3-dipoles, although the cycloaddition products tend to rearrange to restore the aromaticity of the heteroaromatic ring.[244,245] Pyridine *N*-oxides undergo reaction with Grignard reagents and electrophiles to form 2,3-dihydropyridine *N*-oxides.[246] The photolysis of cyclic *N*-hydroxylamines in the presence of 1,4-dicyanonaphthalene provides high yields of cyclic nitrones that are trapped by cycloaddition with dimethyl fumarate.[247] Thermally promoted 2-aza-Cope rearrangements lead to isomeric cyclic allyl nitrones.[248−250] The gold(III) bromide[251] or palladium(II)-catalyzed[252] cycloisomerization of 2-alkynylnitrobenzenes affords benzo-fused *C*-aryl 3-oxopyrroline *N*-oxides (isatogens). The presence of a dipolarophile tethered to the alkynyl moiety allows domino formation of the nitrone and further cycloaddition.[253] Medium-sized cyclic nitrones undergo ring-expanding dimerization/oligomerization in the presence of organic or inorganic acids. Novel macrocyclic polynitrones as large as a 50-membered ring are obtained with ring-size-dependent specificity. Cyclic nitrones with odd-number-membered rings are converted selectively into dimers, whereas even-number-membered cyclic nitrones undergo consecutive ring-expansion reactions to afford several macrocyclic polynitrones.[254]

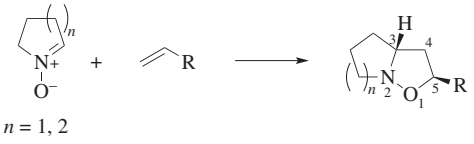
Cycloaddition Reactions

The discussion below, concerning the scope and limitations of the [3 + 2] dipolar cycloaddition reaction, is organized primarily according to the inter- or intramolecular nature of the cycloaddition. In each category, examples are further

divided on the basis of the nitrone ring size (four-, five-, six-membered, and larger rings). Examples of cyclic nitrones containing an additional heteroatom in the ring, particularly important for five- and six-membered cyclic nitrones, are reported as well. The examples that are cited illustrate the range of isoxazolidines available from each type of cycloaddition. The key contributing features are the alkene structure (cyclic or acyclic), its degree of substitution, and the electronic features of the substituents. All of these characteristics influence the regio- and/or stereoselectivity of the cycloaddition process.

Intermolecular Cycloadditions. Essential features of the alkenes involved in the cycloadditions are summarized briefly here, since these factors have already been outlined in the 1988 *Organic Reactions* chapter on nitrone cycloadditions.[1] The most important innovation in the intervening period concerns the use of chiral nitrones, alkenes, or additives to access enantiomerically pure or enriched compounds. Several examples of the use of chiral auxiliaries[174,218,255–258] and chiral catalysts[82,259–262] have been reported. Another development has been the use of less common strained dipolarophiles. In addition, the range of cyclic nitrones available has expanded enormously.

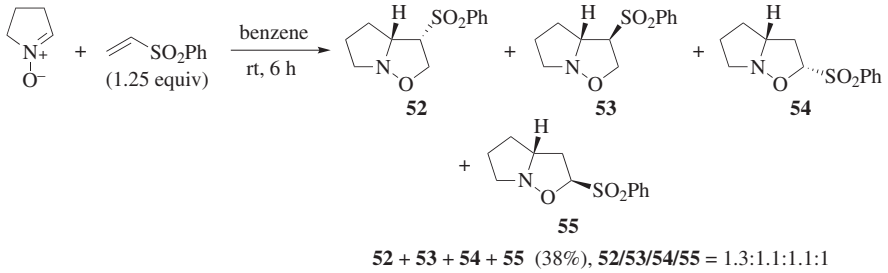
The Alkene Component. Simple unsubstituted cyclic nitrones and their substituted congeners have been subjected to cycloaddition with a large variety of alkene dipolarophiles, differing in terms of both the degree of substitution and the electronic nature of the substituents. With simple monosubstituted alkyl and aryl alkenes, the cycloaddition of pyrroline *N*-oxide or tetrahydropyridine *N*-oxide furnishes primarily the 5-substituted isoxazolidine (isoxazolidine numbering used throughout) derived from an *exo* addition (Scheme 37).[263–266] When very strong electron-withdrawing substituents (nitro, sulfonyl, acyl) are present on the alkene, 4-substituted isoxazolidines are also obtained; in these cases, the stereoselectivity is also diminished, as illustrated by the formation of both *exo* (**53** and **55**) and *endo* (**52** and **54**) adducts (Scheme 38).[267] A considerable variation in the temperature required for the cycloaddition to occur is observed depending on the nature of the substituents. Non-activated alkenes require heating, usually at ca. 100°, whereas activated alkenes cycloadd at room temperature. The *exo/endo* diastereoselectivity can also be modulated by using chiral auxiliaries on the dipolarophiles (e.g., in acrylic esters).[268,269]



$n = 1, 2$

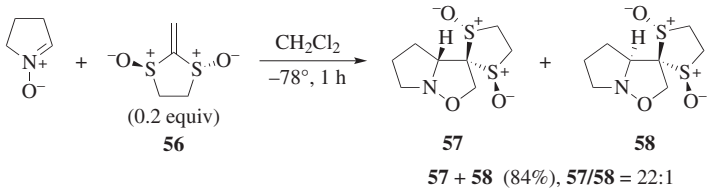
Scheme 37

1,1-Disubstituted alkenes generate only the 5,5-disubstituted isoxazolidines unless both substituents are strongly electron-withdrawing, as in the case of

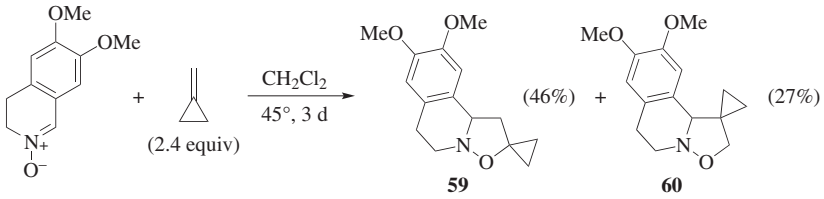


Scheme 38

bis-sulfoxide **56**, which affords exclusively the 4,4-disubstituted isomers **57** and **58** (Scheme 39).[270] Particularly strained alkenes (e.g., methylenecyclopropane) usually produce mixtures of the 4,4- and 5,5-disubstituted isoxazolidines, as illustrated in Scheme 40, where constitutional isomers **59** and **60** are both formed.[61,271–274]

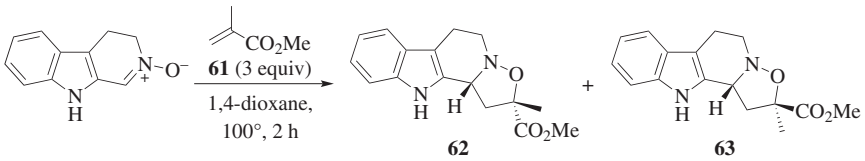


Scheme 39



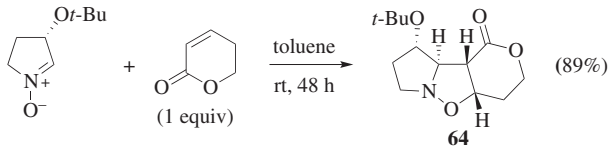
Scheme 40

With unsymmetrical 1,1-disubstituted alkenes, the issue of stereoselectivity arises and both 5,5-disubstituted isoxazolidine diastereoisomers are usually obtained.[275] When the two alkene substituents have different electronic properties, as in acrylate **61**, high diastereoselectivity is often observed, favoring the isomer in which the electron-withdrawing group occupies the *endo* position. In the [3 + 2] cycloaddition using acrylate **61**, products **62** and **63** are formed as a mixture, with the former cycloadduct predominating (Scheme 41).[59]

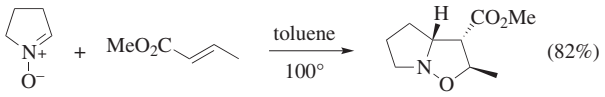


Scheme 41

1,2-Disubstituted alkenes are prone to afford mixtures of constitutional isomers. However, the vast majority of examples involve 1,2-disubstituted alkenes containing groups with opposite electronic properties. In such cases, the electron-withdrawing group (formyl, acyl, sulfenyl, sulfonyl, cyano, nitro, phosphonyl, or phosphonate) shows a high preference to be at C(4) of the isoxazolidine ring (Schemes 42 and 43). *Cis*-configured alkenes, including endocyclic systems, afford *exo*-adducts like compound **64** as the major stereoisomers.[276] A large majority of the acyclic alkenes employed are *trans*-alkenes, and in these cases, the electron-withdrawing group resides preferentially in an *endo* position in the product, and sometimes no other adducts are isolated.[277]

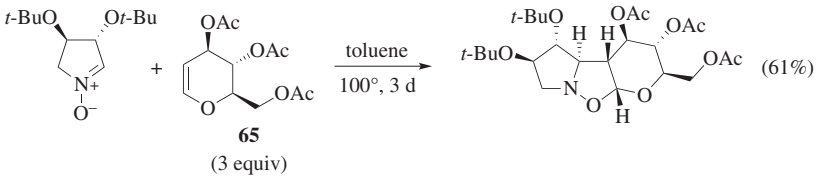


Scheme 42



Scheme 43

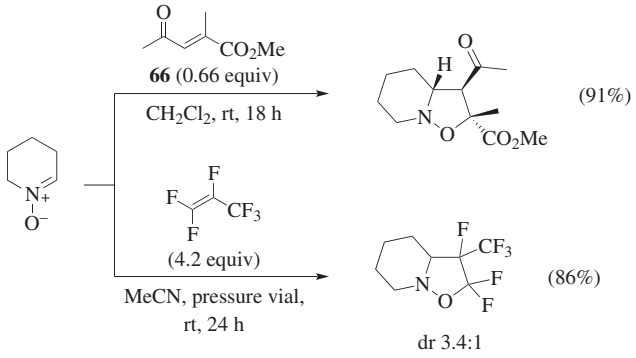
With alkenes bearing two electron-donating substituents, the strongest donor takes up the C(5) position, as is the case with dihydrofurans and dihydropyrans[278,279] or with glycals such as **65** (Scheme 44).[280,281]



Scheme 44

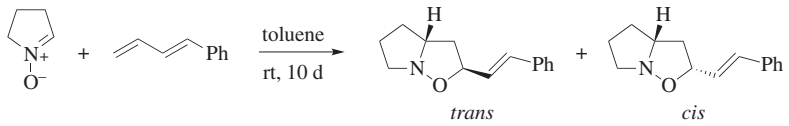
Fewer examples of cycloaddition reactions have been reported using tri- and tetrasubstituted acyclic alkenes. Here again, the tendency to place the largest

number of substituents (for trisubstituted alkenes such as substrate **66**) and the strongest electron-donating substituent at C(5) of the isoxazolidine ring is observed (Scheme 45).[282,283] Nitrone cycloadditions with tri- and tetrasubstituted cyclic alkenes, in which the double bond is exo- or endocyclic, have been studied to a larger extent. The presence of one or more electron-withdrawing groups controls the regioselectivity of the cycloaddition to afford the isoxazolidine product with the electron-withdrawing group at the 4-position.[284–286]



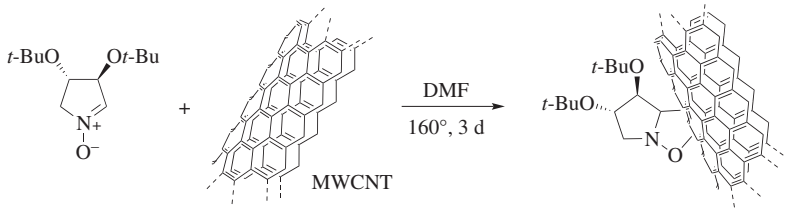
Scheme 45

Dienes usually react at the less-substituted double bond with high selectivity, as illustrated in Scheme 46.[287,288]



Scheme 46

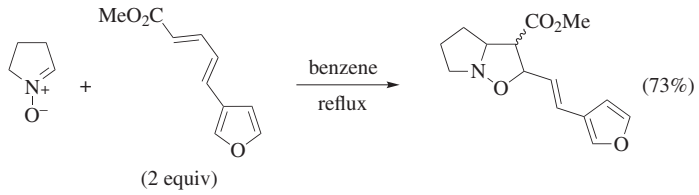
Special types of fully substituted, conjugated carbon–carbon double bonds, such as those present in multi-walled carbon nanotubes (MWCNT), have been successfully employed in cycloadditions with chiral cyclic nitrones, affording MWCNTs with a degree of functionalization that is 10% by weight (Scheme 47).[56,289]



MWCNT = multi-walled carbon nanotube

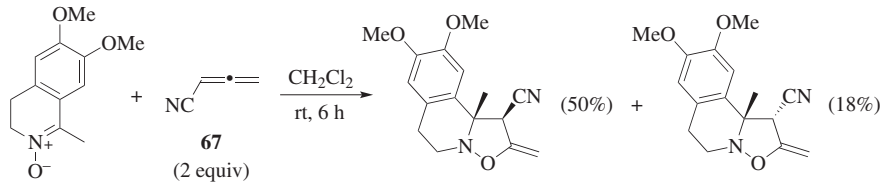
Scheme 47

If an activating, electron-withdrawing group is linked to the diene moiety, that substituent controls both site- and regioselectivity, with the electron-withdrawing group positioned at C(4) of the isoxazolidine, as in the example shown in Scheme 48, in which a mixture of diastereoisomers is formed.[290,291]



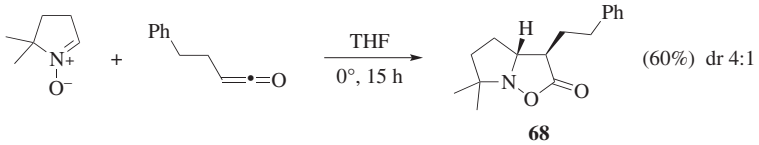
Scheme 48

This behavior is also observed in the case of electron-deficient allenes such as substrate **67** (Scheme 49).[292,293]



Scheme 49

The carbon–carbon double bond of ketenes has rarely been involved in [3 + 2] cycloadditions with nitrones. In the few successful cases of dipolar cycloadditions, the ketene invariably furnishes isoxazolidin-5-ones (e.g., **68**) regardless of the degree and type of substitution (Scheme 50).[294,295]

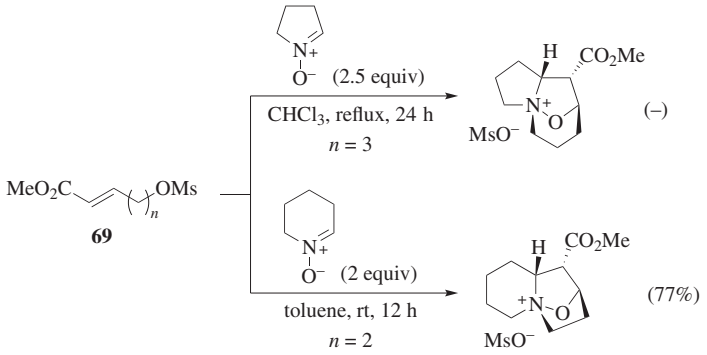


68

Scheme 50

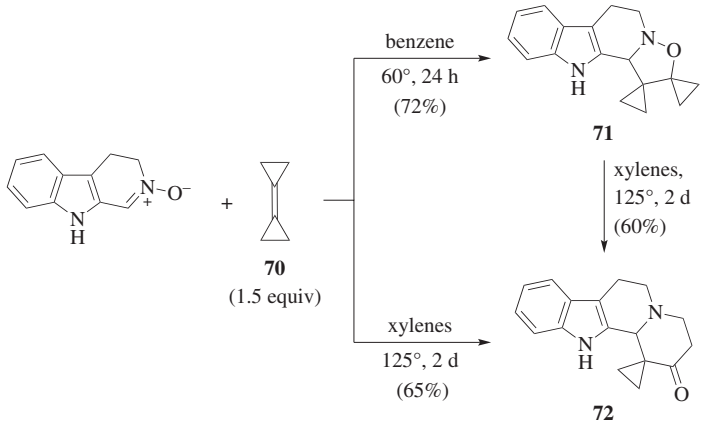
Certain types of dipolarophiles generate non-isoxazolidine products, which result from further transformations of the primary cycloadducts. For example, reactions of five- or six-membered cyclic nitrones with alkenes **69**, which bear a leaving group,

furnish an additional five- or six-membered ring by cyclization at nitrogen to provide the corresponding isoxazolidinium salts (Scheme 51).[296,297]



Scheme 51

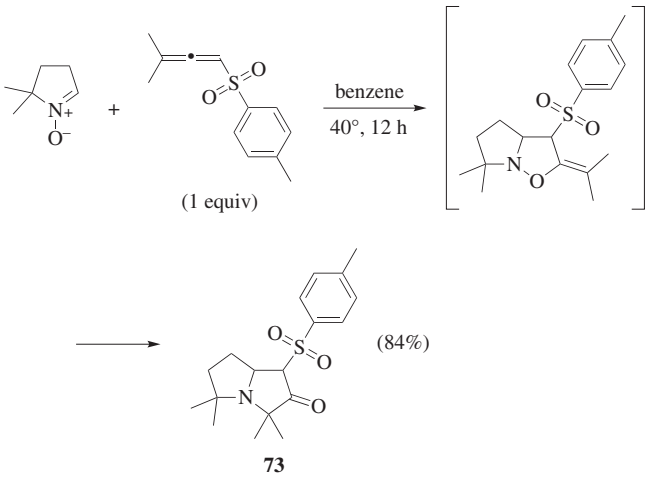
Cycloadditions with methylenecyclopropane and its derivatives afford cyclopropane-5-spiroisoxazolidines, which can rearrange thermally to generate the corresponding 4-pyridones. The latter products can also be obtained directly from the cycloaddition partners upon heating at higher temperature. For example, bicyclopropylidene (**70**) undergoes cycloaddition to form spiroisoxazolidine **71**, and further heating generates piperidone **72** (Scheme 52).[298]



Scheme 52

Similar behavior is seen in the cycloadditions of nitrones with allenes, in which the primary 5-alkylidene isoxazolidines undergo a thermal rearrangement with nitrogen–oxygen cleavage and re-closure to afford 3-pyrrolizidinone **73** (Scheme 53).[293] In some cases, this transformation occurs directly under the

cycloaddition conditions, depending on the structure of both the starting nitrone and the allene. In other cases, a simple isomerization (1,3-hydrogen shift) of the initially formed 5-*exo*-methylene isoxazolidine affords the Δ^4-isoxazoline.[292,293]

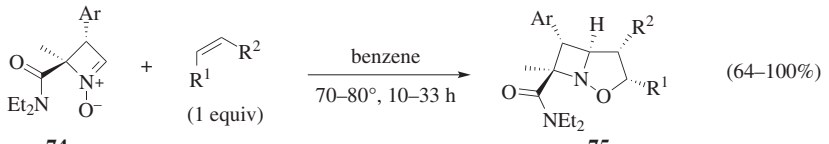


73

Scheme 53

The Nitrone Component.

FOUR-MEMBERED CYCLIC NITRONES. The cycloadditions of 3-aryl-substituted azetine 1-oxides **74** with alkenes bearing electron-withdrawing groups has been described in a single report (Scheme 54).[299] The alkene can be cyclic, acyclic, monosubstituted, or *cis*-disubstituted. The reactions are performed in benzene at 60–80° and furnish exclusively the *exo* adducts **75** in high yields and, in the case of monosubstituted alkenes, with complete regioselectivity for the 5-substituted isoxazolidine.



74 **75**

$R^1 = R^2 = EtO_2C$
$R^1 = R^2 = –CON(Ph)CO–$
$R^1 = MeO_2C$; $R^2 = H$
$R^1 = MeCO$; $R^2 = H$

Scheme 54

FIVE-MEMBERED CYCLIC NITRONES. One of the most important advances has been the synthesis of enantiomerically pure isoxazolidines by the use of either

enantiomerically pure alkenes or nitrones. Particular attention has been devoted to the use of mono- and polyhydroxylated nitrones derived from readily available precursors from the chiral pool (e.g., malic and tartaric acids, hydroxyproline, carbohydrates, etc.) as outlined in Figure 5. These nitrones have been employed extensively for the synthesis of natural iminosugar-type alkaloids and congeners (see examples in "Applications to Synthesis") by exploiting the high stereoselectivity displayed in the key cycloaddition step.[70,72,124,273,300–305]

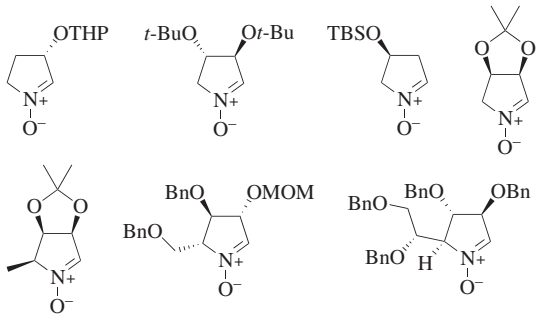
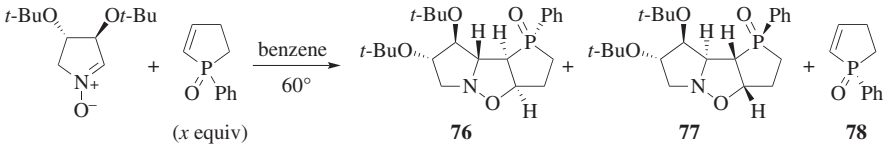


Figure 5. Examples of polyhydroxylated enantiopure 5-membered cyclic nitrones derived from the chiral pool.

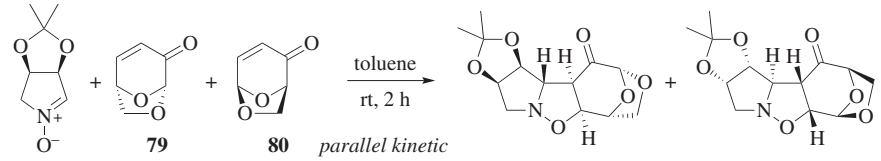
A combination of a chiral nitrone and a chiral dipolarophile results in the potential for double asymmetric induction resulting from matched and mismatched pairs of reagents. High stereodifferentiation is usually observed, mainly attributed to steric repulsions arising from the rigid structure of the cyclic nitrones. Consequently, kinetic resolution of either racemic nitrones[281,306] or alkenes[276,307–309] can be achieved by cycloaddition with the appropriate enantiopure partner. The enantiomeric purity of the resolved starting material ranges from moderate to high, depending on the conversion of the cycloaddition reaction. For example, the reaction shown in Scheme 55 produces cycloadducts **76** and **77** in addition to enantioenriched phosphine oxide **78**.[307]



		Yield (%)			
x	Time (h)	**76** + **77**	**76**/**77**	**78** Yield (%)	er **78**
1.5	38	91	2.9:1	27	98.0:2.0
1.8	8	67	6.4:1	39	74.5:25.5

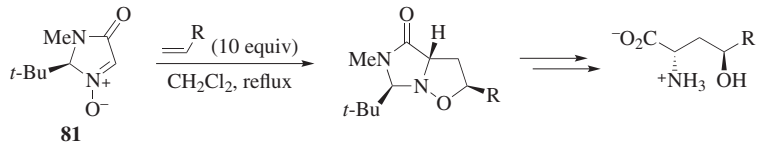
Scheme 55

If kinetic resolutions produce low selectivities, the racemic substrate (either nitrone or dipolarophile) can be used to access specific synthetic targets by means of a "Parallel Kinetic Resolution" (PKR). This strategy requires the appropriate choice of a quasi-enantiomeric pair of reagents (constitutionally different—but closely related—chemical species having opposite chirality)[310] that display similar rates and complementary selectivities in the cycloaddition reaction with each enantiomer of the racemate. PKR is illustrated in Scheme 56 for the cycloaddition of a racemic dioxygenated nitrone with quasi-enantiomers levoglucosenone (**79**) and isolevoglucosenone (**80**).[281,311,312]



Scheme 56

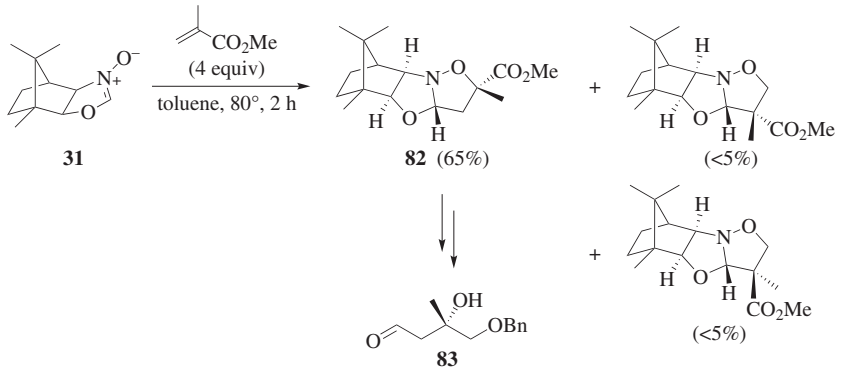
Several five-membered cyclic nitrones containing an additional heteroatom within the ring have also been synthesized and employed in cycloaddition reactions. In particular, chiral nitrones possessing a nitrogen or oxygen atom are significant for certain synthetic purposes; the resulting products can be easily elaborated by hydrolysis, which involves removal of the chiral portion which had imparted high stereoselectivity in the cycloaddition. One representative application consists of the synthesis of enantiomerically pure amino acids and derivatives by the use of chiral 3-oxazolinone-[231,313,314] and 3-imidazolone-[24,315–317] derived nitrones such as substrate **81** (Scheme 57).[315] The (*E*)-configuration of the cyclic nitrones ensures much higher sterocontrol in the cycloaddition compared to the acyclic counterparts which are subject to facile (*Z*)/(*E*) equilibration.



R	Time (h)	Yield (%)	dr
Ph	6	89	10:1
4-(*t*-Bu)C_6H_4	5	95	>20:1
c-Hex	52	86	10:1

Scheme 57

Other relevant examples involve the use of chiral 3-oxazoline *N*-oxides, especially those derived from camphor. Compound **31** affords adduct **82** with >19:1 regioselectivity and diastereoselectivity; this transformation has been applied to the synthesis of enantiomerically pure aldol-type products such as aldehyde **83** (Scheme 58).[165,318]



Scheme 58

Additional examples of cycloaddition with heteroaromatic *N*-oxides have been reported.[244,245,319,320]

SIX-MEMBERED CYCLIC NITRONES. Intense effort has been devoted to the synthesis of enantiomerically pure six-membered cyclic nitrones over the past 10–20 years, either by enantioselective synthesis[69] or by employing derivatives from the chiral pool as starting materials.[176,177,182,221,321] Some examples of mono- or polyhydroxylated nitrone derivatives are shown in Figure 6.[69,176,177,182,321,322] Compared to the corresponding pyrroline *N*-oxides, these nitrones have reduced thermal stability, which often requires generation in situ in the presence of the dipolarophile for direct trapping.

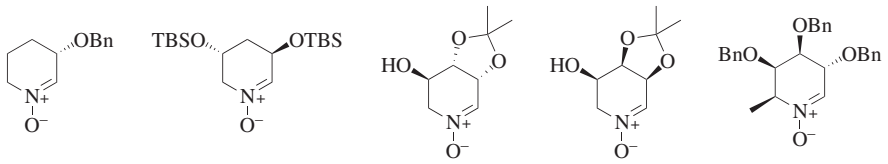
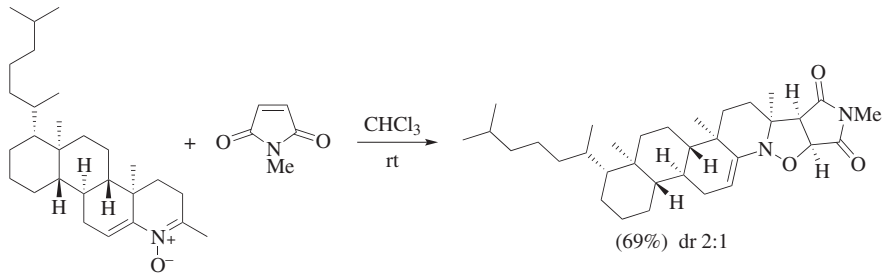


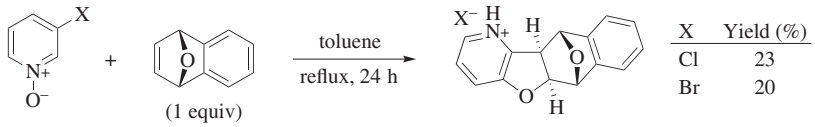
Figure 6. Examples of polyhydroxylated enantiopure six-membered cyclic nitrones derived from the chiral pool.

A few notable examples of steroid-type nitrones have been reported, and these systems react with activated alkenes, such as maleimides, to afford fused hexacyclic cycloadducts (Scheme 59).[323−325]



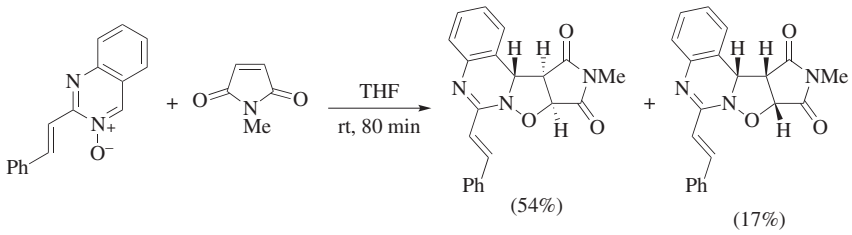
Scheme 59

Some examples of cycloadditions involving pyridine *N*-oxides have been documented (Scheme 60).[326] In these cases, the intermediate isoxazolidines are not isolated, but rather undergo 1,5-sigmatropic rearrangement and aromatization by dehydrohalogenation.

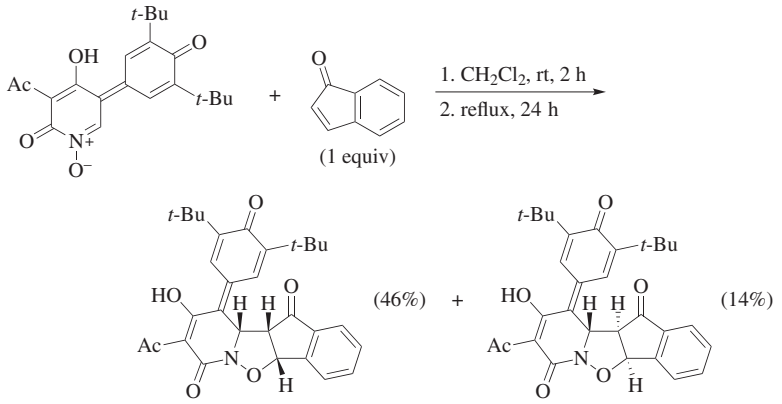


Scheme 60

Cycloaddition with other heteroaromatic *N*-oxides[245,327,328] or their quinoid congeners[329,330] have been documented (Schemes 61 and 62).

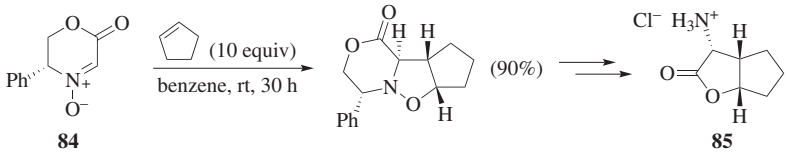


Scheme 61



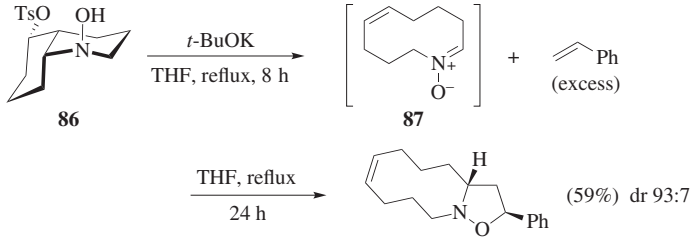
Scheme 62

Six-membered cyclic nitrones derived from condensation of the hydroxylamine of phenylglycinol with methyl glyoxylate (e.g., substrate **84**) provide access to the synthesis of bicyclic amino acid derivatives such as product **85** (Scheme 63).[64,331–333]



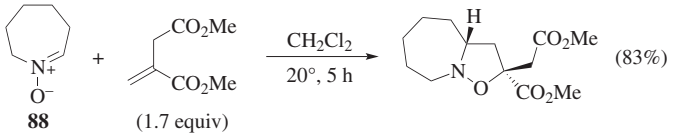
Scheme 63

n-MEMBERED CYCLIC NITRONES ($n > 6$). Many cycloadditions of seven- and eight-membered cyclic nitrones have been reported using a broad range of diversely substituted cyclic or acyclic dipolarophiles. However, very few examples involve nitrones with larger rings, such as nitrone **87**, which is generated by Grob-type fragmentation from bicyclic hydroxylamine **86** (Scheme 64).[229]

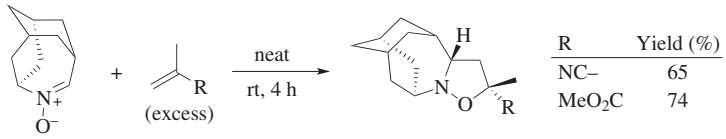


Scheme 64

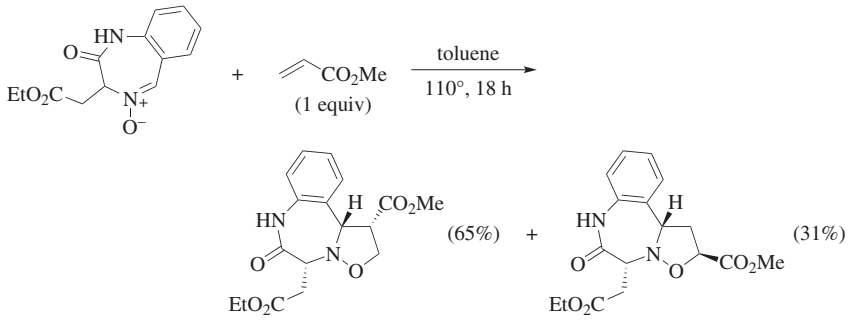
The scope of the seven- and eight-membered cyclic nitrone cycloadditions is very broad, as illustrated by the reactions shown in Schemes 65–67. The range of nitrone substrates includes both simple ones such as azepine-[275] and azocine *N*-oxides (i.e., **88** and **89**, respectively)[334] and more complex polycyclic structures[187,335–337] that often contain additional nitrogen or oxygen atoms (Figure 7).[338,339]



Scheme 65



Scheme 66



Scheme 67

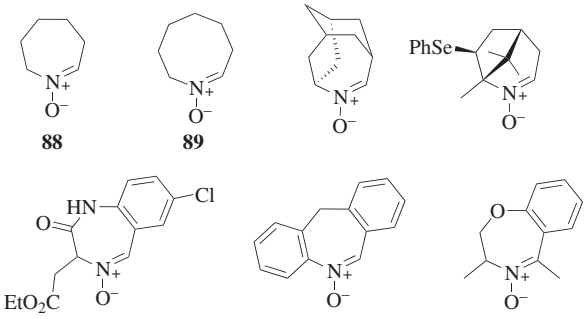
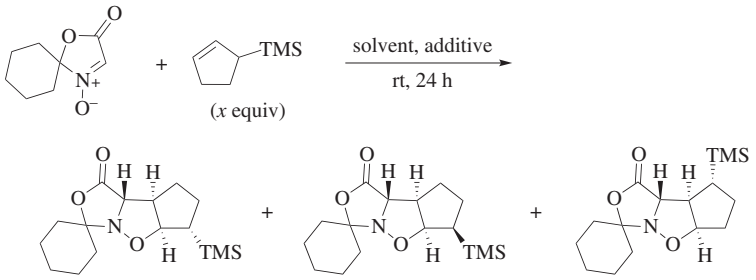


Figure 7. Examples of seven- and eight-membered cyclic nitrones used in cycloaddition reactions.

Catalyzed Cycloadditions. Many Lewis acid- and metal-catalyzed nitrone cycloadditions have been reported in recent years, especially with the goal of producing isoxazolidines enantioselectively.[80,81,340,341] Most examples employ acyclic nitrones in this process, likely because the nitrone oxygen in acyclic nitrones is much less Lewis basic than that in cyclic systems, particularly in *N*-aryl substituted nitrones.

One of the earliest examples of a Lewis acid catalyzed dipolar cycloaddition employs a heterocyclic nitrone and either 3-(trimethylsilyl)cyclopent-1-ene or allyltrimethylsilane. One equivalent of boron trifluoride is necessary to promote the cycloaddition, which occurs with complete regio- and stereocontrol and forms adduct **90** exclusively.[313,342] Without the additive, the reaction proceeds only at high pressure and also forms diastereoisomer **91** and constitutional isomer **92** (Scheme 68).[314]



90 **91** **92**

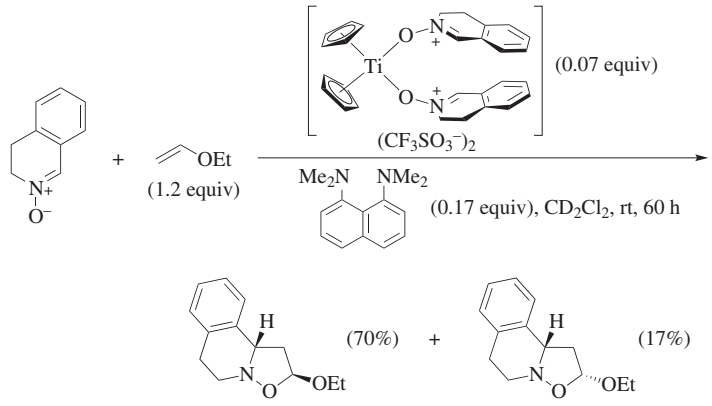
				Yield (%)		
x	Solvent	Additive	Pressure	**90**	**91**	**92**
1.2	MeCN	BF_3•Et_2O	1 atm	96	—	—
5	CH_2Cl_2	—	8 kbar	70	13	13

Scheme 68

It is suggested that boron trifluoride is coordinated with the oxygen of the nitrone in the transition state, inducing a preferential approach of the nitrone to the less hindered face of the allyl silane. When a related enantiopure nitrone is mixed with 3-(trimethylsilyl)cyclopent-1-ene, only one enantiomer of the racemic silane reacts, and thus a kinetic resolution of the dipolarophile occurs.[313]

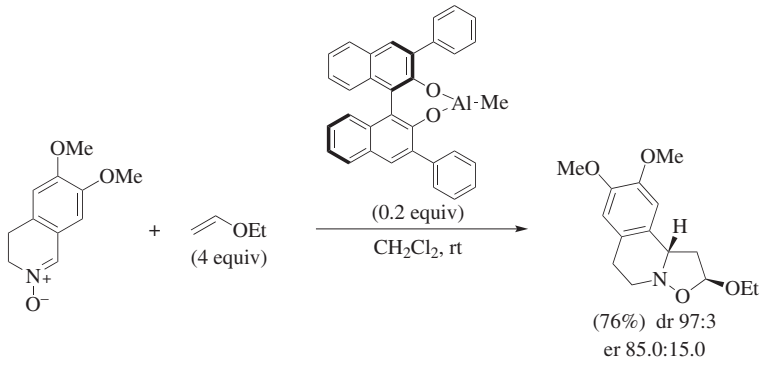
Chiral oxazaborolidines catalyze the otherwise sluggish reaction of cyclic nitrones with ethyl vinyl ether and 2,3-dihydrofuran at room temperature, affording good yields of cycloadducts, but poor enantioselectivities.[278]

The *exo/endo* diastereoselectivity can be also modulated by using catalysts. Various titanium(IV) species accelerate the cycloaddition of pyrroline *N*-oxide (as well as of acyclic nitrones) with vinyl ethers.[343] Similarly, $Cp_2Ti(OTf)_2$ has been used to catalyze the cycloaddition of dihydroisoquinoline *N*-oxide with ethyl vinyl ether.[344] In this case, a bis(nitrone) adduct with titanium ($[Cp_2Ti(nitrone)_2](OTf)_2$, prepared by addition of the nitrone to a solution of $Cp_2Ti(OTf)_2$ in THF), is used as the catalyst (Scheme 69).

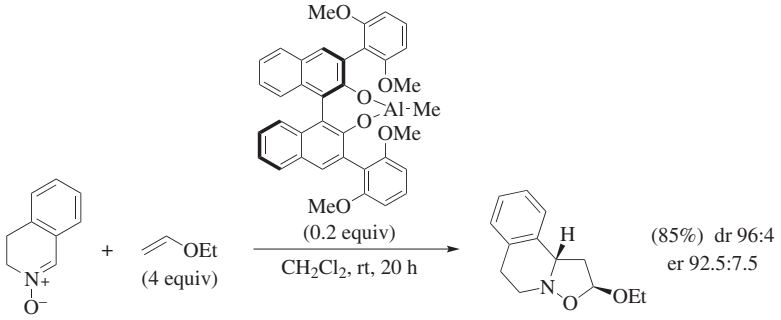


Scheme 69

The catalytic effect of aluminum chloride and trimethylaluminum in the cycloaddition of 3,4-dihydroisoquinoline *N*-oxide with vinyl ethers prompted a study of the asymmetric cycloaddition using various BINOL/AlMe (BINOL = 1,1′-bi-2-naphthol) or BINOL/AlX complexes.[260] The cycloadditions take place in good to excellent yields, providing mainly *exo* products and good enantiomeric purities (Schemes 70 and 71).

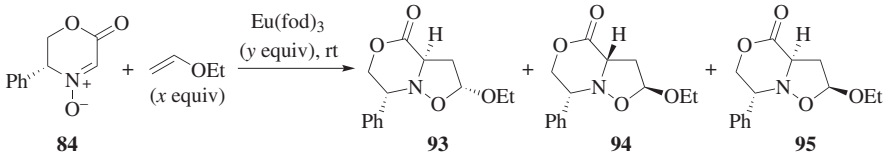


Scheme 70



Scheme 71

The cycloaddition of heterocyclic nitrone **84** with ethyl vinyl ether results in a mixture of cycloadducts **93–95** (Scheme 72). In the uncatalyzed thermal reaction, *exo-anti* isomer **93** is the major product, but in the presence of $Eu(fod)_3$ *exo-syn* isomer **94** dominates the reaction mixture. This result is explained by coordination of $Eu(fod)_3$ with the oxygen atom of the nitrone that hinders the *anti* face of the nitrone, allowing the ethyl vinyl ether to approach preferentially from the *syn* face.[64,345]



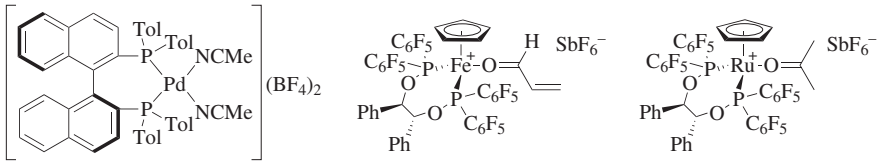
84 **93** **94** **95**

fod = (3*Z*)-6,6,7,7,8,8,8-heptafluoro-2,2-dimethyl-5-oxo-3-octen-3-olate

				Yield (%)		
x	*y*	Solvent	Time (h)	**93–95**	**93/(94 + 95)**	**93/94/95**
10	0	—	16	87	83:17	—
2.9	1	benzene	15	88	13:87	13:48:39

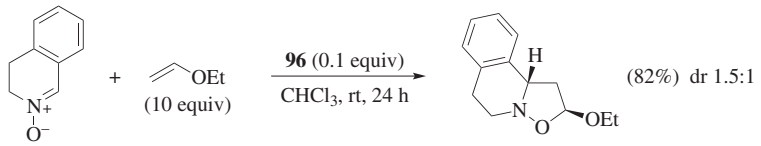
Scheme 72

Studies of transition-metal-catalyzed reactions have mainly employed acyclic nitrones, but a few examples with cyclic nitrones have been reported. For example, the cycloaddition of dihydroisoquinoline *N*-oxide with ethyl vinyl ether in the presence of enantiopure (*S*)-BINAP$(MeCN)_2$Pd(II) complex **96** (BINAP = (1,1′-binaphthalene-2,2′-diyl)bis(diphenylphosphine)) (Figure 8) at room temperature affords a 1.5:1 mixture of *exo*/*endo* cycloadducts in 82% yield (Scheme 73), but in racemic form.[346]



96 **97** **98**

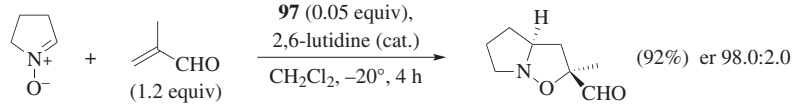
Figure 8. Examples of palladium-, iron-, and rethenium-based catalysts used in cycloaddtion reactions.



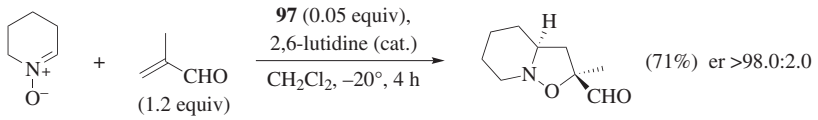
Scheme 73

Chiral iron and ruthenium cyclopentadienyl complexes **97** and **98** have been used to catalyze cycloadditions of α,β-unsaturated aldehydes such as methacrolein with

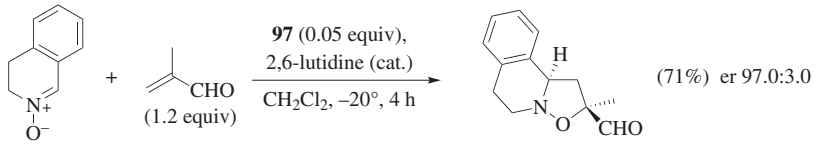
cyclic nitrones in excellent yields and enantioselectivities (Schemes 74–76). The iron catalyst shows a superior level of enantiodiscrimination and higher activity.[82] The X-ray structure of the ruthenium catalyst–methacrolein complex shows that the enal adopts an *s-trans* conformation, which explains the absolute configuration of the isoxazolidines formed via an *endo* approach of the nitrone to the coordinated dipolarophile.



Scheme 74



Scheme 75



Scheme 76

Rhodium complexes **99** and **100** and iridium complexes **101** and **102** (Figure 9) have been employed in cycloadditions of cyclic nitrones with methacrolein with complete *endo* selectivity and with enantiomeric ratios up to 93.0:7.0 (Scheme 77).[259] Thus, 3,4-dihydroisoquinoline *N*-oxide reacts with enals with excellent regioselectivity, total *endo* selectivity, and with enantiomeric ratios up to 87.0:13.0 (Scheme 78).[347]

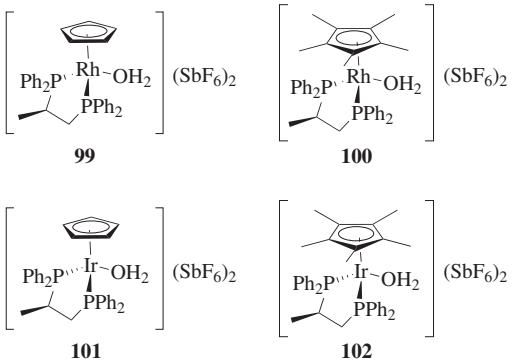
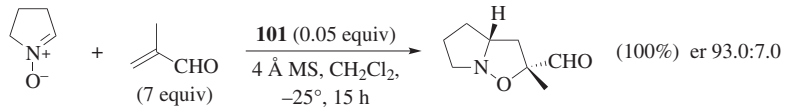
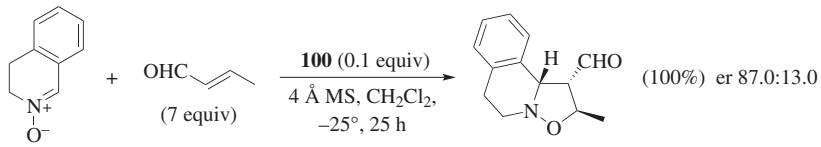


Figure 9. Examples of rhodium- and iridium-based catalysts used in cycloaddtion reactions.

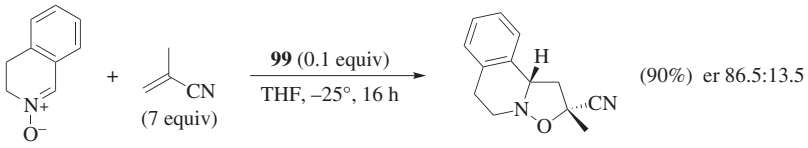
Similarly, 3,4-dihydroisoquinoline *N*-oxide reacts with methacrylonitrile with excellent regioselectivity and *endo* selectivity and with enantiomeric ratios up to 86.5:13.5 (Scheme 79).[261]



Scheme 77



Scheme 78



Scheme 79

Chiral half-sandwich ruthenium complexes **103–106** (Figure 10) have also been employed in cycloadditions of cyclic nitrones with methacrolein, affording quantitative yields of adducts with complete *endo* selectivity and moderate enantioselectivity (Scheme 80).[348]

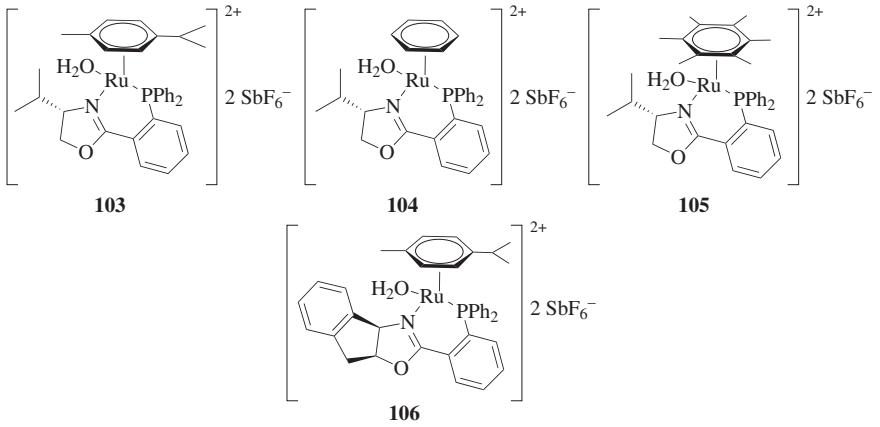
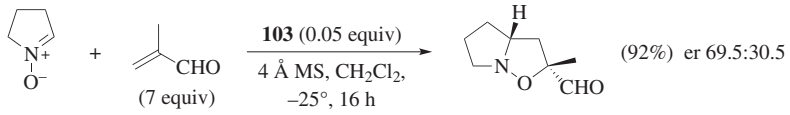
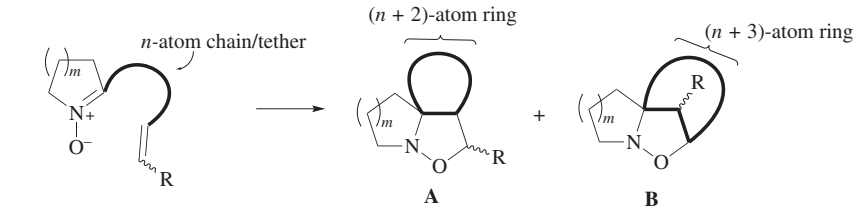


Figure 10. Examples of chiral half-sandwich ruthenium complexes used in cycloaddition reactions.



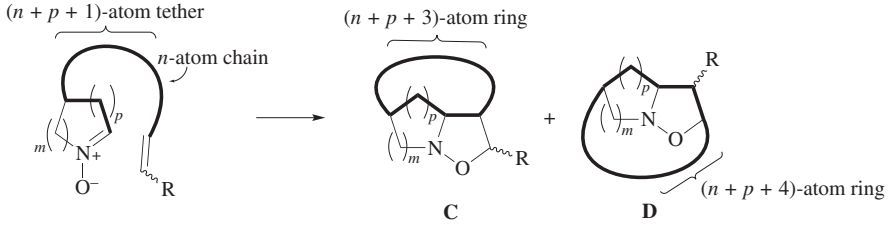
Scheme 80

Intramolecular Cycloadditions. Intramolecular [3 + 2] dipolar cycloadditions of endocyclic nitrones with alkenes provide complex tricyclic isoxazolidines, usually with high regio- and stereoselectivities. The length, structure, and flexibility of the tether (depicted in bold in Figure 11) between the dipolarophile and the C(2) carbon of the cyclic nitrone impact the reactivity of alkenyl nitrones as well as the constitution and configuration of the adducts.



5-membered nitrone
Type **Ia** *m* = 1

6-membered nitrone
Type **Ib** *m* = 2



5-membered nitrone
Type **IIa** *p = 0, m* = 2
Type **IIIa** *p = 1, m* = 1
Type **IVa** *p = 2, m* = 0

6-membered nitrone
Type **IIb** *p = 0, m* = 3
Type **IIIb** *p = 1, m* = 2
Type **IVb** *p = 2, m* = 1
Type **Vb** *p = 3, m* = 0

Figure 11. Types of intramolecular 1,3-dipolar cycloadditions of five-membered (Type **a**) and six-membered (Type **b**) cyclic nitrones with tethered alkenes (the tether in the substrates is depicted in bold, as is the newly formed ring that contains the tether in the adducts; *Tether Length*: number of all the atoms between the cyclic nitrone C(2) and the dipolarophile).

The intramolecular cycloadditions of five- and six-membered ring nitrones are the most thoroughly studied and can be classified according to the attachment point of the free chain of the tether, which can be at the nitrone carbon [C(2)] (Type **I**, Figure 11) or at another ring atom (Types **II–V**, Figure 11). To date, intramolecular cycloadditions of cyclic nitrones have been explored less than the corresponding intermolecular reactions, and the full scope of this valuable process has yet to be established. In most cases, the nitrone substrates are not isolated, but instead are generated or liberated in situ and directly subjected to thermal cycloaddition with a pendant alkene.

A convenient classification of the tricyclic isoxazolidines **A–D** is based on the size of the ring containing the tether (depicted in bold in Figure 11), which is different for the constitutionally isomeric adducts of a specific substrate. However, the size of the ring containing the tether is the same for the constitutionally isomeric adducts that result when cyclic nitrones with identical ring sizes and tether lengths are employed (Figure 12).

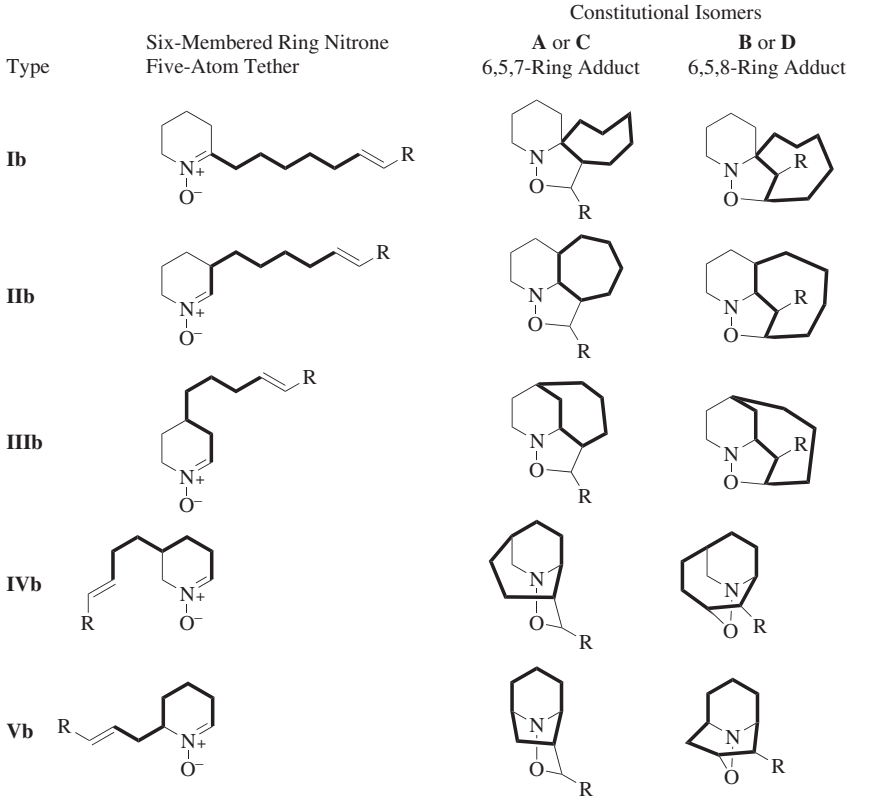


Figure 12. Examples of classification of constitutionally isomeric cycloadducts according to the size of the nitrone ring (six in the examples), the isoxazolidine ring (five) and the ring containing the tether (seven and eight, show in bold).

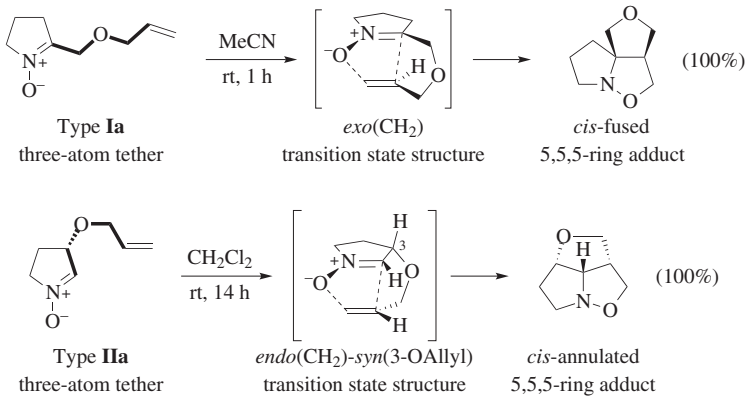
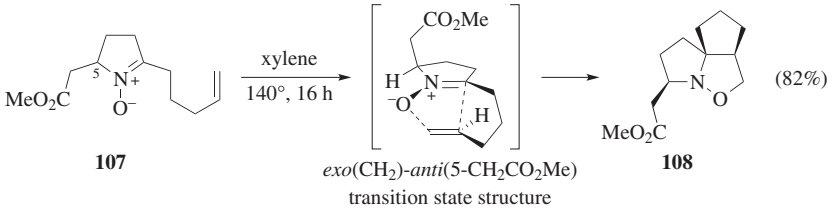


Figure 13. Examples of Type **Ia** and **IIa** intramolecular 1,3-dipolar cycloadditions of 5-membered cyclic nitrones with a three-atom tethered alkene (tether shown in bold).

Five-Membered Cyclic Nitrones.

THREE-ATOM TETHER. 2-(4-Alkenyl)- and 3-(3-alkenyl)-pyrroline *N*-oxide cycloadditions (Types **Ia** and **IIa**, Figure 11) afford tricyclic 5,5,5-ring adducts (isomers **A** and **C**, respectively, Figure 11) with complete regioselectivity that is opposite to that of the intermolecular cycloadditions of terminal alkenes (Figure 13 and Scheme 13).[67,349] In both cases, the intramolecular process provides exclusively *cis*-fused and *cis*-annulated adducts through an *exo* and an *endo*(tether) approach, respectively.

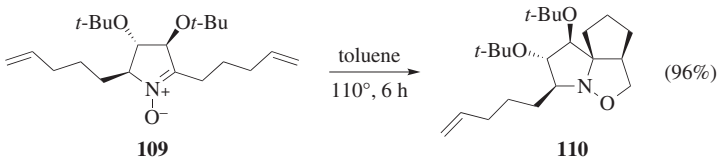
Aliphatic tethers as well as tethers containing an ether, ester, or amide moiety have been used in these systems. Cycloadditions of mono- and 1,2-disubstituted olefins afford the corresponding adducts in good to high yields. A high *anti* facial stereoselectivity is observed in Type **Ia** additions of five-membered cyclic nitrones substituted at the C(5) position. For example, nitrone **107** affords exclusively the tricyclic adduct **108** (Scheme 81). [201,350–352]



Scheme 81

Analogous to bimolecular cycloadditions, *trans*-3,4-disubstituted and *trans*,*trans*-3,4,5-trisubstituted 2-(4-alkenyl)pyrroline *N*-oxides undergo cycloadditions exclusively through an *anti* addition of the alkene with respect to the C(3) [and C(5)]

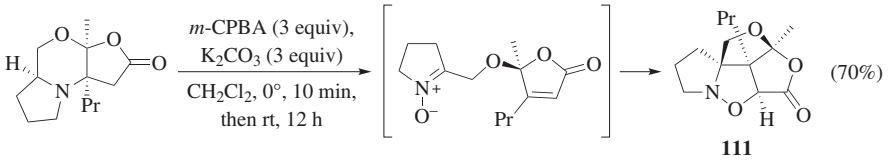
substituent as demonstrated by the conversion of nitrone **109** into tricyclic isoxazolidine **110** (Scheme 82).[77] The chemoselective formation of **110** demonstrates that the reaction rate of intramolecular cycloadditions is higher for alkenyl nitrones featuring a **Ia** three-atom tether than for those with a **IVa** six-atom tether (see "Five- and Six-Atom Tethers" and Figure 11).



109 **110**

Scheme 82

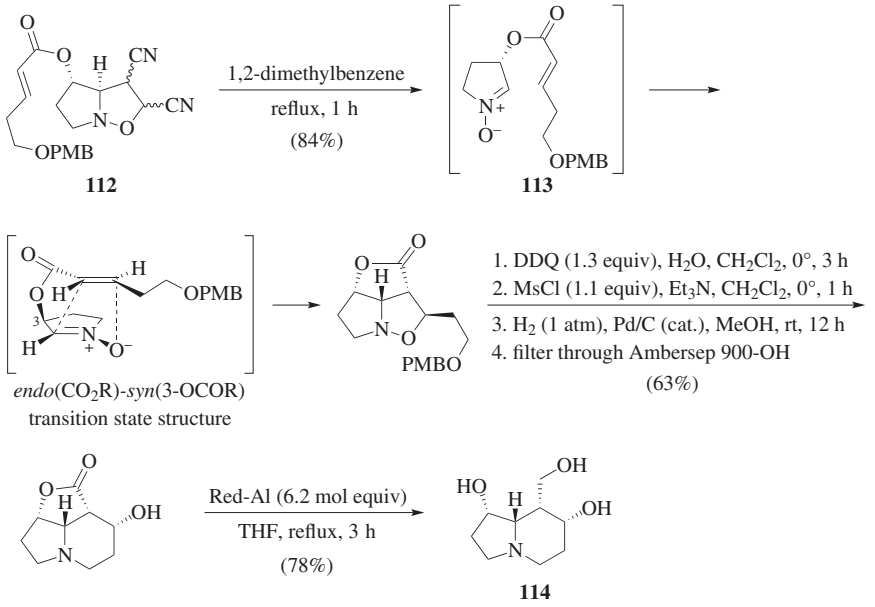
Various tetracyclic derivatives, such as **111**, can be prepared by an intramolecular cycloaddition of enantiomerically pure 2-{[(*S*)-5-oxo-2,5-dihydrofuran-2-yloxy]methyl}pyrroline *N*-oxide, which is generated in situ through a Cope elimination of hexahydro-5*H*-furo[2,3-b]pyrrolo[1,2-*d*][1,4]oxazin-2(1*H*)-ones with *m*-CPBA under mildly basic conditions (Scheme 83).[353]



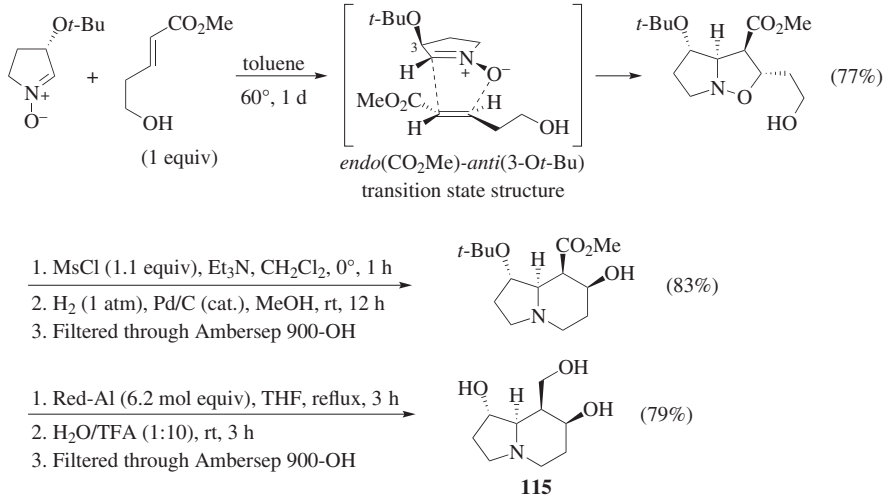
111

Scheme 83

The intramolecular cycloaddition of 3-hydroxypyrroline *N*-oxides acylated with α,β-unsaturated carboxylic acids (Type **IIa** cycloaddition, Figure 11) has proven to be particularly useful in the synthesis of natural products and their analogs (see examples in "Applications to Synthesis"). This intramolecular process, which occurs through a *syn*(3-OCOR) transition state (Scheme 84),[60] is complementary to the *anti*(3-OR) addition that occurs with an intermolecular cycloaddition (Scheme 85).[60] These two modes of cycloaddition allow access to different stereoisomers of the final product with total control of the relative configurations of the new stereocenters.[60,219,220,354−358] For example, the diastereomeric hydroxyindolizidines **114** and **115** are obtained with complete control of the relative and absolute configurations through intramolecular and intermolecular cycloaddition of suitable enantiopure 3-hydroxypyrroline *N*-oxides and 5-hydroxy-2-pentenoates, respectively, followed by similar elaborations of the cycloadducts (Schemes 84 and 85).[60] In the intramolecular process, alkenyl nitrone **113** is generated in situ by cycloreversion of adduct **112** (see also Schemes 32 and 33).



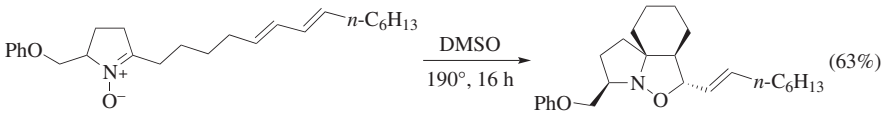
Scheme 84



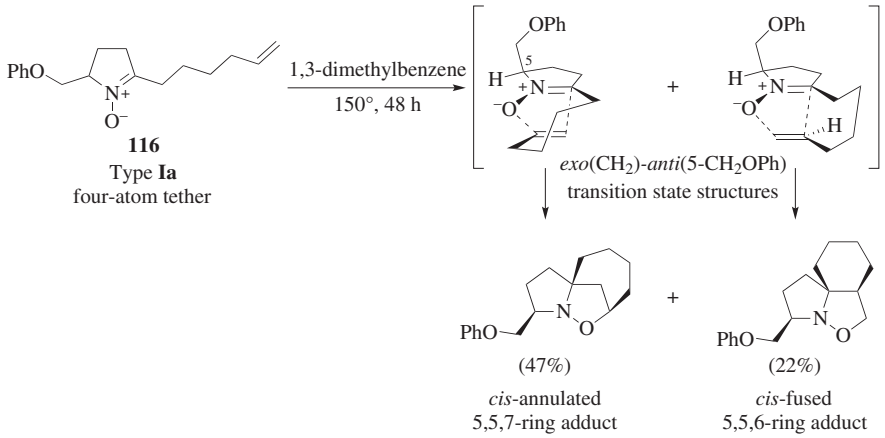
Scheme 85

FOUR-ATOM TETHER. 2-(5-Alkenyl)pyrroline *N*-oxides (Type **Ia**, Figure 11) undergo intramolecular cycloaddition at high temperature (80–195°). 1,2-Disubstituted dipolarophiles afford *cis*-fused 5,5,6-adducts (isomers **A**) with high regioselectivities (Figure 11 and Scheme 86), whereas terminal alkenes

produce mixtures of bridged and fused constitutional isomers (isomers **B** and **A**, respectively, Figure 11 and Scheme 87). The exclusive formation of *cis*-fused/*cis*-annulated adducts deriving from an *exo*(tether) transition state is observed in these cases. 5-Substituted pyrroline *N*-oxides such as **116** afford both bridged and fused adducts with complete selectivity for the *anti*(5-CH_2OPh) approach (Scheme 87).[153,350,359–361]



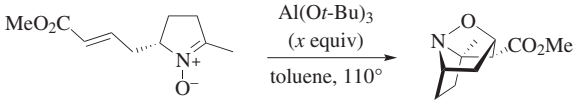
Scheme 86



Scheme 87

Only two examples of Type **IIa** additions have been reported. In both cases, the 3-(3-cyclopentenylpropyl)pyrroline *N*-oxide derivatives afford *cis*-annulated 5,5,6-ring adducts (isomer **C**, Figure 11).[362]

5-Allylpyrroline *N*-oxides undergo intramolecular cycloaddition (Type **IVa**) at 110–120° to afford 5,5,7-adducts (isomers **D**, Figure 11); this regioselectivity is analogous to that observed in the corresponding intermolecular addition.[248,249,363–365] For example, (*E*)-2-alkyl-5-(4-methoxy-4-oxobut-2-enyl) pyrroline *N*-oxide **117** undergoes a highly stereoselective intramolecular cycloaddition to afford tricyclic isoxazolidine **118**. The yield of the cycloadduct is improved by Al(O*t*-Bu)$_3$ catalysis (Scheme 88). In general, Lewis acids can also coordinate to the nitrone, but a bulky Lewis acid such as Al(O*t*-Bu)$_3$ preferentially activates the α,β-unsaturated ester group in the substrate. The tricyclic adducts were then converted into cocaine analogs.[129,366,367]

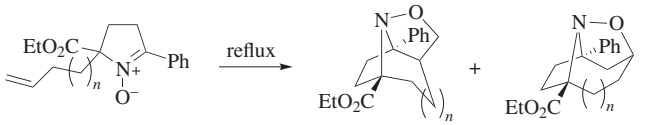


117 **118**

x	Time (h)	Yield (%)
—	24	20
—	48	50
0.1	24	25
0.5	72	70
1	72	40

Scheme 88

FIVE- AND SIX-ATOM TETHERS. Few examples of 5-(2-alkenyl)- and 5-(3-alkenyl)pyrroline *N*-oxide cycloadditions (Type **IVa**, Figure 11) have been reported. In the case of the shorter five-atom tether, the regioselectivity of the cycloaddition depends both on the substitution pattern of the dipole and dipolarophile moieties and on the reaction conditions. For example, nitrone **119** ($n = 1$) reacts to form a mixture of isomers **120** and **121** that is dependent on reaction temperature (Scheme 89). In contrast, 5-(3-alkenyl) nitrone **119** ($n = 2$), which possesses a six-atom tether, affords 5,5,9-ring adduct **121** ($n = 2$) (isomer **D**, Figure 11) with high regio- and diastereoselectivity (Scheme 89).[364] Elegant applications of type **IVa** intramolecular cycloadditions can also be found in the syntheses of the *Securinega* alkaloids (+)-virosaine A[368] and virosaine B.[369]



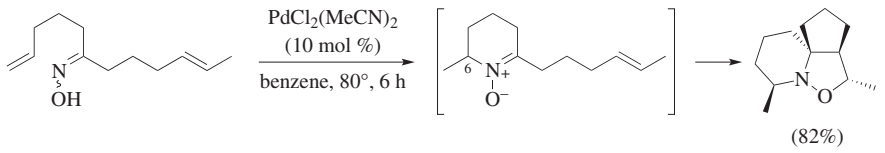
119 **120** **121**

			Yield (%)	
n	Solvent	Time (d)	**120**	**121**
1	toluene	2	84	5
1	xylene	2	65	28
2	toluene	3	—	77

Scheme 89

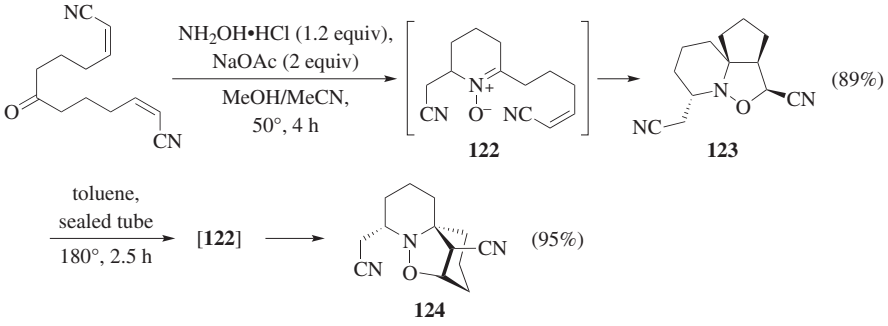
Six-Membered Cyclic Nitrones. The most numerous examples of intramolecular cycloadditions of six-membered cyclic nitrones involve substrates featuring a three-atom tether of Type **Ib** (Figure 11).

THREE-ATOM TETHER. Intramolecular cycloadditions of 2-(4-alkenyl) tetrahydropyridine *N*-oxides (Type **Ib**, Figure 11) featuring a terminal or a (*Z*)/(*E*)-alkyl disubstituted alkene afford tricyclic 6,5,5-ring *cis*-fused adducts (isomers **A**, Figure 11) with complete regio- and stereoselectivities (Scheme 90). Aliphatic chains, as well as linkers containing an ether, ester, or amide moiety, have been used as tethers. 6-Substituted nitrones afford exclusively products deriving from an *anti*(6-Me) approach, as shown in the example in Scheme 90.[370,371]



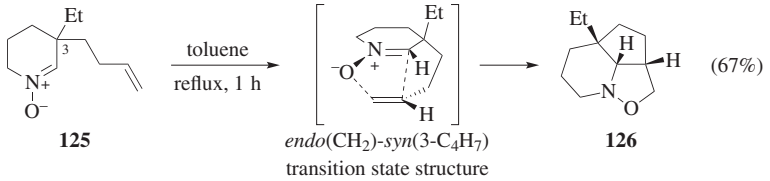
Scheme 90

If the dipolarophile is substituted with an electron-withdrawing group such as an ester or a cyano group, cycloreversion can occur, and the constitutionally isomeric 6,5,5- and 6,5,6-ring adducts (isomers **A** and **B**, Figure 11) can be obtained in different ratios depending on the reaction conditions. For example, the two isoxazolidines **123** and **124** are obtained with complete selectivity and in high yield under kinetic and thermodynamic control, respectively, via nitrone **122** (Scheme 91).[372,373] This process also operates in flow mode using a microreactor system.[373a] DFT calculations are in good agreement with the formation of a kinetic 6,5,5-ring adduct and a thermodynamic 6,5,6-ring adduct in the intramolecular cycloaddition of *C*-(cyanoalkenyl)nitrones.[373−376]



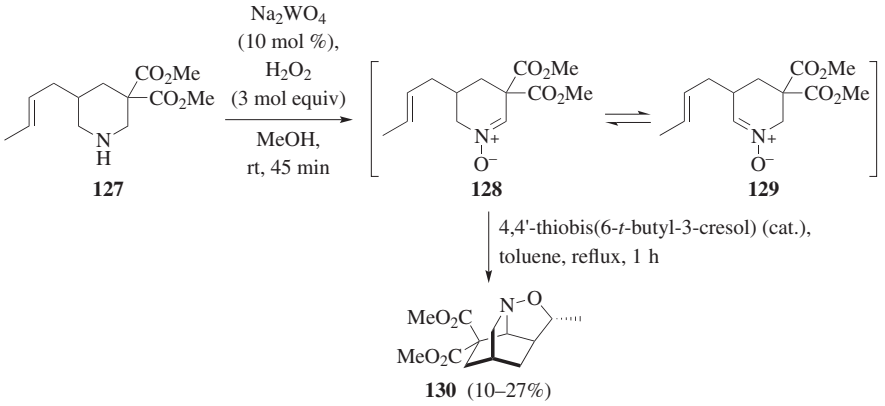
Scheme 91

The few reported intramolecular cycloadditions of 3-(but-3-enyl)tetrahydropyridine *N*-oxides (Type **IIb**, Figure 11) show a high preference for *syn-endo* approach with formation of the *cis*-6,5,5-adduct (isomer **C**, Figure 11). For example, nitrone **125** affords the tricyclic isoxazolidine **126** with complete regio- and diastereoselectivity (Scheme 92).[179,350,377,378]



Scheme 92

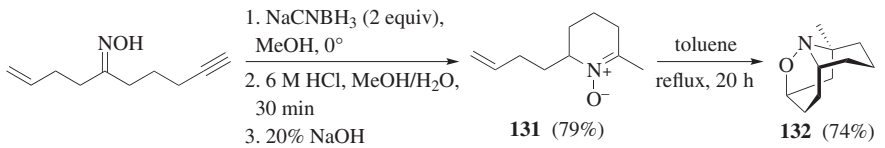
FOUR-ATOM TETHER. A few examples of intramolecular cycloadditions of alkenyl tetrahydropyridine *N*-oxides featuring four-atom tethers of Types **Ib**, **IIb**, **IIIb**, and **IVb** (Figure 11) have been reported.[350,377–383] **Type Ib** substrates (i.e., 2-(pent-4-enyl)tetrahydropyridine *N*-oxides) should afford mixtures of constitutionally isomeric isoxazolidines,[350] but in all other cases, only the 6,5,6-ring adducts (isomers **C**, Figure 11) are reported. For example, oxidation of piperidine **127** affords a mixture of the two unstable nitrones **128** and **129**, which undergo equilibration by a 1,3-prototropic shift (Behrend rearrangement)[384,385] upon heating in refluxing toluene (Scheme 93). Under these conditions, the mixture is converted into caged isoxazolidine **130**, which contains the isoquinuclidine core of the *Iboga* alkaloids. None of the cycloadduct derived from **129** is observed.[381]



Scheme 93

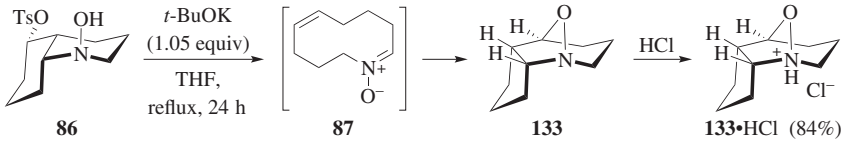
FIVE-ATOM TETHER. Intramolecular cycloadditions of 6-allyltetrahydropyridine *N*-oxides and 5-(2*E*)-2-buten-1-yl-5,6-dihydro-2*H*-1,4-oxazin-2-one 4-oxides (Type **Vb**, Figure 11) preferentially afford tricyclic 6,5,8-ring adducts (isomers **D**, Figure 11). For example, oxazinone *N*-oxide **12** affords a 10:1 mixture of constitutional isomers **13** and **14** by heating at 200° (Scheme 12).[68,386–388] Improved regioselectivity (**13**/**14** = 12:1) is obtained by treatment of nitrone **12** with scandium triflate at room temperature for three days.

SIX-ATOM TETHER. Only one example of an intramolecular cycloaddition of an alkenyl-tetrahydropyridine *N*-oxide featuring a six-atom tether has been reported. Cyclic nitrone **131**, which slowly polymerizes upon standing at room temperature, is first purified and then converted into the 6,5,9-ring adduct **132** (isomer **D**, Figure 11) by heating in dry toluene (Scheme 94).[389]



Scheme 94

n-Membered Cyclic Nitrones (n > 6). Very few examples of intramolecular cycloadditions of seven-membered cyclic nitrones are known, and only two involving larger ring nitrones (10- and 12-membered rings) have been reported. For instance, hexahydroazecine *N*-oxide **87**, which was generated by Grob fragmentation of *N*-hydroxydecahydroquinoline **86** under basic conditions, undergoes in situ intramolecular cycloaddition to afford adduct **133**, which is isolated as its hydrochloride salt in 84% yield (Scheme 95).[229]



86 **87** **133** **133**•HCl (84%)

Scheme 95

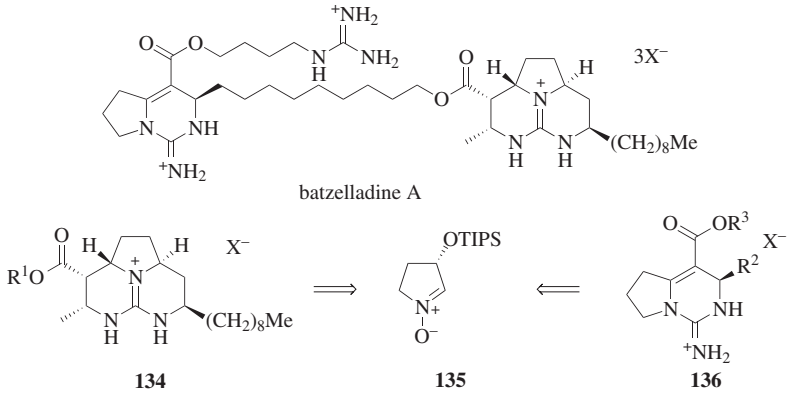
APPLICATIONS TO SYNTHESIS

Overview

In the last three decades, the [3 + 2] dipolar cycloaddition of cyclic nitrones with alkenes has been greatly expanded in the synthesis of natural products. The design of synthetic strategies for the synthesis of polycyclic ring systems of natural products benefits greatly from the use of cyclic nitrones, especially in intramolecular cycloaddition processes that are accompanied by a high degree of stereocontrol. Moreover, substitutions on the nitrone ring and the dipolarophiles can be designed to meet the requirements of the final products because the cycloaddition process is quite chemoselective and is compatible with many functional groups. In general, only the method of synthesizing the nitrone by oxidation processes represents a potential limitation to the choice of nitrone substituents. Moreover, the formation of an isoxazolidine ring provides the possibility of introducing a masked 1,3-amino alcohol functionality in the cycloaddition product, and this group is amenable to further transformations. Because the cycloadduct has a nitrogen atom incorporated in a ring, some of the best synthetic targets are nitrogen heterocycles, especially alkaloids.

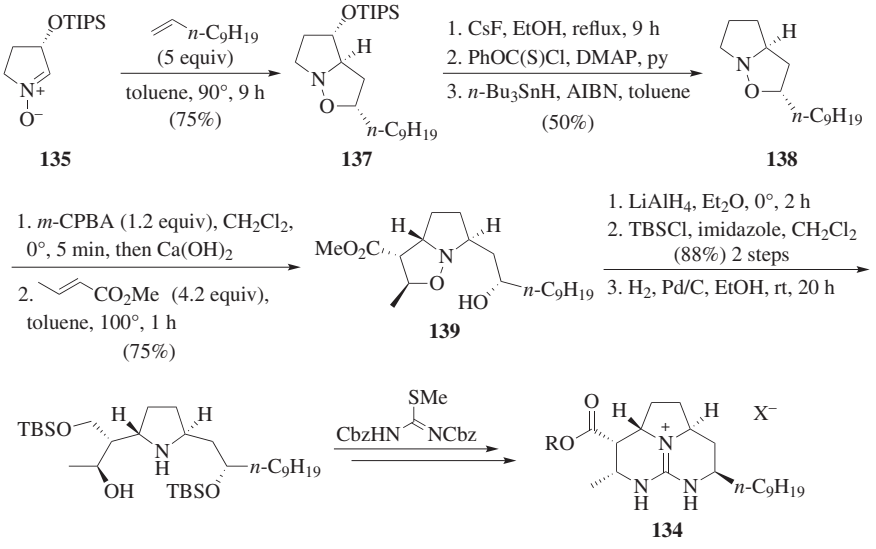
Intermolecular Cycloadditions.

Batzelladines. Batzelladines A–N are members of a large class of polycyclic, guanidine-containing, marine alkaloids isolated from Caribbean sponges (Scheme 96).[390−393] The unusual structures and their diverse biological activities of potential clinical importance have stimulated considerable synthetic activity in this area. Numerous synthetic approaches to these metabolites have been reported, including one that involves stereoselective cycloadditions of enantiopure pyrroline *N*-oxide **135**[141,394,395] to access both the tricyclic guanidine core (**134**) and the bicyclic guanidine moiety **136** of batzelladine A.



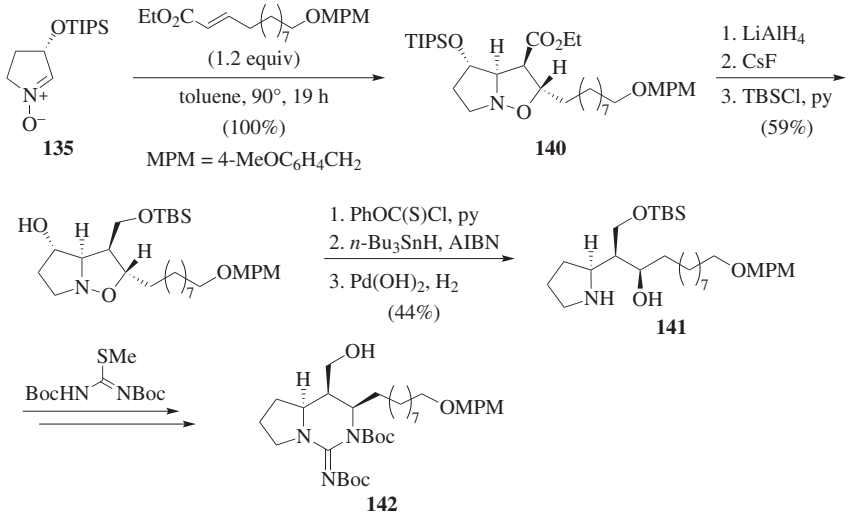
Scheme 96

Enantiopure nitrone **135** undergoes cycloaddition with 1-undecene to produce isoxazolidine **137** with complete stereoselectivity. Having played its role in controlling the stereoselectivity in the cycloaddition step, the TIPS group is then removed (Scheme 97). Oxidation of isoxazolidine **138** furnishes a new nitrone, which undergoes a cycloaddition with methyl crotonate to install the second chain on the pyrrolidine ring, forming product **139**. The stereochemical course of this reaction is controlled by the stereocenters produced in the first cycloaddition. Appropriate elaboration of **139** and coupling with a protected thiourea derivative provide tricyclic guanidine **134**. The analogous tricyclic guanidine cores of batzelladines D and K are synthesized in a similar manner.[141,395]



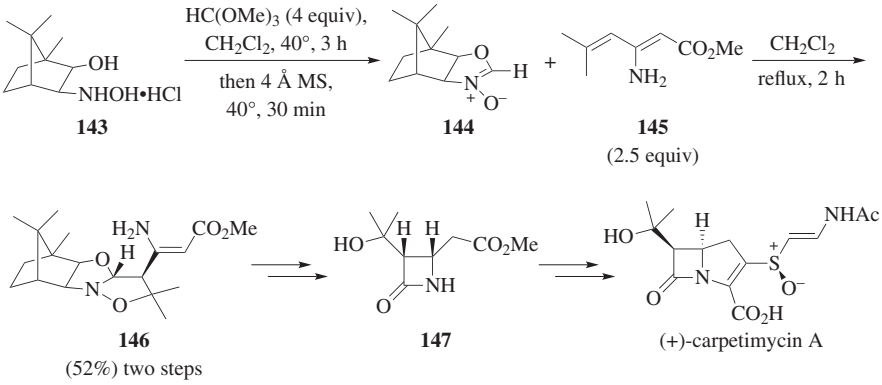
Scheme 97

The formation of bicyclic guanidine moiety **142** follows the same strategy; a highly stereoselective cycloaddition of nitrone **135** to an α,β-unsaturated ester containing an appropriate side chain provides cycloadduct **140**. Elaboration of this product, followed by removal of the TIPS group and cleavage of the nitrogen–oxygen bond, generates pyrrolidine **141**, which reacts with a protected thiourea to afford bicyclic guanidine **142** (Scheme 98).



Scheme 98

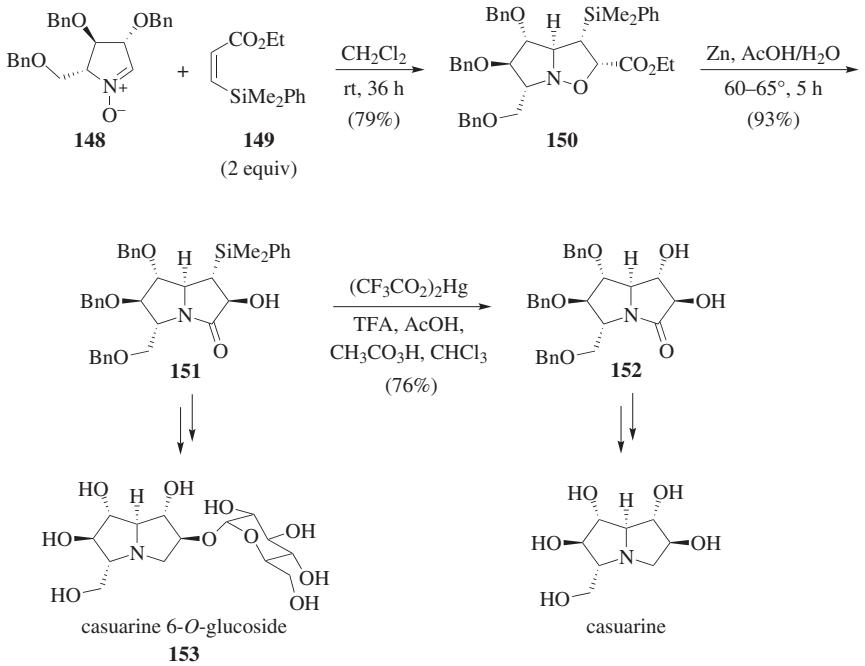
(+)-Carpetimycin A. β-Lactam **147**, a direct precursor of (+)-carpetimycin A, a potent β-lactam antibiotic isolated from the fermentation broth of *Streptomyces* sp. KC-6643, has been synthesized by a highly stereoselective dipolar cycloaddition of a camphor-derived oxazoline *N*-oxide **144** (Scheme 99).[396] Nitrone **144**, produced in situ by reaction of camphor-derived hydroxylamine **143** with trimethyl



Scheme 99

orthoformate, reacts with dienamine ester **145** in a highly regio- and stereoselective fashion, affording a single cycloadduct (**146**) in 52% yield over two steps (Scheme 99). Further elaboration of cycloadduct **146** leads to the β-lactam precursor (**147**) of (+)-carpetimycin A.

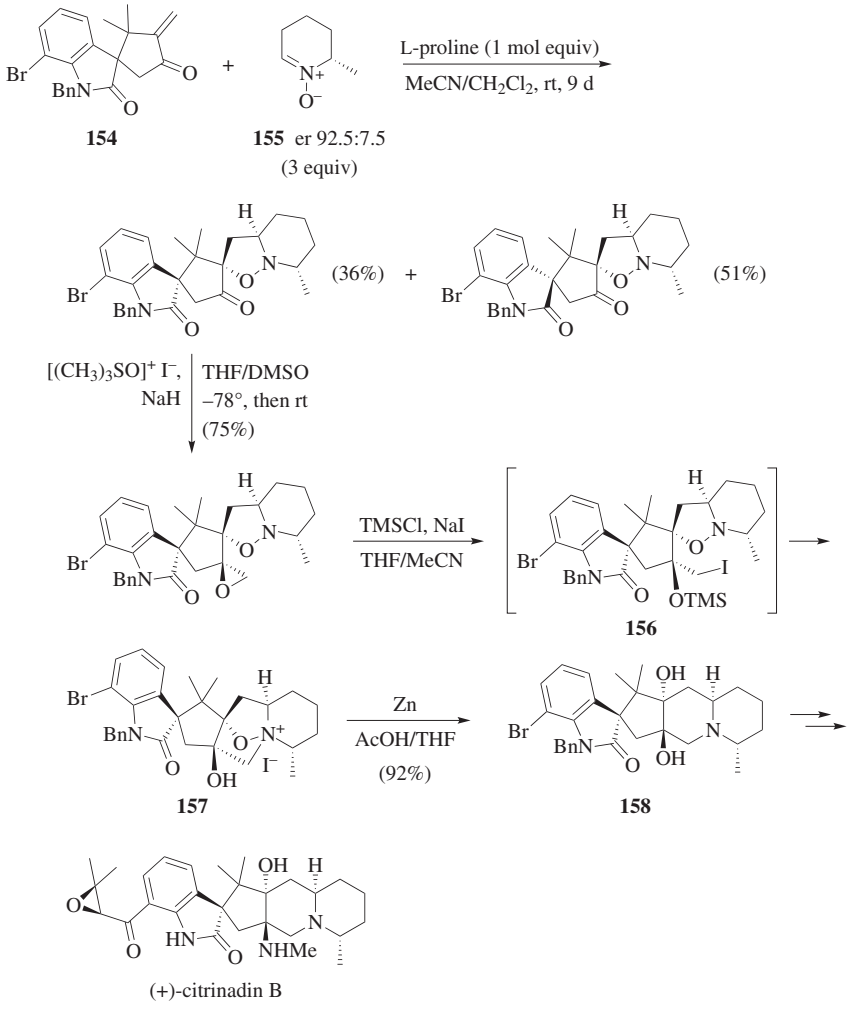
Casuarine. Casuarine and its 6-*O*-α-glucoside (**153**) have been isolated from *Casuarina equisetifolia* L. (Casuarinaceae) and *Eugenia jambolana* Lam. (Myrtaceae), plants well known for their therapeutic action against breast cancer, diabetes, and bacterial infections.[397,398] These compounds are strong inhibitors of the fungal glucoamylase from *Aspergillus niger* (Scheme 100).[397−399] Casuarine can be accessed by an efficient synthetic strategy involving a highly regio- and stereoselective dipolar cycloaddition of arabinose-derived nitrone **148**,[72] which has the correct relative and absolute configurations at C(1), C(2), and C(3) of the target molecule, and silylated (*Z*)-alkene **149** (Scheme 100). The cycloaddition affords adduct **150** (79% yield), which is then subjected to reductive cleavage of the nitrogen–oxygen bond followed by spontaneous cyclization, leading to lactam **151**. A Tamao–Fleming oxidation[400,401] effects the conversion of the carbon–silicon bond to a carbon–oxygen bond with retention of configuration. Final reduction of the lactam moiety in compound **152** and catalytic hydrogenation to remove the benzyl protecting groups afford casuarine in 44% overall yield in five steps from nitrone **148**.[74] The 6-*O*-α-glucoside (**153**) can be obtained from intermediate **151**. An even better overall yield of casuarine from the same nitrone (**148**) has been accomplished



Scheme 100

by means of a stereoselective addition of a lithiated 1-benzyloxyallene as the key step.[402] Using nitrone **148**, cycloaddition with a different dipolarophile allows the synthesis of (+)-hyacinthacine A_2 (6,7-dideoxycasuarine).[72,75] An epimeric ribose-derived nitrone is employed in a cycloaddition reaction with *tert*-butyl acrylate as the key step in a total synthesis of (+)-hyacinthacine A,[403] a related natural product isolated from the bulbs of *Muscari armeniacum* (Hyacinthaceae) that is reported to inhibit several glycosidases.[404]

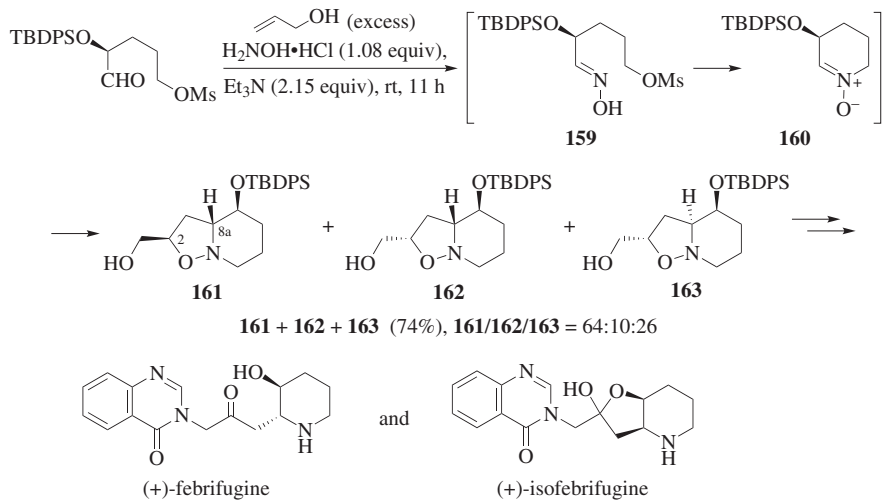
(+)-Citrinadin B. A member of a family of alkaloids isolated from *Penicillium* strains,[405] citrinadin B has been synthesized in a convergent manner by employing a stereoselective intermolecular cycloaddition reaction of an enantioenriched six-membered nitrone as a key step (Scheme 101).[406] The total synthesis enabled



Scheme 101

a revision of the structure assigned to the natural product. The cycloaddition of enantioenriched nitrone **155** (derived from L-alanine) with racemic dipolarophile **154** affords two diastereoisomeric products in 36% and 51% yield, differing only in the configuration of the spiroindole stereocenter; the minor isomer has the configuration needed for the alkaloid synthesis. L-Proline has beneficial effects on both the rate and the stereoselectivity of the cycloaddition reaction. The formation of the quinolizidine substructure of intermediate **158** relies on the formation of isoxazolidinium salt **157** by cyclization of the isoxazolidine nitrogen of compound **156** onto an alkyl iodide fragment, followed by reductive cleavage of the nitrogen–oxygen bond by zinc in acetic acid (Scheme 101).

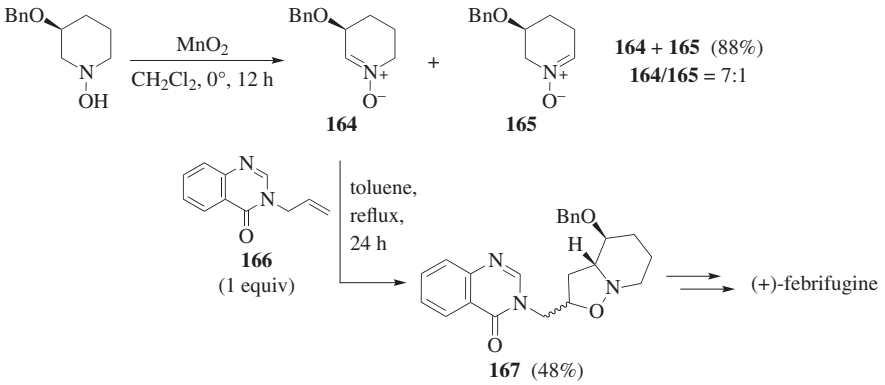
(+)-Febrifugine. Febrifugine and isofebrifugine are antimalarial alkaloids isolated from the roots of *Dichroa febrifuga*,[407−409] an important herb used in traditional Chinese medicine (Scheme 102).[410] Because isofebrifugine can be isomerized to febrifugine, the cycloaddition of six-membered ring nitrone **160** with allyl alcohol allows straightforward access to both compounds.[69] Nitrone **160** is generated in situ by intramolecular *N*-alkylation of oxime mesylate **159** in allyl alcohol as the solvent (Scheme 102). The cycloaddition affords three isomers with complete regioselectivity, 90:10 *exo/endo* selectivity, and 74:26 diastereofacial selectivity. The mixture of compounds is converted by standard transformations to either febrifugine (from adducts **161** and **162**) or isofebrifugine (from adduct **163**).



Scheme 102

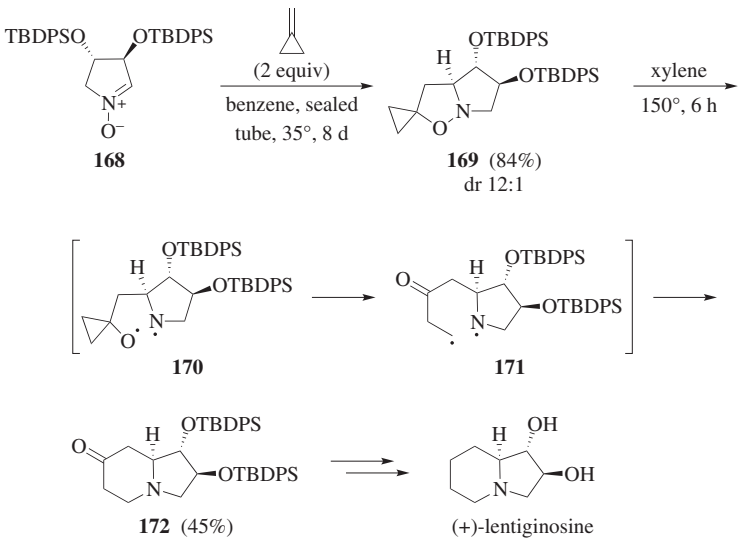
The synthesis of febrifugine is achieved in a more convergent approach by cycloaddition of 3-*N*-allylquinazolinone **166** with six-membered ring nitrone **164**. This nitrone is generated along with isomer **165** by regioselective oxidation of the precursor hydroxylamine with manganese(IV) oxide (Scheme 103).[321] The major product of the cycloaddition, compound **167**, is isolated in 48% yield as a mixture

of *exo/endo* diastereoisomers, both leading to febrifugine through subsequent nitrogen–oxygen bond cleavage, oxidation, and deprotection.



Scheme 103

(+)-Lentiginosine. Since its discovery in 1990, (+)-lentiginosine, a natural iminosugar,[411] has been the object of wide synthetic interest (Scheme 104). (+)-Lentiginosine is a potent and selective inhibitor of fungal amyloglucosidase,[412,413] with a potency twice that of castanospermine, and it is also a good inhibitor of Hsp90.[414] Interestingly, the non-natural (–)-enantiomer is a good proapoptotic agent.[415,416] Among the numerous syntheses of lentiginosine, three employ a cycloaddition with a five-membered cyclic nitrone derived from D- or L-tartaric acid,[16] which provides the required absolute configuration for the synthesis of both

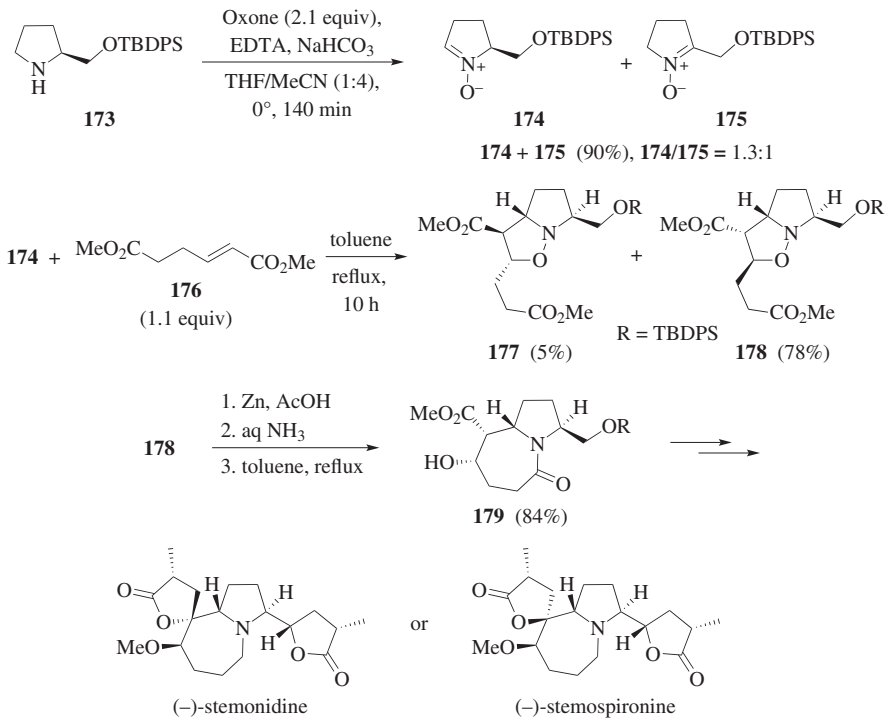


Scheme 104

enantiomers.[358] The key step of one of these syntheses is the thermal rearrangement of a 5-spirocyclopropaneisoxazolidine **169**, which is obtained by cycloaddition of TBDPS-protected nitrone **168** with methylenecyclopropane (Scheme 104).[273] Compounds **169** undergos a thermal homolytic cleavage of the isoxazolidine nitrogen–oxygen bond to afford the diradical **170** that spontaneously rearranges to ethyl ketone radical **171**.[417–420] Coupling of diradical **171** affords indolizidinone **172**, which possesses the skeleton of (+)-lentiginosine.

The bulky protecting groups on the nitrone are necessary to maximize the diastereoselectivity of the cycloaddition by forcing the dipolarophile to approach *anti* to the substituent on C(3) of the nitrone. Routine deoxygenation of the ketone/carbonyl in intermediate **172** and deprotection afford (+)-lentiginosine in a straightforward manner and with high enantiomeric purity.

Stemonidine and Stemospironine. A central pyrrolo[1,2-*a*]azepine system is featured in many alkaloids isolated from several plants of the *Stemonaceae* family, whose extracts have long been used in Chinese and Japanese traditional medicines. Total syntheses of two of these alkaloids, stemonidine and stemospironine, have been achieved by applying an intermolecular cycloaddition of enantiopure pyrroline *N*-oxide **174** as a key step (Scheme 105).[421,422] Nitrone **174** is synthesized by oxidation



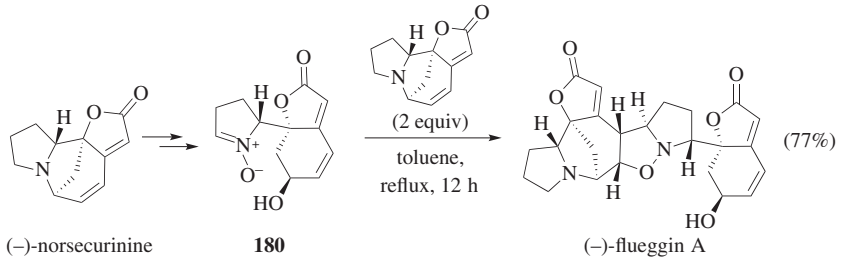
Scheme 105

of enantiopure TBDPS-protected prolinol (**173**) with Oxone to afford a 1.3:1 mixture of two constitutionally isomeric nitrones (**174** and **175**) in 90% overall yield.

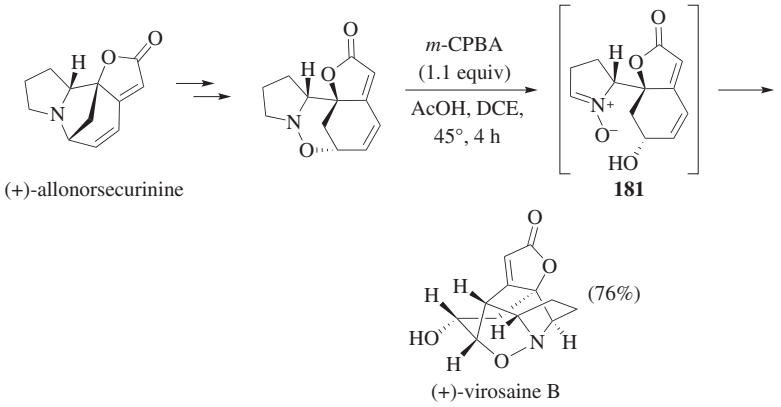
The construction of the pyrrolo[1,2-*a*]azepine skeleton of both alkaloids is achieved by a highly regio- and stereoselective dipolar cycloaddition of nitrone **174** with α,β-unsaturated diester **176** to form cycloadducts **177** and **178** (Scheme 105). The major isomer of the cycloaddition, compound **178**, derives from an *endo-anti* approach of the α,β-unsaturated ester of **176** to the nitrone **174**. Standard transformations of isoxazolidine **178** afford pyrrolo[1,2-*a*]azepine lactam **179**, which is a precursor to both alkaloids.

Intramolecular Cycloadditions.

(−)-Flueggin A and (+)-Virosaine B. Very recently, the question arose whether Nature might employ inter- or intramolecular 1,3-dipolar cycloadditions of cyclic nitrones with alkenes in the biosynthesis of some complex polycyclic alkaloids. Those containing a central isoxazolidine ring, such as the flueggines, virosaines, and lycojaponicumins, appear well suited for assembly by such a transformation,[329,369,423−425] as exemplified by the formation of (−)-flueggin A shown in Scheme 106[369,423] and (+)-virosaine B in Scheme 107. [369,424]



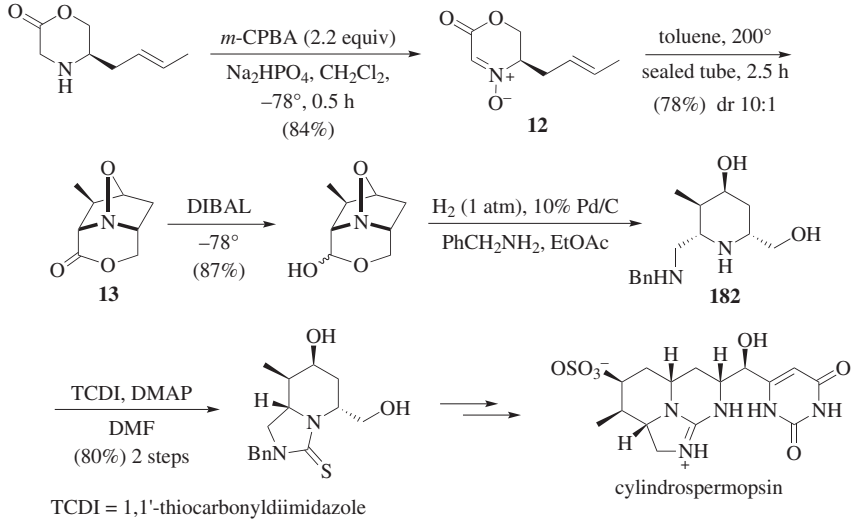
Scheme 106



Scheme 107

With the aid of DFT calculations, it was shown that both the intermolecular 1,3-dipolar cycloadditions of five-membered nitrone **180** and the intramolecular 1,3-dipolar cycloaddition of its diastereomer, compound **181**, may occur spontaneously. Therefore, these cycloadditions are potentially viable steps in the biosynthesis of the flueggines and virosaines, respectively, without the need of enzymatic intervention.[426]

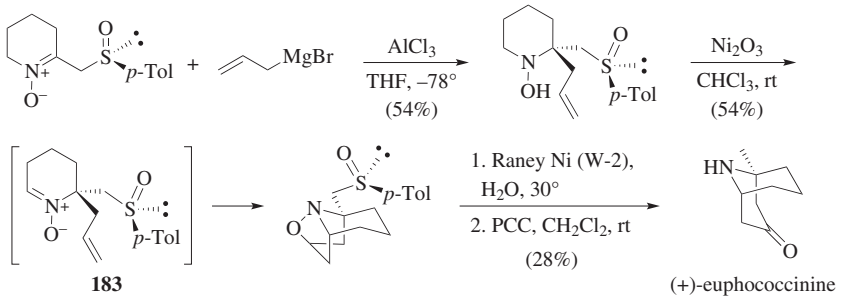
Cylindrospermopsin. Cylindrospermopsin is a member of a large family of hepatotoxic metabolites produced by cyanobacteria.[427] The core tricyclic skeleton of cylindrospermopsin, which contains a guanidinium moiety, is easily constructed through simple transformations of key piperidine precursor **182**, which contains the correct configurations of all the stereocenters in the molecule (Scheme 108).[386] The piperidine derivative is produced by intramolecular cycloaddition of glycine-derived six-membered nitrone **12**, which is substituted with the appropriate crotyl chain. Diastereoselective intramolecular cycloaddition of nitrone **12** at 200° affords two constitutionally isomeric tricyclic lactones in a 10:1 ratio; the major isomer, compound **13**, is exploited for the total synthesis of cylindrospermopsin (Scheme 108).



Scheme 108

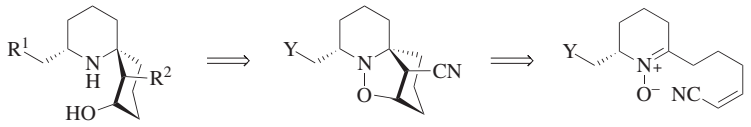
(+)-Euphococcinine. A straightforward synthesis of the homotropane alkaloid (+)-euphococcinine[428] exemplifies the advantages of an intramolecular 1,3-dipolar cycloaddition process: cyclic nitrone **183** is easily prepared, and the reaction enables an elegant construction of the complex bicyclic skeleton (Scheme 109). This

cycloaddition is one of the few examples that uses a β-sulfinyl group as a chiral auxiliary to direct nitrone cycloaddition.



Scheme 109

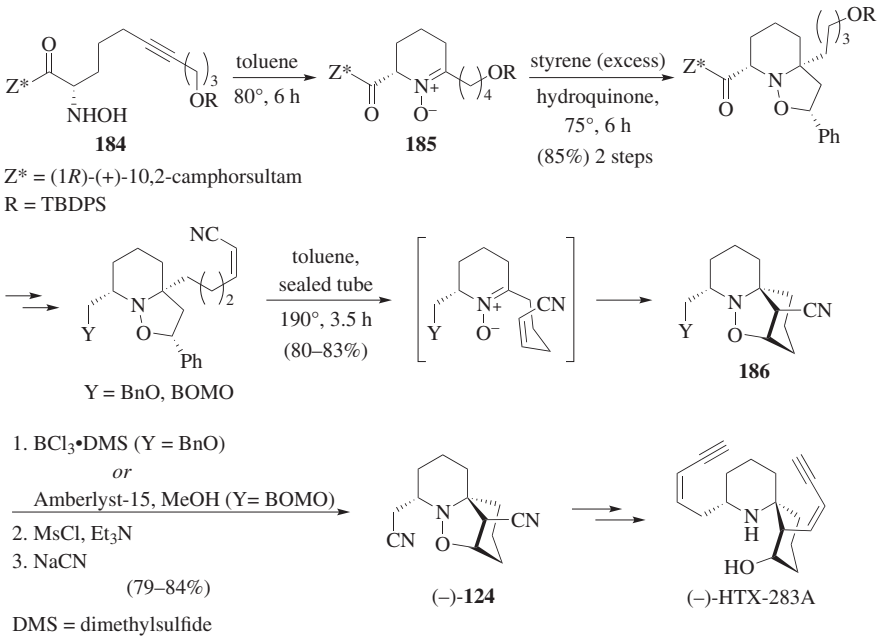
Histrionicotoxins. The histrionicotoxins (HTXs) are a family of frog poison alkaloids featuring a 6,6-bicyclic spiropiperidine structure. The parent alkaloid (–)-HTX-283A has two *cis*-enyne side chains, whereas the side chains of the other members of the family vary in the length and degree of unsaturation of the two chains. An intramolecular 1,3-dipolar cycloaddition between a six-membered cyclic nitrone and an α,β-unsaturated nitrile is the key step in the syntheses of several natural HTXs (Scheme 110).[174,218,372,374,429–432]



Scheme 110

One approach, based on the synthesis outlined in Scheme 111, involves construction of cyclic nitrone **185** by intramolecular hydroxylamine–alkyne cyclization.[174,218] The Oppolzer camphorsultam is used as a chiral auxiliary to produce the starting hydroxylamine, compound **184**, as a single diastereoisomer. Temporary protection of the nitrone moiety by intermolecular dipolar cycloaddition with styrene allows introduction of a pendant cyano-substituted alkene dipolarophile. After additional steps, cycloreversion of the styrene adduct is followed by an intramolecular cycloaddition under thermodynamic control (see also Scheme 32) to afford a single product (isoxazolidine **186**), which features the core ring system of the HTXs, with complete regio- and diastereoselectivity. Conversion of isoxazolidine **186**

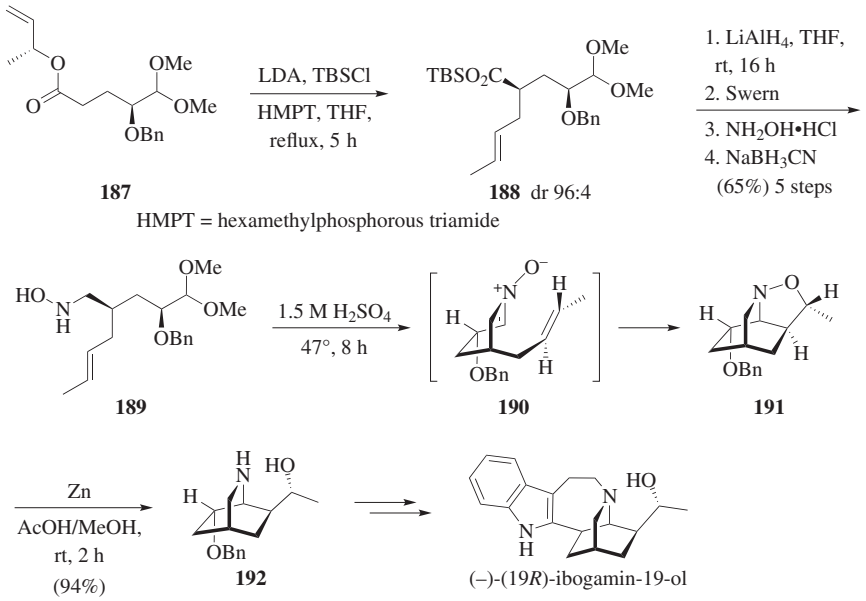
into bis-nitrile **124** allows the simultaneous elaboration of the two side chains of (–)-HTX-283A.



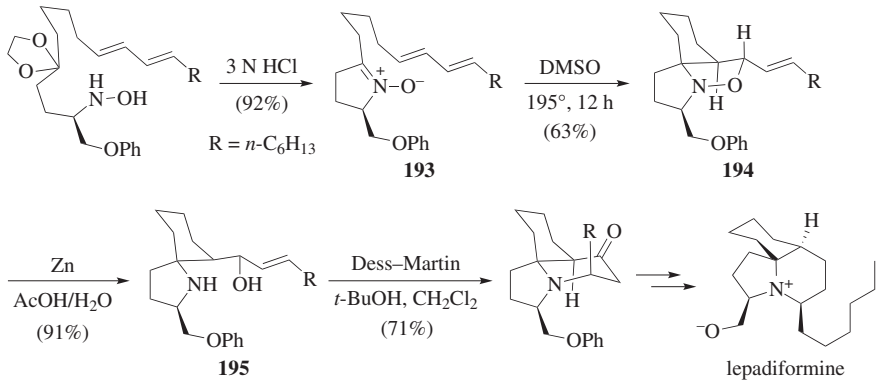
Scheme 111

*(–)-(19*R*)-Ibogamin-19-ol.* The monoterpene indole alkaloid (–)-(19*R*)-ibogamin-19-ol belongs to the *Iboga*-alkaloid family, which occurs in tropical shrubs and comprises more than 80 structurally related members, many of which exhibit interesting pharmacological profiles.[433] Compound **192** features an azabicyclo[2.2.2]octane ring system onto which the indole moiety is appended later in the total synthesis, and this core is assembled through an intramolecular cycloaddition of enantiopure six-membered nitrone **190** to form isoxazolidine **191** (Scheme 112).[434] It is interesting to note that compound **188**, the precursor to protected hydroxylamine aldehyde **189**, is obtained from the silyl ketene acetal of ester **187** via an Ireland–Claisen rearrangement that occurs with very high stereospecificity (dr 96:4).

Lepadiformine. A key step in the synthesis of the marine alkaloid lepadiformine is an elegant intramolecular nitrone/1,3-diene dipolar cycloaddition of compound **193** to form the complex tricyclic skeleton found in isoxazolidine **194** (Scheme 113).[153,359] Reductive nitrogen–oxygen bond cleavage of isoxazolidine **194**, followed by oxidation of allylic alcohol **195**, forms an α,β-unsaturated ketone that undergoes conjugate addition to produce the remaining ring of lepadiformine.

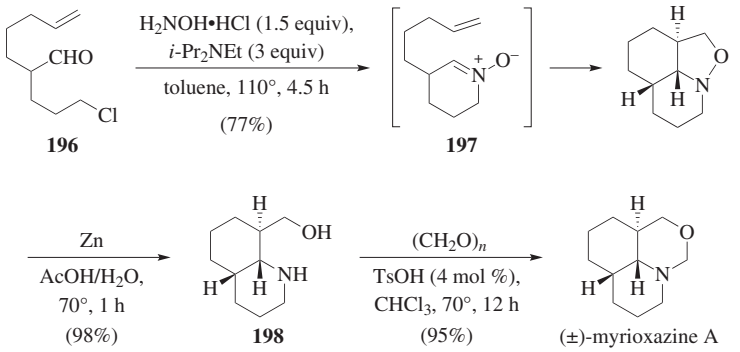


Scheme 112



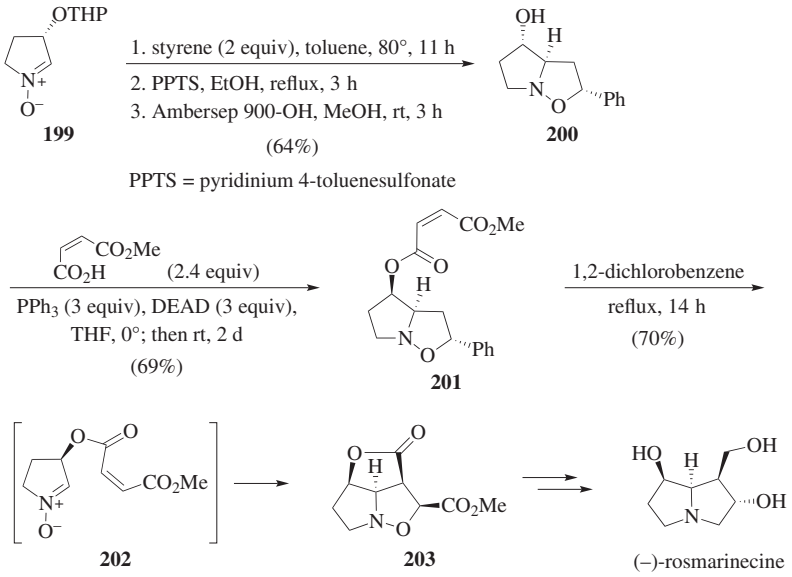
Scheme 113

(±)-Myrioxazine A. A cascade cyclization/1,3-dipolar cycloaddition strategy has been used for the synthesis of (±)-myrioxazine A.[378] Condensation of hydroxylamine with the aldehyde in substrate **196** affords nitrone intermediate **197**, which then undergoes intramolecular cycloaddition. After cleavage of the isoxazolidine nitrogen–oxygen bond, methylenation of γ-amino alcohol **198** produces (±)-myrioxazine A in excellent yield (Scheme 114).



Scheme 114

(–)-Rosmarinecine. (–)-Rosmarinecine is the necine base component of several pyrrolizidine alkaloids.[435] One synthesis of the alkaloid employs an intramolecular cycloaddition of the 3-hydroxypyrroline nitrone **202** tethered to a maleate dipolarophile moiety as the key step (Scheme 115).[220] The required configuration at the ring fusion center of rosmarinecine must derive from an *endo-syn* approach, which is favored in an intramolecular cycloaddition. Enantiomerically pure nitrone **202** was initially produced by introduction of the maleate dipolarophile moiety through a Mitsunobu reaction after *O*-deprotection of THP-protected nitrone **199**. Unfortunately, the deprotection of the nitrone was accompanied by racemization.



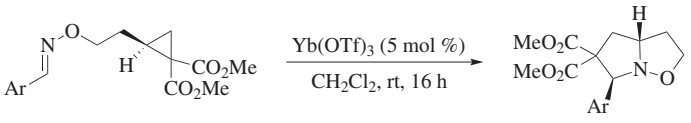
Scheme 115

Instead, 3-THPO-pyrroline *N*-oxide **199** was protected by cycloaddition with styrene, followed by deprotection, to yield isoxazolidine **200** in optically pure form. A Mitsunobu reaction with maleic acid monomethyl ester installs the dipolarophile moiety and the correct configuration of the stereocenter in isoxazolidine **201**. By heating at 180° in 1,2-dichlorobenzene, isoxazolidine **201** undergoes a retrocycloaddition with loss of styrene and formation of nitrone **202**; the latter compound spontaneously undergoes the stereoselective intramolecular cycloaddition to form isoxazolidine **203**. Routine reduction steps provide (–)-rosmarinecine in good overall yield (Scheme 115).

COMPARISON WITH OTHER METHODS

A number of efficient synthetic methods have recently been developed to access monocyclic isoxazolidines, mainly by transition-metal-catalyzed cyclization reactions of hydroxylamino alkenes,[436] allenes,[437] or alkynes,[438] or by formal [3 + 2] cycloaddition of cyclopropanes with nitrosoarenes.[439] However, relatively few strategies have been reported for accessing [2,3]-fused isoxazolidines. The most straightforward method (without resorting to the use of cyclic nitrones) involves forming the isoxazolidine ring by methods such as cyclization of hydroxylamines[440–443] or the use of acyclic nitrones in cycloaddition processes followed by formation of the second ring by further cyclization of an appropriate substituent on the nitrogen of the resulting isoxazolidine.[389,444,445] A complementary method is the cyclization of a cyclic hydroxylamine that can occur spontaneously[446] by formation of an hemiacetal; alternatively, this cyclization can be promoted by iodine in the presence of an alkene.[447] None of these methods has a wide enough scope to be a general alternative approach for the synthesis of polycyclic [2,3]-fused isoxazolidines.

Much broader in substrate scope is the diastereoselective annulation reaction involving oxime ether-tethered cyclopropane diesters, such as substrate **204**. This reaction is catalyzed by ytterbium(III) triflate (5 mol %) and affords substituted pyrrolo[1,2-*b*]isoxazolidines **205** (Scheme 116).[448,449] The reaction can be extended

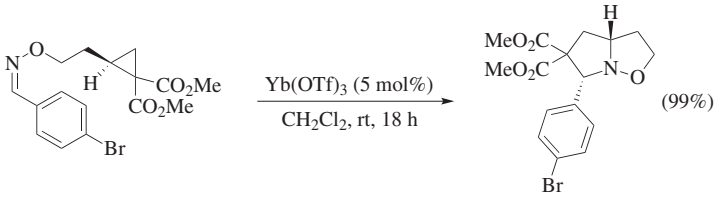


204 **205**

Ar	Yield (%)
Ph	98
4-BrC_6H_4	99
4-$MeOC_6H_4$	99
4-$O_2NC_6H_4$	97
2-py	99
6-Br-2-naphthyl	99

Scheme 116

to aliphatic oxime ethers and α,β-unsaturated oxime ethers. Furthermore, the reaction is stereospecific: (*Z*)-oxime ethers cyclize selectively to the corresponding *cis*-configured products, as in the conversion of oxime **206** to isoxazolidine **207** (Scheme 117), and therefore, this method provides general access to either 2,5-*trans*- or 2,5-*cis*-substituted pyrrolidines.



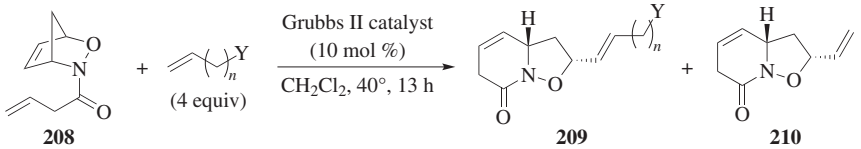
206 **207**

Scheme 117

The reaction of the same cyclopropane diesters with nitrones under ytterbium(III) triflate catalysis[450–453] leads to substituted 1,2-oxazines, higher homologues of isoxazolines that cannot be generated by 1,3-dipolar cycloaddition chemistry.

Isoxazolidines are also formed in good yields by cyclization of α-halo hydroxamates tethered to a furan ring; this formal [4 + 3] cycloaddition is mediated by a base in hexafluoro-2-propanol or trifluoroethanol as the solvent.[454]

Strained nitroso Diels–Alder adducts of cyclopentadiene that are functionalized with alkene side chains, such as substrates **208** and **211** (Schemes 118 and 119), undergo a ring-rearrangement olefin metathesis mediated by the Hoveyda–Grubbs II catalyst to afford fused bicyclic products of various ring sizes, all of which contain an isoxazolidine ring. The metathesis cascade, carried out in the presence of an external alkene, consists of a ring-opening metathesis (ROM), a ring-closing metathesis (RCM), and a cross-metathesis (CM).[455–457]

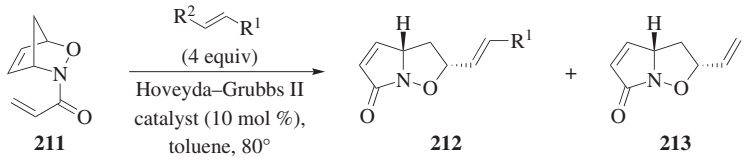


208 **209** **210**

		Yield (%)	
Y	*n*	**209 + 210**	**209/210**
HO	1	75	55:45
HO	2	87	90:10
HO	3	91	96:4
Br	3	86	80:20
Me	5	85	60:40

Scheme 118

Monosubstituted alkenes react with butenoate precursor **208** and Grubbs II catalyst to afford pyrido[1,2-*b*]isoxazolines **209** in good yields along with simple vinyl homologue **210**, the latter of which is likely derived from cross metathesis with ethylene formed in situ (Scheme 118). Starting from acrylate precursor **211**, pyrrolo[1,2-*b*]isoxazolidines **212** are obtained using the Hoveyda–Grubbs II catalyst under somewhat harsher conditions and in lower yields, again along with unsubstituted homologue **213** (Scheme 119)[457] The use of ethylene or symmetrically substituted alkenes leads to higher product selectivity.

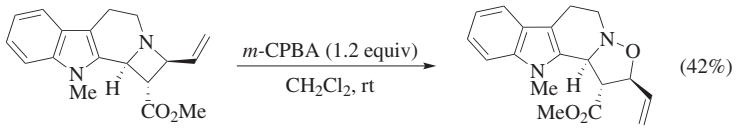


211 **212** **213**

			Yield (%)	
R^1	R^2	Time	**212 + 213**	**212/213**
H	H	4 h	52	—
Me	Me	4 h	30	100:0
n-C_6H_{13}	H	40 min	52	60:40
$AcOCH_2$	H	40 min	30	66:34
$TMSCH_2$	H	40 min	27	91:9

Scheme 119

The Meisenheimer rearrangement of *N*-allylazetidine *N*-oxides has found some application in the synthesis of indole-fused isoxazolidines, as illustrated by the reaction of azetidine **214** to form tetracycle **215** (Scheme 120).[458–460]

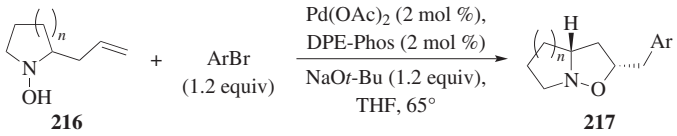


214 **215** (42%)

Scheme 120

The palladium-catalyzed carboetherification reactions of unsaturated hydroxylamine substrates (e.g., **216**) represents a new stereoselective method (competitive with the [3 + 2] dipolar cycloaddition strategy) for the construction of substituted isoxazolidines (Scheme 121).[461] The yields of both monocyclic and bicyclic isoxazolidines are good to excellent, and the reaction of hydroxylamine **216** favors the formation of [2,3]-fused isoxazolidines **217**. This transformation shows high diastereoselectivity (>20:1), and in several cases, the stereochemical

outcome of these transformations is complementary to that of nitrone/alkene cycloadditions.



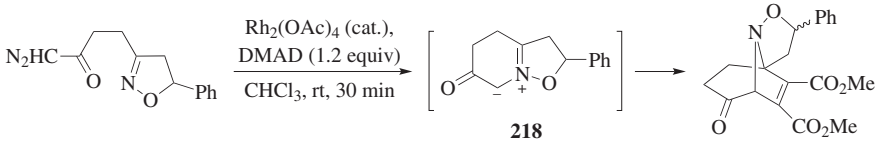
216 **217**

DPE-Phos = bis[(2-diphenylphosphino)phenyl] ether

Ar	*n*	dr	Yield (%)
2-MeC_6H_4	1	>20:1	82
3-py	1	>20:1	85
3-$MeOC_6H_4$	2	19:1	94
4-ClC_6H_4	2	>20:1	89

Scheme 121

There are only a handful of examples in which a bicyclic isoxazolidine is synthesized from an isoxazoline. In one case, azomethine ylide **218** is prepared by a rhodium(II)-catalyzed intramolecular reaction of an α-diazo ester with an isoxazoline carbon–nitrogen double bond. Cycloaddition of ylide **218** with dimethyl acetylenedicarboxylate (DMAD) provides polycyclic product **219**, which incorporates an isoxazolidine ring (Scheme 122).[462] In another example, a 2-isoxazoline bearing an electron-withdrawing substituent on the 3-aryl moiety undergoes a [2 + 2] cycloaddition upon irradiation with indene to afford a mixture of *syn* and *anti* cycloadducts **220**, both of which feature a cyclobutane-fused isoxazolidine skeleton (Scheme 123).[463]

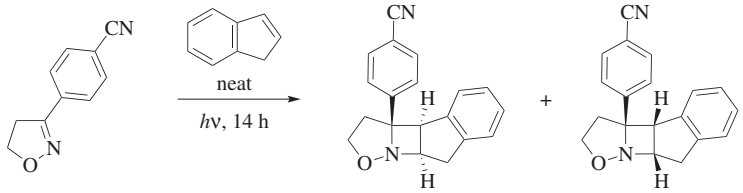


218

DMAD = dimethyl acetylenedicarboxylate

219 (85%)
dr 3:1

Scheme 122



syn-**220** (64%) *anti*-**220** (11%)

Scheme 123

EXPERIMENTAL CONDITIONS

Reactions are generally carried out in solution, most commonly in CH_2Cl_2, $CHCl_3$, MeOH, EtOH, benzene, or toluene. Toluene is often preferred for safety reasons and when the reaction has to be carried out at higher temperatures. A few examples of reactions with no solvent are reported, mainly in cases where the alkene is a liquid that is inexpensive and has low reactivity. Reactions in water are rare,[170,300] as is also the case for acyclic nitrones,[464,465] but are particularly convenient when unprotected, sugar-derived nitrones and dipolarophiles are reaction partners.[300] Cyclic nitrones are more stable in water than acyclic nitrones, which undergo facile hydrolysis.[464]

The most common conditions involve heating the reaction mixture at the boiling point of the solvent used. However, reactions are often performed in a sealed tube at a temperature higher than the boiling point of the solvent. In a study of these two different conditions for an intramolecular cycloaddition, changes in the regioselectivity of the cycloaddition have been recorded.[373] More recently, microwave heating has become increasingly popular, and in several instances it has enabled high yields of products to be obtained with reduced reaction times compared to conventional heating.[221,373,466–468] In some cases, microwave heating does not yield any improvement, or even induces decomposition of the nitrone.[469]

High pressure (10–12 kbar, using a hydraulic pressure vessel) has been occasionally applied to achieve better yields and lower reaction times in cycloadditions of cyclic[278,342,470,471] and acyclic nitrones.[472] The effects of pressure on regioselectivity and stereoselectivity are generally negligible.

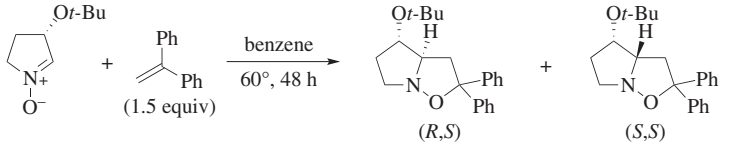
Many Lewis acid- and metal-catalyzed cycloadditions (discussed in "Scope and Limitations") have been reported in recent years, especially with the goal of effecting asymmetric cycloadditions.[80,81,340] Most of these examples employ acyclic nitrones rather than cyclic nitrones, probably due to the fact that the nitrone oxygens in acyclic nitrones—especially those that are *N*-aryl-substituted—is much less Lewis basic than in cyclic analogs.

Cycloadditions of polymer-bound alkenes and nitrones have been described only rarely. Examples include about an equal number of polymer-bound alkenes[473–476] and polymer-bound nitrones.[473,477–479] The method is suitable for the synthesis of isoxazolidine libraries. Of the polymer-bound nitrones, only one involves a cyclic nitrone, specifically a pyrazinone *N*-oxide.[478,479] Merrifield or Wang (4-benzyloxybenzyl alcohol) resins are the most common solid phases used. The nitrone can be generated directly on the solid support by oxidation of the parent amine or by condensation of a supported hydroxylamine with carbonyl compounds for the acyclic nitrones. Removal of the cycloadducts (or further elaboration products) from the resin can be achieved in standard ways. In the case of pyrazinone *N*-oxide cycloadducts, a Mitsunobu method has been applied selectively for their removal from the resin.[478,479] In one case, the solid-supported alkene behaves as a protecting group for the cyclic nitrone.[475] The cycloadduct formed on the resin may undergo further elaboration; for example, a second dipolarophile moiety on the nitrone can be introduced. Appropriate heating of the cycloadduct-bound resin then produces a retrocycloaddition that liberates the original alkenyl resin and, at

the same time, produces the final cycloadduct that can be easily recovered from the solution.[475]

A few examples of intramolecular cycloadditions carried out under flow conditions have been reported.[221,373a]

EXPERIMENTAL PROCEDURES

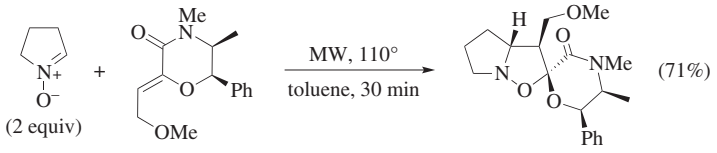


(*R*,*S*) + (*S*,*S*) (41%), (*R*,*S*)/(*S*,*S*) = 3:1

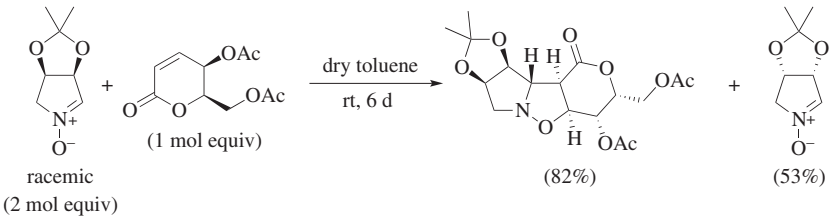
(3a*R-cis*)-4-(1,1-Dimethylethoxy)hexahydro-2,2-diphenylpyrrolo[1,2-*b*]isoxazole and (3a*S-trans*)-4-(1,1-Dimethylethoxy)hexahydro-2,2-diphenylpyrrolo [1,2-*b*]isoxazole [Cycloaddition of a Chiral Five-Membered Cyclic Nitrone with a 1,1-Disubstituted Acyclic Alkene].[480] 1,1-Diphenylethylene (270 mg, 1.5 mmol) was added to a solution of (4*S*)-4-(1,1-dimethylethoxy)-3,4-dihydro-2*H*-pyrrole-1-oxide (158 mg, 1 mmol) in benzene (1 mL) at rt. The reaction mixture was stirred for 48 h at 60°. The crude reaction mixture was concentrated to afford a brown oily residue. Silica gel column chromatography (Et_2O/petroleum ether, 1:2) provided a mixture of the two cycloaddition products (138 mg, 41%, (*R*,*S*)/(*S*,*S*) = 3:1).

(3a*R-cis*)-4-(1,1-Dimethylethoxy)hexahydro-2,2-diphenylpyrrolo[1,2-*b*]isoxazole: mp 122–123°; R_f 0.24 (Et_2O/petroleum ether, 1:2); $[\alpha]^{18}_D$ – 40.1 (*c* 0.71, CH_2Cl_2); IR (CH_2Cl_2) 3055, 2972, 2948, 1362, 1187, 1073 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 7.58–7.52 (m, 2H), 7.38–7.20 (m, 8H), 3.96 (dt, *J* = 6.2, 3.1 Hz, 1H), 3.63–3.50 (m, 1H), 3.50–3.29 (m, 3H), 2.49 (dd, *J* = 12.3, 6.8 Hz, 1H), 2.42–2.20 (m, 1H), 1.78–1.62 (m, 1H), 1.14 (s, 9H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 145.3, 144.4, 128.2, 127.0, 126.8, 125.8, 87.1, 77.8, 74.1, 73.5, 55.7, 46.6, 33.1, 28.4; EIMS (70 eV) (*m/z*): M^+ 337, 280, 264, 191, 180, 179, 165, 105, 91, 77, 57. Anal. Calcd for $C_{22}H_{27}NO_2$: C, 78.30; H, 8.06; N, 4.15. Found: C, 78.32; H, 7.90; N, 4.17.

(3a*S-trans*)-4-(1,1-Dimethylethoxy)hexahydro-2,2-diphenylpyrrolo[1,2-*b*] isoxazole: mp 147–149°; R_f 0.11 (Et_2O/petroleum ether, 1:2); $[\alpha]^{22}_D + 2.1$ (*c* 0.58, $CHCl_3$); IR ($CHCl_3$): 2975, 1446, 1361, 1181, 1101 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 7.60–7.52 (m, 2H), 7.42–7.16 (m, 8H), 4.19 (q, *J* = 7.6 Hz, 1H), 3.66 (q, *J* = 7.8 Hz, 1H), 3.43 (ddd, *J* = 13.4, 7.3, 3.1 Hz, 1H), 3.14–2.83 (m, 3H), 2.16–1.99 (m, 1H), 1.93–1.78 (dtd, *J* = 8.4, 6.6, 3.3 Hz, 1H), 1.19 (s, 9H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 145.7, 144.7, 128.8, 128.6, 127.6, 127.4, 127.0, 126.6, 88.4, 74.2, 72.9, 68.2, 54.0, 43.3, 32.1, 28.8; EIMS (70 eV) (*m/z*): M^+ 337, 336, 280, 191, 180, 179, 165, 105, 77, 57. Anal. Calcd for $C_{22}H_{27}NO_2$: C, 78.30; H, 8.06; N, 4.15. Found C, 77.94; H, 8.21; N, 3.86.



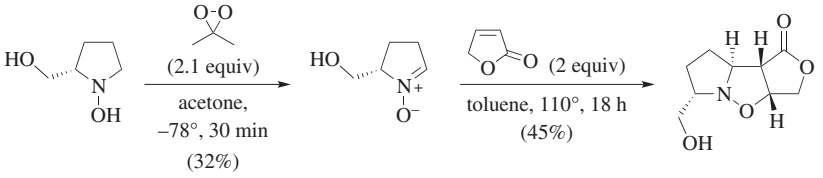
(2*R*,3′*S*,3′a*R*,5*S*,6*R*)-Tetrahydro-3′-(methoxymethyl)-4,5-dimethyl-6-phenyl-spiro[morpholine-2,2′(3′*H*)-pyrrolo[1,2-*b*]isoxazol]-3-one [Cycloaddition of a Five-Membered Cyclic Nitrone with a Trisubstituted Exocyclic Alkene Under Microwave Irradiation].[481] A solution of (2*Z*,5*S*,6*R*)-2-(2-methoxyethylidene)-4,5-dimethyl-6-phenyl-3-morpholinone (0.15 g, 0.57 mmol) and 3,4-dihydro-2*H*-pyrrole-1-oxide (0.1 g, 1.14 mmol) in toluene (4 mL) was subjected to microwave irradiation in a sealed microwave reaction vessel for 30 min at 110°. The mixture was cooled to rt and concentrated. The residue was purified by silica gel column chromatography (EtOAc/hexanes, 1:1) to afford the title compound (0.14 g, 71%) as a colorless foam: IR (neat) 2930, 1720, 1658, 1449, 1246, 1196, 1144, 1105, 1006 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.36–7.33 (m, 2H), 7.31–7.27 (m, 3H), 5.57–5.56 (d, J = 3.0 Hz, 1H), 3.82–3.79 (t, J = 9.0 Hz, 1H), 3.68–3.64 (m, 1H), 3.59–3.56 (dd, J = 9.3, 6.6 Hz, 1H), 3.47 (dq, J = 6.5, 3.0 Hz, 1H), 3.40–3.37 (m, 2H), 3.35 (s, 3H), 3.08–3.05 (m, 1H), 3.05, (s, 3H), 2.14–2.05 (m, 1H), 1.95–1.91 (m, 2H), 1.79–1.72 (m, 1H), 0.95 (d, J = 6.5 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 163.9, 137.6, 128.2, 127.5, 125.7, 104.4, 71.4, 70.4, 67.6, 58.96, 58.85, 57.0, 55.7, 34.2, 29.9, 23.0, 12.2; MS (APCI) (*m/z*): 347.1 $(M+H)^+$; HRMS (EI) (*m/z*): M^+ calcd for $C_{19}H_{26}N_2O_4$, 346.1893; found, 346.1890.



(3a*S*,6a*S*,7*S*,8*R*,10a*R*,10b*S*,10c*R*)-7-(Acetyloxy)-8-[(acetyloxy)methyl] octahydro-2,2-dimethyl-10*H*-1,3-dioxolo[3,4]pyrrolo[1,2-*b*]pyrano[3,4-*d*] isoxazol-10-one and (3a*R*,6a*S*)-3a,6a-Dihydro-2,2-dimethyl-4*H*-1,3-dioxolo [4,5-*c*]pyrrole-5-oxide [Kinetic Resolution of a Chiral Racemic Five-Membered Cyclic Nitrone Through Cycloaddition with an Endocyclic Disubstituted Alkene].[482] (5*R*,6*R*)-5-Acetoxy-6-(acetoxymethyl)-5,6-dihydro-2*H*-pyran-2-one (228 mg, 1.0 mmol) and racemic (3a*RS*,6a*SR*)-3a,6a-dihydro-2,2-dimethyl-4*H*-1,3-dioxolo[4,5-*c*]pyrrole-5-oxide (314 mg, 2 mmol) were dissolved

in dry toluene (40 mL), and the mixture was stired at rt for 6 d under nitrogen. The solvent was evaporated, and the residue was purified by silica gel column chromatography (hexane/EtOAc, 1:1) to afford the cycloadduct (316 mg, 82%): mp 106–108°; $[\alpha]_D + 30.7$ (*c* 0.8, CH_2Cl_2); IR (film) 1747, 1223 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 5.08 (dd, *J* = 2.6, 1.1 Hz, 1H), 4.93 (dd, *J* = 6.2, 1.1 Hz, 1H), 4.91 (ddd, *J* = 6.6, 5.5, 2.1 Hz, 1H), 4.80 (dd, *J* = 6.6, 1.8 Hz, 1H), 4.51 (dd, *J* = 8.6, 2.6 Hz, 1H), 4.23 (m, 2H), 3.85 (dd, *J* = 6.5, 1.8 Hz, 1H), 3.44 (dd, *J* = 13.0, 2.1 Hz, 1H), 3.38 (dd, *J* = 8.6, 6.5 Hz, 1H), 3.08 (dd, *J* = 13.0, 5.5 Hz, 1H), 2.11 (s, 3H), 2.09 (s, 3H), 1.50 (s, 3H), 1.31 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.2, 169.3, 167.4, 113.1, 82.4, 79.1, 76.5, 75.1, 73.7, 65.8, 61.8, 59.3, 48.6, 26.4, 24.7, 20.6, 20.6; HRMS (*m/z*): $[M + Na]^+$ calcd for $C_{17}H_{23}NO_9Na$, 408.1265; found, 408.1284.

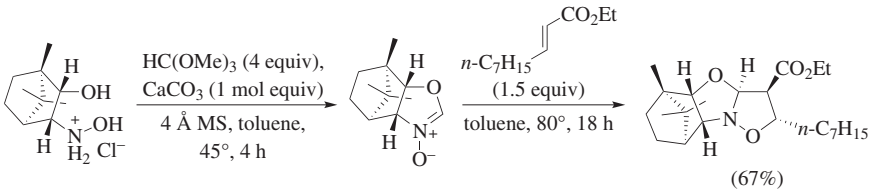
Further elution afforded the unreacted 3a*R*,6a*S* nitrone (166 mg, 53%): mp 101.5–102.5°; $[\alpha]^{30}_D + 26.1$ (*c* 0.56, CH_2Cl_2); IR (thin film) 1580 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 6.89 (q, *J* = 1.6 Hz, 1H), 5.30 (br d, *J* = 6.4 Hz, 1H), 4.92 (ddd, *J* = 6.5, 5.2, 1.3 Hz, 1H), 4.14 (ddd, *J* = 15.2, 5.4, 1.9 Hz, 1H), 4.06 (dq, *J* = 15.2, 1.3 Hz, 1H), 1.46 (s, 3H), 1.39 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 132.5, 112.2, 79.8, 73.6, 67.9, 27.2, 25.7; HRMS (*m/z*): $[M + H]^+$ calcd for $C_7H_{12}NO_3$, 158.0812; found, 158.0804.



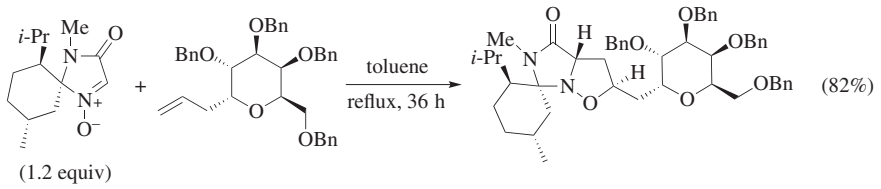
[3a*R*-(3aα,6β,8aβ,8bα)]-Hexahydro-6-(hydroxymethyl)furo[3,4-*d*]pyrrolo [1,2-*b*]isoxazol-1(3*H*)-one [Synthesis of an Enantiopure Five-Membered Cyclic Nitrone by Oxidation of a Secondary Amine and Cycloaddition with an Endocyclic Alkene].[483] A stirred solution of (2*S*)-2-pyrrolidinemethanol, (500 mg, 4.94 mmol) in acetone (15 mL) was cooled to –78° and a solution of dimethyldioxirane (0.17 M in acetone, 64 mL, 10.9 mmol) was added. The mixture was stirred at –78° for 30 min, and then the solvent was evaporated under vacuum. The oily residue was dissolved in toluene (20 mL) and heated at reflux for 6 h. Evaporation of the solvent and purification by silica gel column chromatography (EtOAc/MeOH, 5:1) yielded (2*S*)-2*H*-3,4-dihydropyrrole-2-methanol-1-oxide (182 mg, 32%): $[\alpha]_D + 83$ (*c* 2.65, $CHCl_3$); ^1H NMR (250 MHz, $CDCl_3$) δ 6.91 (d, *J* = 1.5 Hz, 1H), 4.05 (m, 1H), 4.00 (dd, *J* = 12.1, 2.6 Hz, 1H), 3.78 (dd, *J* = 12.1, 7.1 Hz, 1H), 2.66 (m, 2H), 2.30 (m, 1H), 1.93 (m, 1H); ^{13}C NMR (60 MHz, $CDCl_3$) δ 136.7, 72.8, 62.1, 27.0, 21.0.

The nitrone, prepared from 250 mg (2.47 mmol) of (2*S*)-2-pyrrolidinemethanol, was added to a solution of 2(5*H*)-furanone (138 mg, 1.64 mmol) in toluene (10 mL)

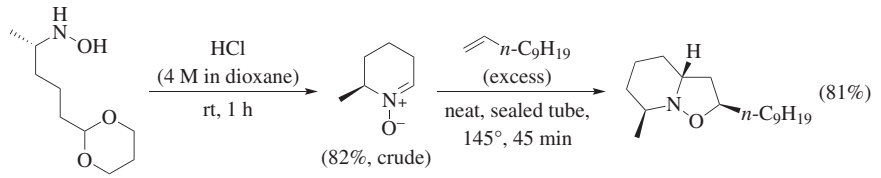
and the mixture was heated at 110° for 18 h. The reaction mixture was concentrated and the residue was purified by silica gel column chromatography (EtOAc) to afford the title compound (71 mg, 45%): mp 66–67°; $[\alpha]_D$ – 26.0 (*c* 0.50, $CHCl_3$); IR (thin film) 3402, 2945, 2875, 1771, 1173, 1040 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 4.92 (ddd, *J* = 6.4, 3.7, 1.8 Hz, 1H), 4.40 (m, 2H), 3.98 (td, *J* = 7.3, 1.2 Hz, 1H), 3.64 (dd, *J* = 11.0, 3.9 Hz, 1H), 3.44 (dd, *J* = 11.0, 6.7 Hz, 1H), 3.34 (qd, *J* = 7.3, 3.9 Hz, 1H), 3.25 (dd, *J* = 6.4, 1.8 Hz, 1H), 2.35 (br s, 1H), 2.22 (dtd, *J* = 11.3, 7.3, 3.3 Hz, 1H), 1.98 (dtd, *J* = 12.2, 8.0, 3.3 Hz, 1H), 1.77 (dq, *J* = 12.8, 8.2 Hz, 1H), 1.57 (dq, *J* = 12.8, 8.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.2, 76.3, 71.4, 68.8, 67.6, 63.8, 54.8, 30.2, 25.9; EIMS (70 eV) (*m/z*): M^+ 199, 168. Anal. Calcd for $C_9H_{13}NO_4$: C, 54.26; H, 6.58; N, 7.03. Found C, 54.22; H, 6.49; N, 6.89.



(2*S*,3*S*,3a*S*,4a*S*,5*R*,8*S*,8a*R*)-5,10,10-Trimethyl-2-heptyl-5,8-methanooctahydro-2*H*-isoxazolo[3,2-*b*]benzoxazole-3-carboxylic Acid, Ethyl Ester [In Situ Synthesis of an Enantiopure Five-Membered Cyclic Nitrone Containing One Heteroatom and Its Cycloaddition with a 1,2-Disubstituted Alkene].[166] Trimethyl orthoformate (1.2 mL, 9 mmol) was added to a suspension of 3-hydroxylamino-2-isoborneol hydrochloride (0.5 g, 2.26 mmol), $CaCO_3$ (226 mg, 2.26 mmol), and powdered 4 Å molecular sieves (0.3 g) in toluene (10 mL). The mixture was stirred at 45° for 4 h. A solution of (*E*)-ethyl 2-decenoate (720 mg, 3.4 mmol) in 2 mL of toluene was added, the oil bath temperature was raised to 80°, and the mixture was stirred overnight at that temperature. After cooling to rt, the reaction mixture was filtered through a pad of Celite, and the filtrate was concentrated. The residue was purified by silica gel column chromatography (Et_2O/pentane, 10:90, R_f = 0.27) to afford the title compound as a colorless oil (595 mg, 67%): $[\alpha]^{20}_D$ – 113 (*c* 0.52, $CHCl_3$); ^1H NMR (250 MHz, $CDCl_3$) δ 5.38 (d, *J* = 7.6 Hz, 1H), 4.35 (dt, *J* = 10.4, 5.9 Hz, 1H), 4.18 (2H, m), 3.88 (d, *J* = 7.5 Hz, 1H), 3.27 (d, *J* = 7.5 Hz, 1H), 2.89 (dd, *J* = 10.4, 7.6 Hz, 1H), 2.04 (d, *J* = 4.3 Hz, 1H), 1.68 (m, 2H), 1.50 (m, 2H), 1.35 (m, 2H), 1.30–1.18 (m, 13H), 0.95–0.70 (m, 12H); ^{13}C NMR (62.5 MHz, $CDCl_3$) δ 169.0, 98.6, 89.8, 78.4, 75.8, 60.9, 58.3, 49.2, 48.4, 45.8, 32.0, 31.6, 31.4, 29.5, 29.0, 25.7, 25.4, 22.6, 22.1, 18.9, 14.2, 14.0, 10.7; MS–CI (NH_3) (*m/z*): $[M + H]^+$ 394, 232, 199, 180 (100%); HRMS calcd for $C_{23}H_{39}NO_4$, 393.2879; found, 393.2875.



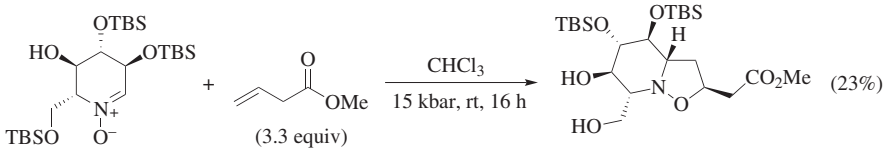
2,6-Anhydro-7-deoxy-1,3,4,5-tetrakis-*O*-(phenylmethyl)-7-[(1*S*,2*S*,2′*S*,3′a*S*,5*R*)-tetrahydro-5,5′-dimethyl-2-(1-methylethyl)-4′-oxospiro[cyclohexane-1,6′(2′*H*)-imidazo[1,5-*b*]isoxazol]-2′-yl]-D-glycero-L-galactoheptitol [Cycloaddition of an Enantiopure Five-Membered Cyclic Nitrone Containing One Heteroatom with a Monosubstituted Alkene].[24] 2,6-Anhydro-7,8,9-trideoxy-1,3,4,5-tetrakis-*O*-(phenylmethyl)-D-glycero-L-galactonon-8-enitol (565 mg, 1 mmol) and (5*S*,6*S*,9*R*)-1,9-dimethyl-6-(1-methylethyl)-1,4-diazaspiro[4.5]dec-3-en-2-one-4-oxide (285 mg, 1.2 mmol) were dissolved in toluene (5 mL) and refluxed for 36 h. The crude reaction mixture was concentrated under vacuum, and the residue was purified by silica gel column chromatography (petroleum ether/EtOAc, 1:1) to afford the title compound as an oil (658 mg, 82%): R_f 0.56 (petroleum ether/EtOAc, 1:1); $[\alpha]^{20}_{D} + 58.9$ (*c* 0.87, CH_2Cl_2); IR (thin film) 3022, 2956, 2919, 2862, 1698, 1450, 1382, 1093 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ 7.46–7.11 (m, 20H), 4.99–4.49 (m, 8H), 4.40–4.29 (m, 1H), 4.03–3.99 (m, 2H), 3.80–3.62 (m, 6H), 2.63 (s, 4H), 2.29–1.19 (m, 12H), 1.02 (d, $J = 4.9$ Hz, 3H), 0.91 (d, $J = 6.5$ Hz, 6H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 173.4, 139.1, 138.6, 138.5, 138.4, 128.8–128.0 (20C), 89.9, 82.6, 79.7, 78.3, 75.8, 75.4, 73.9, 73.4, 73.0, 72.0, 71.6, 69.4, 66.5, 48.6, 40.8, 39.2, 35.1, 30.3, 28.4, 26.36, 24.8, 24.6, 22.9, 22.8, 18.9. Anal. Calcd for $C_{50}H_{62}N_2O_7$: C, 74.48; H, 7.78; N, 3.49. Found: C, 74.70, H 7.76, N 3.80.



(2*R*,3a*R*,7*S*)-Hexahydro-7-methyl-2-nonyl-2*H*-Isoxazolo[2,3-*a*]pyridine [In Situ Synthesis of an Enantiopure Six-Membered Cyclic Nitrone and Cycloaddition with a Monosubstituted Alkene].[149] A solution of HCl (2.0 mL,

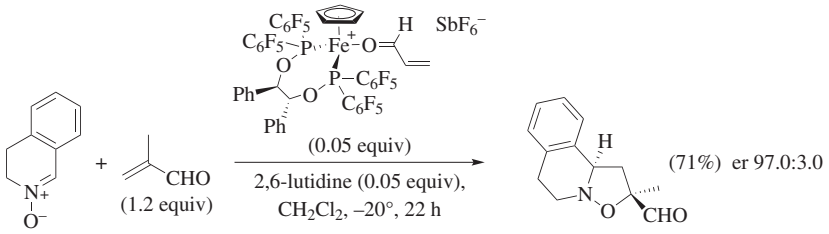
4 M in dioxane) was added to a solution of *N*-hydroxy-α(*S*)-methyl-l,3-dioxane-2-butanamine (420 mg, 2.2 mmol) in dioxane/water (4:1, 1.0 mL). The reaction mixture was stirred at rt for 1 h. Aqueous sodium hydroxide (10%) was added to the reaction mixture to bring the pH to 12. The mixture was diluted with dioxane (5 mL) and then was concentrated to dryness. The residue was suspended in dichloromethane (20 mL) and the suspension was stirred vigorously. The suspension was dried over magnesium sulfate, filtered, and concentrated to afford (2*S*)-2,3,4,5-tetrahydro-2-methyl-pyridine-1-oxide as an oil (218 mg, 87%) which was used immediately.

To the above residue was added undec-1-ene (2 mL) under argon. The mixture was heated in a sealed tube at 145° for 45 min. The reaction mixture was cooled and then was directly purified by silica gel column chromatography (EtOAc/hexane, 10:90) to provide the title compound as an oil (421 mg, 81% based on nitrone): $[\alpha]^{24}_{D}$ + 26.4 (*c* 0.30, MeOH); ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.31–4.24 (m, 1H), 3.51–3.50 (m, 1H), 2.68–2.55 (m, 1H), 2.29 (q, *J* = 10.9 Hz, 1H), 2.02–1.91 (m, 1H), 1.83–1.67 (m, 1H), 1.68–1.50 (m, 2H), 1.50–1.14 (m, 20H), 1.12 (d, *J* = 6.0 Hz, 3H), 0.87 (dd, *J* = 5.3, 5.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 69.5, 53.0, 46.5, 28.5, 28.3, 25.7, 24.9, 22.7, 22.6, 22.5, 22.3, 18.9, 18.5, 15.7, 13.5, 11.8, 7.1; MS(CI) (*m/z*): $[M + H]^+$ 268; HRMS (*m/z*): $[M + H]^+$ calcd for $C_{17}H_{34}NO$, 268.2640; found, 268.2636.

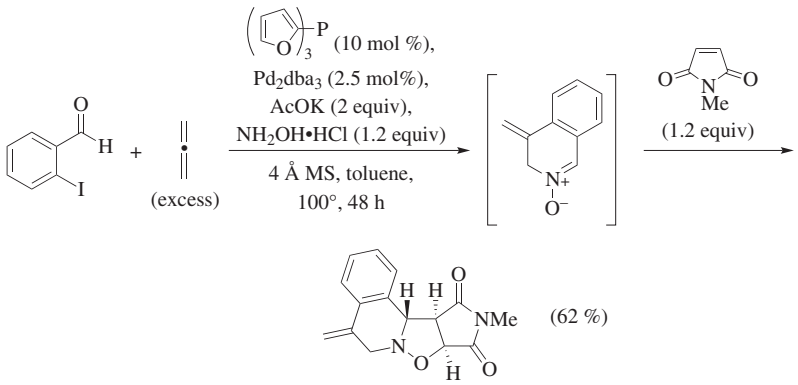


[2*S*-(2α,3aβ,4α,5β,6α,7β)]-4,5-bis[[(1,1-Dimethylethyl)dimethylsilyl]oxy] hexahydro-6-hydroxy-7-(hydroxymethyl)-2*H*-isoxazolo[2,3-*a*]pyridine-2-acetic Acid, Methyl Ester [Cycloaddition under High Pressure of an Enantiopure Six-Membered Cyclic Nitrone with a Monosubstituted Alkene].[484] A solution of [2*R*-(2α,3β,4α,5β)]-4,5-bis[[(1,1-dimethylethyl)dimethylsilyl]oxy]-2-[[[(1,1-dimethylethyl)dimethylsilyl]oxy]methyl]-2,3,4,5-tetrahydro-3-pyridinol-1-oxide (467 mg, 0.9 mmol), methyl 3-butenoate, (300 mg, 3.0 mmol), and a catalytic amount of a radical scavenger in $CHCl_3$ (7.5 mL) was held at rt under 15 kbar in a pressure vial overnight. The reaction mixture was concentrated and the residue was purified by silica gel column chromatography (EtOAc/heptane, 4:6) to afford the title compound as a colorless oil (116 mg, 23%): R_f 0.32 (EtOAc/heptane, 4:6); ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.66–4.58 (m, 1H), 3.86 (dd, *J* = 7.0, 4.5 Hz, 1H), 3.84–3.77 (m, 1H), 3.70 (s, 3H), 3.70–3.66 (m, 1H), 3.49–3.42 (m, 1H), 3.12–2.98

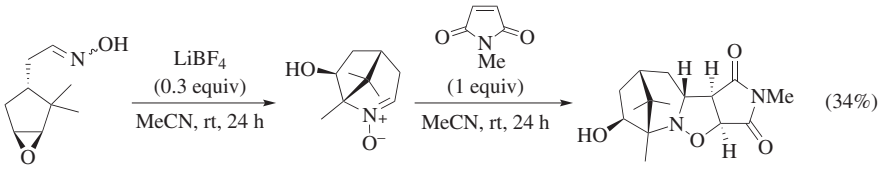
(br s, 1H), 2.66 (dd, J = 15. 5, 6.0 Hz, 1H), 2.68–2.60 (m, 1H), 2.55 (dd, J = 15.5, 7.0 Hz, 1H), 2.53–2.43 (m, 1H), 2.06–1.99 (m, 1H), 1.66 (br s, 1H), 0.92 (s, 3H), 0.90 (s, 3H), 0.13 (s, 3H), 0.12 (s, 3H), 0.11 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.7, 74.3, 72.3, 71.0, 70.7, 63.6, 60.8, 51.7, 39.3, 34.2, 26.0, 25.9, 18.0; EIMS (*m/z*): [M^+] 505, 490, 474, 448; HRMS (*m/z*): $[M+H]^+$ calcd for $C_{23}H_{48}NO_7Si_2$, 506.2969; found, 506.2929.



(3*R*,5*S*)-2-Methyl-1,5,6,10b-tetrahydro-2*H*-isoxazolo[3,2*a*]isoquinoline-2-carboxaldehyde [Enantioselective Cycloaddition of a Six-Membered Cyclic Nitrone with a 1,1-Disubstituted Alkene Catalyzed by an Enantiopure Iron Complex].[82] The (η^5-2,4-cyclopentadien-1-yl)[(1*R*,2*R*)-1,2-diphenyl-1,2-ethanediyl bis[bis(pentafluorophenyl)phosphinite-κP]](2-propenal)-iron hexafluoroantimonate complex (81 mg, 0.06 mmol) was dissolved in CH_2Cl_2 (1.5 mL) at –20°. After addition of 2,6-lutidine (7 μl, 0.06 mmol, 0.05 equiv), the solution was stirred for 10 min before 2-methyl-2-propenal (100 mg, 1.44 mmol) was added dropwise. A solution of the nitrone (180 mg, 1.2 mmol) in CH_2Cl_2 (1.5 mL) was then added dropwise with a syringe pump over 18 hours at –20°. After 4 h of additional stirring at –20°, the reaction mixture was poured into hexane (10 mL). Filtration through Celite and removal of volatiles afforded an oily residue that was purified by silica gel column chromatography (CH_2Cl_2/EtOAc, 90:10) to provide the title compound as an oil (185 mg, 71%): $[\alpha]^{20}_D + 60.7$ (*c* 0.87, CH_2Cl_2); IR (CH_2Cl_2) 3054, 2979, 2934, 2851, 2360, 1730, 1605, 1493, 1454, 1358, 1119, 940, 804 cm^{-1}; ^{1}H NMR (500 MHz, C_6D_6) δ 9.41 (s, 1H), 6.99–6.97 (m, 1H), 6.81–6.79 (m, 1H), 6.67–6.65 (m, 1H), 4.45–4.43 (m, 1H), 3.06–3.04 (m, 1H), 2.80–2.74 (m, 1H), 2.61–2.55 (m, 1H), 2.32–2.29 (m, 1H), 2.20–2.14 (m, 1H,), 1.82–1.79 (m, 1H), 1.18 (s, 3H); ^{13}C NMR (125 MHz, CD_2Cl_2) δ 200.9, 134.9, 133.7, 128.8, 127.8, 127.4, 126.8, 88.0, 63.9, 50.1, 43.9, 29.1, 21.4; EIMS (70 eV) (*m/z*): M^+ 217, 188, 147, 132; HRMS (*m/z*): M^+ calcd for $C_{13}H_{15}N_1O_2$, 217.1103; found, 217.1107. The enantiomeric composition of the title compound was determined by ^{1}H NMR spectroscopy with the use of the chiral shift reagent Eu(hfc)$_3$ (hfc = 3-(heptafluoropropylhydroxymethylene)-(+)-camphorate). ^{1}H NMR (400 MHz, C_6D_6): aldehydic proton: (*S*)-enantiomer 13.37 ppm; (*R*)-enantiomer 13.13 ppm.

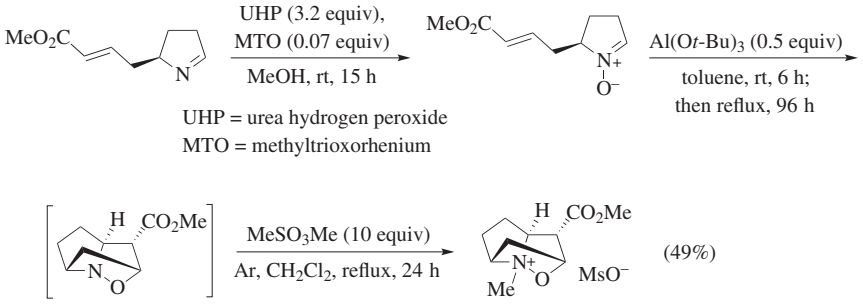


(8a*RS*,11a*SR*,11b*RS*)-5,6,11a,11b-Tetrahydro-10-methyl-5-methylene-pyrrolo[3′,3′:4,5]isoxazolo[3,2-*a*]isoquinoline-9,11(8a*H*,10*H*)-dione [In Situ Synthesis of a Six-Membered Nitrone and Cycloaddition with an Endocyclic Alkene].[237] Hydroxylamine hydrochloride (83 mg, 1.2 mmol), 2-iodobenzaldehyde (232 mg, 1 mmol), *N*-methylmaleimide (1.2 mmol, 133 mg), Pd_2dba_3 (dba = dibenzylideneacetone) (23 mg, 2.5 mol %), tris-2-furylphosphine (23 mg, 10 mol%), KOAc (196 mg, 2 mmol), 4 Å molecular sieves (1.5 g), and toluene (10 mL) were added to a Schlenk tube. The mixture was frozen in liquid N_2 and subjected to two freeze, pump, and thaw cycles. Allene (excess, 1 bar) was then introduced. The mixture was allowed to warm to rt, and then was heated to 100°. The reaction mixture was stirred at this temperature for 24–48 h. The Schlenk tube was allowed to cool to rt, excess allene was vented, and the mixture was filtered through Celite. The filtrate was evaporated under reduced pressure, and the residue was purified by silica gel column chromatography (EtOAc/hexane, 1:5). The title product (168 mg, 62%) crystallized as pale yellow plates: mp 125–127°; IR (film) 2999, 1782, 1504, 1482, 1436, 1380, 1286 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.65 (d, J = 8.1 Hz, 1H), 7.38–7.32 (m, 2H), 7.30 (t, J = 7.7 Hz, 1H), 5.78 (s, 1H), 5.17 (s, 1H), 4.84 (s, 1H), 4.71 (d, J = 7.5 Hz, 1H), 4.15 (d, J = 15.2 Hz, 1H), 3.88 (d, J =15.2 Hz, 1H), 3.76 (d, J = 7.5 Hz, 1H), 3.10 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 189.2, 175.8, 175.3, 135.3, 132.5, 132.0, 129.7, 128.0, 127.6, 124.3, 112.4, 65.9, 57.4, 55.3, 25.6; EIMS (*m/z*): $[M^+ + 1]$ 271. Anal. Calcd for $C_{15}H_{14}N_2O_3$: C, 66.66; H, 5.22; N, 10.36. Found: C, 66.55; H, 5.35; N, 5.45.



(3a*S*,6*S*,7*S*,9*S*,10a*R*,10b*R*)-Octahydro-7-hydroxy-2,6,11,11-tetramethyl-6,9-methano-1*H*-pyrrolo[3′,3′:4,5]isoxazolo[2,3-*a*]azepine-1,3(2*H*)-dione [In Situ Synthesis of an Enantiopure Seven-Membered Cyclic Nitrone and Cycloaddition with an Endocyclic Alkene].[485] A stirred solution of

(1*R*,3*R*,5*S*)-1,2,2-trimethyl-6-oxabicyclo[3.1.0]hexane-3-acetaldoxime (350 mg, 1.91 mmol) in dry acetonitrile (35 mL) was treated with a solution of $LiBF_4$ (54 mg, 0.57 mmol) in dry acetonitrile (15 mL). The resulting solution was stirred at rt for 24 h. *N*-Methylmaleimide (212 mg, 1.91 mmol) was added, and stirring was continued for a further 24 h at rt. The acetonitrile was then removed under vacuum, water (20 mL) was added and the mixture was extracted with $CHCl_3$ (2 × 40 ml). The combined organic layers were washed with brine and then were dried over anhydrous $MgSO_4$. The solvent was removed under vacuum, and the residue was purified by silica gel column chromatography (hexane/EtOAc, 2:3) to afford the title product (390 mg, 34%) as colorless prisms: mp 142–144°; $[\alpha]_D$ −35.0 (*c* 0.4, $CHCl_3$); ^1H NMR (400 MHz, C_6D_6) δ 4.65 (d, J = 9 Hz, 1H), 3.70 (m, 1H), 3.21 (t, J = 9 Hz, 1H), 2.91 (t, J = 9 Hz, 1H), 2.55 (s, 3H), 2.02–1.50 (m, 5H), 1.34 (s, 3H), 1.02 (s, 3H), 0.87 (s, 3H); EIMS (*m/z*): M^+ 294 (3), 279, 166, 149, 83, 71, 57, 43. Anal. Calcd For $C_{15}H_{22}N_2O_4$: C, 55.2; H, 6.85; N, 8.3. Found: C, 55.1; H, 6.9; N, 8.2.

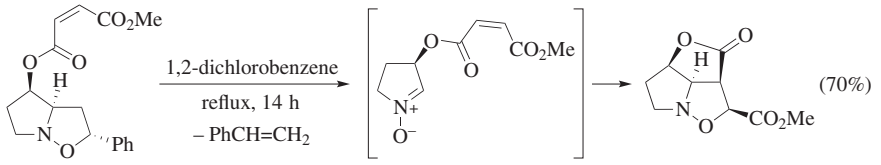


(2*R*,3*S*,3a*S*,6*R*,7*S*)-Hexahydro-3-(methoxycarbonyl)-7-methyl-2,6-methanopyrrolo[1,2-*b*]isoxazolium Methanesulfonate [In Situ Synthesis of an Enantiopure Five-Membered Cyclic Nitrone and Intramolecular Cycloaddition Followed by Alkylation of the Cycloadduct].[129] In a 25-mL oven-dried, single-neck round-bottomed flask equipped with a magnetic stirring bar and a rubber septum was placed a solution of methyltrioxorhenium (MTO) (0.008 g, 0.033 mmol) and urea hydrogen peroxide (UHP) (0.148 g, 1.57 mmol) in anhydrous MeOH (5 mL) under argon, and the mixture was stirred for 15 min. A solution of (2*E*)-4-[(2*R*)-3,4-dihydro-2*H*-pyrrol-2-yl]-2-butenoic acid, methyl ester (0.081 g, 0.484 mmol) in MeOH (4 mL) was added via cannula, and the resultant yellow solution was stirred at rt for 15 h. The reaction mixture was concentrated, the residue was diluted with CH_2Cl_2 (7 mL), and the mixture was then concentrated. To the residue was added CH_2Cl_2 (5 mL), and the urea crystals were removed by filtration. Removal of the solvent provided (2*E*)-4-[(2*S*)-3,4-dihydro-1-oxido-2*H*-pyrrol-2-yl]-2-butenoic acid, methyl ester (0.088 g) as a yellow oil, which was used in the next step without

further purification: IR (neat) 1718, 1653, 1197 cm^{-1}; HRMS (*m*/*z*): $[M + H]^+$ calcd for $C_9H_{14}NO_3$, 184.0968; found, 184.0968.

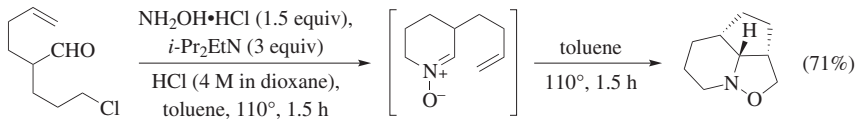
In a 250-mL oven-dried, single-neck round-bottomed flask equipped with a magnetic stirring bar and a rubber septum was placed the nitrone (89 mg, 0.484 mmol) in anhydrous toluene (95 mL). To this solution was added $Al(O\textit{t}\text{-}Bu)_3$ (60 mg, 0.242 mmol), and the resulting solution was stirred for 6 h and then refluxed (maintaining the oil bath temperature at 150°) for 96 h. The reaction mixture was cooled to rt and extracted three times with 5% HCl (12 mL, then 2 × 6 mL). The aqueous layer was extracted with CH_2Cl_2 (4 × 5 mL) after adjusting the pH to ~8 using solid Na_2CO_3. The organic layer was dried over $MgSO_4$, and the solution was used in the next step without further purification because of the product volatility.

In a 50-mL oven-dried, single-neck round-bottomed flask equipped with a magnetic stirring bar and a reflux condenser was placed the above solution under argon. Methyl methanesulfonate (0.410 mL, 4.84 mmol) was added via syringe, and the solution was refluxed for 24 h. Next, the reaction mixture was diluted with water (25 mL) and the aqueous phase was washed with CH_2Cl_2 (3 × 12 mL) to remove the excess methyl methanesulfonate. The aqueous layer was concentrated to provide the title product (0.069 g, 49%) as a colorless oil: $[\alpha]^{20}_D$ – 29.5 (*c* 0.85, MeOH); IR (neat) 1717, 1197 cm^{-1}; ^1H NMR (CD_3OD) δ 5.45 (d, *J* =5.3 Hz, 1H), 4.61 (dd, *J* = 7.9, 3.0 Hz, 1H), 4.28 (m, 1H), 3.69 (s, 3H), 3.54 (s, 3H), 3.37 (d, *J* = 3.0 Hz, 1H), 2.77 (ddd, *J* = 12.9, 10.8, 5.3 Hz, 1H), 2.61 (br s, 3H), 2.50–2.23 (m, 4H), 2.08 (dd, *J* = 12.8, 3.1 Hz, 1H); ^{13}C NMR (CD_3OD) δ 170.7, 85.0, 84.7, 79.6, 77.0, 58.9, 53.7, 44.7, 40.7, 26.2, 25.5; HRMS (*m*/*z*): $[M - OMs]^+$ calcd for $C_{10}H_{16}NO_3$, 198.1125; found, 198.1122.

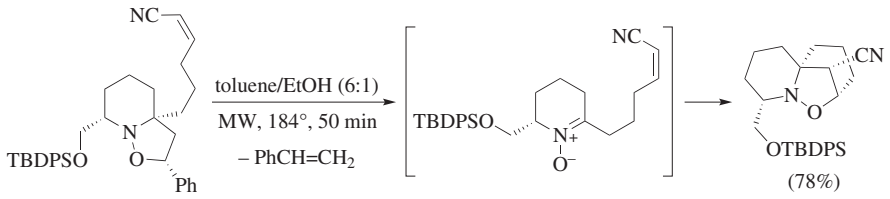


(2a*R*,3*S*,6a*R*,6b*R*)-Hexahydro-2-oxo-2*H*-1,4-dioxa-4a-azacyclopenta[*cd*] pentalene-3-carboxylic Acid, Methyl Ester [In Situ Synthesis of an Enantiopure Five-Membered Nitrone via Retrocycloaddition and Intramolecular Cycloaddition].[220] A solution of (2*R*,3a*R*,4*S*,2*Z*)-hexahydro-2-phenylpyrrolo[1,2-*b*]isoxazol-4-yl-2-butenedioic acid, methyl ester (175 mg, 0.55 mmol) in 1,2-dichlorobenzene (10 mL) was heated at reflux for 14 h. The crude mixture was purified by silica gel column chromatography, eluting first with pentane to remove excess 1,2-dichlorobenzene, then with EtOAc to afford the title compound (82 mg, 70%) as a brown solid, which was recrystallized from pentane to obtain an analytically pure white solid: mp 138–139°; R_f 0.19 (EtOAc); $[\alpha]^{27}_D$ – 53.5 (*c* 0.39, $CHCl_3$); IR (CCl_4) 3007, 1775, 1768, 1169 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 5.13 (m, 1H), 4.74 (d, *J* = 6.3 Hz, 1H), 4.45 (dd, *J* = 7.8, 7.7 Hz, 1H), 3.84 (s, 3H),

3.80–3.74 (m, 2H), 3.10–3.03 (m, 1H), 2.45–2.41 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.1 (s, C=O), 166.3 (s, C=O), 83.2 (d), 79.1 (d), 71.5 (d), 54.5 (t), 52.6 (q), 52.2 (d), 32.4 (t); EIMS (*m/z*): M^+ 213, 183, 169, 154, 108, 83. Anal. Calcd for $C_9H_{11}NO_5$: C, 50.71; H, 5.20; N, 6.57. Found C, 50.70; H, 5.34; N, 6.73.

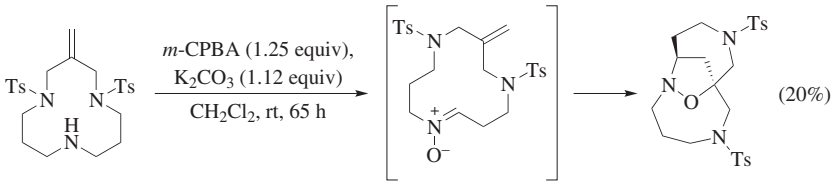


(2a*SR*,4a*SR*,7b*RS*)-Octahydro-1-oxa-7a-azacyclopenta[*cd*]indene [In Situ Synthesis of a Six-Membered Nitrone and Intramolecular Cycloaddition].[378] A solution of 2-(3-chloropropyl)-hex-5-enal (200 mg, 1.15 mmol), hydroxylamine hydrochloride (119 mg, 1.72 mmol), and *N*,*N*-diisopropylethylamine (0.60 mL, 3.44 mmol) in toluene (10 mL) was refluxed for 1.5 h. The reaction mixture was concentrated, and the residue was purified by silica gel column chromatography (EtOAc) to yield the title compound as an oil (125 mg, 71%): R_f 0.24 (EtOAc); IR (thin film) 2940, 2860, 1450 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.89 (td, J = 7.5, 1.0 Hz, 1H), 3.63–3.56 (m, 2H), 3.52 (dt, J = 15.0, 3.0 Hz, 1H), 3.02 (br q, J = 7.5 Hz, 1H), 2.98–2.90 (m, 1H), 1.93 (qt, J = 13.0, 3.0 Hz, 1H), 1.84–1.79 (m, 1H), 1.77–1.57 (m, 5H), 1.49–1.43 (m, 1H), 1.09 (dquint, J = 13.0, 3.0 Hz, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 75.2, 63.8, 51.0, 49.0, 37.0, 33.4, 30.6, 24.7, 14.0; MS (ES) (*m/z*): $[M+H]^+$ 154 (100%); HRMS (ES): $[M+H]^+$ calcd for $C_9H_{16}NO$, 154.1232; found, 154.1238.



(2*S*,5a*R*,9*S*,11*R*)-9-[[[(1,1-Dimethylethyl)diphenylsilyl]oxy]methyl]octahydro-2,5a-methano-5a*H*-pyrido[1,2-*b*][1,2]oxazepine-11-carbonitrile [In Situ Synthesis of an Enantiopure Six-Membered Nitrone via Retrocycloaddition and Intramolecular Cycloaddition].[430] A solution of (2*Z*)-6-[(2*R*,3a*S*,7*S*)-7-[[[(1,1-dimethylethyl)diphenylsilyl]oxy]methyl]hexahydro-2-phenyl-3a*H*-isoxazolo[2,3-*a*]pyridin-3a-yl]-2-hexenenitrile (5.14 g, 9.11 mmol) in toluene (144 mL) and EtOH (24 mL) was divided equally into 24 vials. These vials were

each sealed and irradiated in a microwave reactor for 50 min at 184° (pressure = 12 bar). The contents of the vials were combined and concentrated, and the residue was purified by silica gel column chromatography (EtOAc/hexanes, 2:98, then 4:96, then 6:94) to yield the title compound (3.29 g, 78%) as a colorless solid, a small portion of which was recrystallized (Et_2O/hexanes) to afford colorless needles: mp 154–155°; R_f 0.40 (EtOAc/hexanes, 10:90); $[\alpha]^{24}_D$ −132.1 (*c* 1.16, $CHCl_3$); IR (KBr disc) 2928, 2854, 2236, 1469, 1427, 1134, 1114, 1048, 941, 799, 741, 704, 505 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 7.69–7.63 (m, 4H), 7.45–7.33 (m, 6H), 4.58 (br t, J = 5.2 Hz, 1H), 4.08 (dd, J = 9.7, 3.4 Hz, 1H), 3.53 (dd, J = 9.6, 8.5 Hz, 1H), 3.34 (d, J = 6.5 Hz, 1H), 2.54 (dddd, J = 11.4, 6.2, 3.0, 3.0 Hz, 1H), 2.21–2.12 (m, 2H), 1.93–1.46 (m 8H), 1.36–1.17 (m, 2H); 1.08 (s, 9H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 135.7, 135.6, 133.96, 133.6, 129.6, 127.6, 117.7, 75.6, 66.5, 65.96, 65.4, 38.0, 35.8, 32.2, 27.9, 27.1, 26.9, 19.3, 18.7, 17.4. Anal. Calcd for $C_{28}H_{36}N_2O_2Si$: C, 73.00; H, 7.88; N, 6.08. Found: C, 73.04; H, 8.02; N, 6.03.



3,11-bis[(4-Methylphenyl)sulfonyl]-13-oxa-3,7,11-triazatricyclo[5.5.1.11,6] tetradecane [In Situ Synthesis of a 12-Membered Cyclic Nitrone and Intramolecular Cycloaddition].[486] A mixture of 3-methylene-1,5-bis[(4-methylphenyl)sulfonyl]-1,5,9-triazacyclododecane(0.39 g, 0.8 mmol), *m*-CPBA (0.17 g, 1 mmol), and K_2CO_3 (0.14 g, 0.9 mmol) in CH_2Cl_2 (5 mL) was stirred for 65 h at rt. The reaction mixture was basified by addition of aqueous NaOH (3 M), and the resulting mixture was extracted with $CHCl_3$. The organic layer was dried over $MgSO_4$ and concentrated under vacuum. The product (82 mg, 20%) was isolated by silica gel column chromatography (EtOAc/hexane) and recrystallized from acetonitrile: mp 234–235°; IR ($CDCl_3$) 3040 (w), 3020 (w), 2920 (s), 2860 (m), 1600 (m), 1490 (m), 1470 (m), 1450 (s), 1440 (s), 1330 (s), 1160 (s), 1090 (s), 980 (m), 950 (m), 930 (m), 920 (m), 900 (m), 810 (m), 750 (m), 730 (s), 660 (s) cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.59 (d, J = 8 Hz, 2H), 7.54 (d, J = 8 Hz, 2H), 7.25 (d, J = 8 Hz, 2H), 7.21 (d, J = 8 Hz, 2H), 3.76 (d, J = 13 Hz, 1H), 3.62 (m, 1H), 3.50 (d, J = 13 Hz, 1H), 3.4 (m, 1H), 3.18 (m, 1H), 2.92 (m, 2H), 2.85 (m, 2H), 2.50 (d, J = 13 Hz, 1H), 2.44 (d, J = 13 Hz, 1H), 2.37 (s, 3H), 2.34 (s, 3H), 1.85 (m, 1H), 1.75 (m, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 143.5, 143.3, 136.5, 135.9, 129.8, 129.7, 126.8, 87.6, 63.9, 53.6, 53.1, 52.5, 50.3, 44.7, 34.6, 34.4, 25.6, 21.5; EIMS (*m/z*): M^+ 505, 350. Anal. Calcd for $C_{24}H_{31}N_3O_5S_2$: C, 57.01; H, 6.18; N, 8.31; S, 12.68. Found: C, 56.64; H, 6.16; N, 8.26; S, 12.01.

TABULAR SURVEY

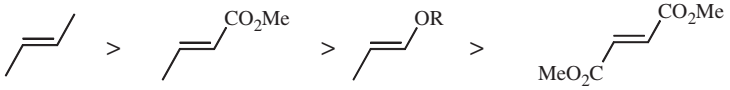
The Tabular Survey covers the literature from 1985 to 2014. Unless otherwise noted, a drawn enantiomer should be assumed to represent a racemic mixture. For intermolecular cycloadditions, the tables are organized according to the nitrone structure (carbon count without protecting groups, followed by the number and type of substitution) as the primary rubric. Substituents on heteroatoms are excluded from the carbon count unless they take part in the reaction. For intramolecular cycloadditions, the tables are organized according to the tether length as the primary rubric, then by the nitrone structure (carbon count, including dipole and dipolarophile moieties, without protecting groups), as the secondary rubric. Tether length is defined as the number of all atoms between the cyclic nitrone C(2) and the dipolarophile (Fig. 11).

Rubrics for the dipolarophiles are based on the hierarchy shown below.

I. Alkene type: monosubstituted > 1,1-disubstituted > 1,2-disubstituted > trisubstituted > tetrasubstituted. In Tables 2C and 4C, endocyclic alkenes are ordered first by ring size (from the smaller to larger), second by the number of rings (mono- to polycycles), and then by the alkene type.

II. Substituent type: alkyl > alkenyl > alkynyl > aryl > heteroaryl > carbonyl > nitrile > amide > carboxyl > heteroatom (according to increasing atomic number and oxidation state). In Tables 3, 5, and 6, cyclic alkenes follow the acyclic alkenes within the same degree of substitution.

Polysubstituted alkenes with the same degree of substitution are ordered according to the rules above. For example, cycloadditions to the disubstituted alkenes shown below are ordered in the following sequence:

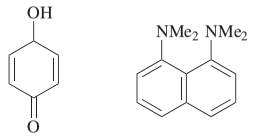


The tables are preceded by a chart, which shows the structures of catalysts and additives that are used in the tables. Bold numbers in the table entries indicate these structures. In addition to those listed in "*The Journal of Organic Chemistry* Standard Abbreviations and Acronyms", the following abbreviations are used in the Tabular Survey:

BOM	benzyloxymethyl
c-C_6H_{11}	cyclohexyl
CTAB	cetyltrimethylammonium bromide
DIPEA	*N*,*N*-diisopropylethylamine

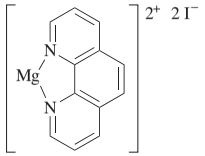
dstd.	distilled
ImH	imidazole
LDA	lithium diisopropylamide
MPa	megapascal
MPM	4-methoxybenzyl
MS	molecular sieves
MW	microwaves
MWCNT	multi-walled carbon nanotube
Np	naphthyl
PMP	4-methoxyphenyl
SDS	sodium dodecylsulfate
TBDPS	*t*-butyldiphenylsilyl
TCE	trichloroethylene or tetrachloroethylene
Tol	4-methylphenyl
UHP	urea hydrogen peroxide complex

CHART 1. CYCLOADDITION CATALYSTS AND ADDITIVES

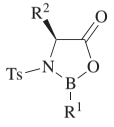


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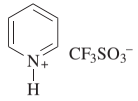
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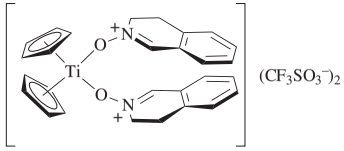
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	R^1	R^2
4a	H	$BnOCH_2$
4b	H	Ph
4c	H	Bn
4d	H	4-$BnOC_6H_4CH_2$
4e	H	4-$PhO_2CC_6H_4CH_2$
4f	*n*-Bu	Ph
4g	*n*-Bu	Bn
4h	*n*-Bu	4-$PhO_2CC_6H_4CH_2$
4i	*n*-Bu	4-$MeOC_6H_4CH_2$



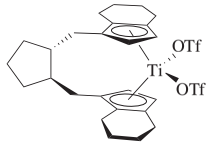
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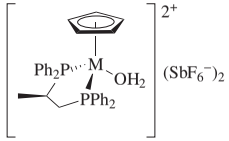
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$Cp_2Ti(OTf)_2$

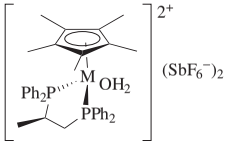
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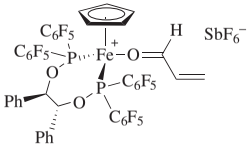
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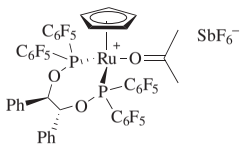
	M
9a	Rh
9b	Ir



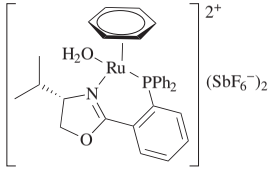
	M
10a	Rh
10b	Ir



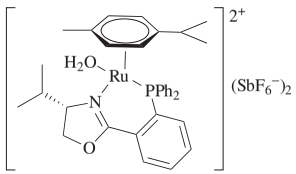
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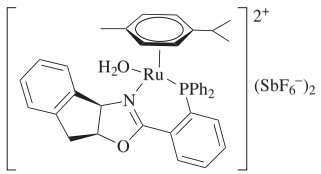
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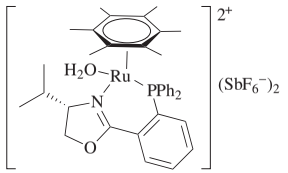
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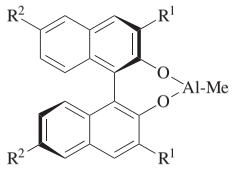
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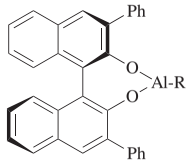
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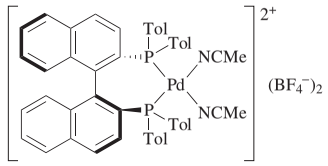
16



	R^1	R^2
17a	H	H
17b	Ph	H
17c	Ph	Br
17d	2,6-$(MeO)_2C_6H_3$	H
17e	2,6-(n-$C_6H_{13}O)_2C_6H_3$	H
17f	2-naphthyl	H
17g	Ph_3Si	H



	R
18a	Cl
18b	I
18c	TfO



19

TABLE 1. INTERMOLECULAR CYCLOADDITIONS OF 4-MEMBERED CYCLIC NITRONES

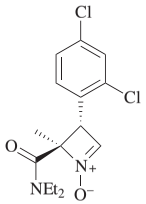
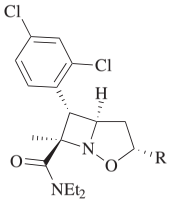
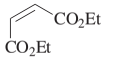
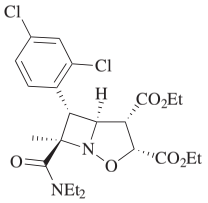
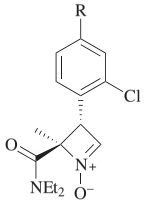
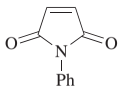
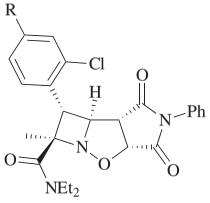
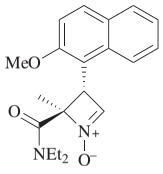
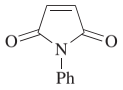
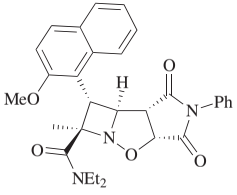
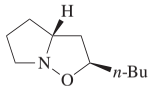
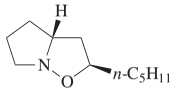
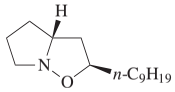
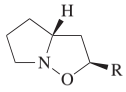
	Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{11}			Alkene (1 eq), benzene, 70°	 R = Ac, 17 h, (64); R = MeO_2C, 10 h, (75)	299
			Alkene (1 eq), benzene, 80°, 33 h	 (75)	299
			Alkene (1 eq), benzene	 R = Cl, 60°, 5 h, (100); R = F, 70°, 21 h, (85)	299
C_{15}			Alkene (1 eq), benzene, 70°, 55 h	 (84)	299

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_4 	$H_2C{=}CH_2$	Alkene (xs), pressure bottle, xylene, 3 atm, 125°, 7 h	 (76)	487
		Toluene, 100°	 (60)	488
		—	 (87)	263
		Toluene, 100°	 (95)	264
		Alkene (*x* eq), toluene, 90°, 48 h		489

R	*x*	
n-$C_{10}H_{21}$	2.2	(77)
n-$C_{14}H_{29}$	1.6	(84)

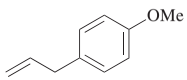
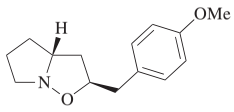
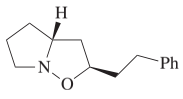
		Alkene (1 eq), toluene, reflux, 4 h	 (70)	490
		Toluene, 110°	 (73)	287

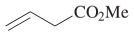
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

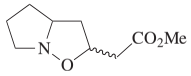
Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

C_4

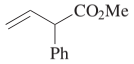




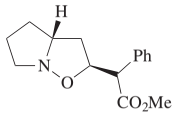
Alkene (1 eq), MW (2450 MHz), neat, 0.25 h



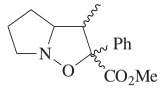
(85) 491



Alkene (0.99 eq), toluene, reflux, 6 h

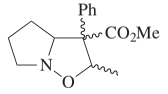


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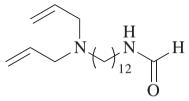


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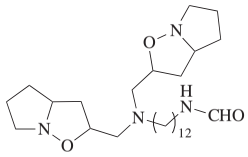
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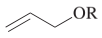
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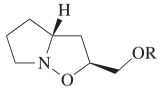
Alkene (0.75 eq), toluene, 90°, 48 h



(63) 489

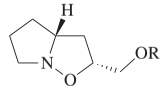


Alkene (*x* eq), solvent



I

+



II 493

R	*x*	Solvent	Temp (°)	Time (h)	**I + II**	**I/II**
H	15	neat	98	2	(79)	76:24
Ac	4.6	toluene	110	0.5	(78)	88:12
TBS	2	toluene	90	1	(61)	92:8

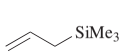
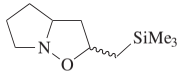
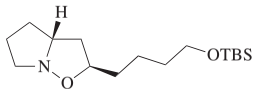
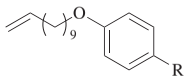
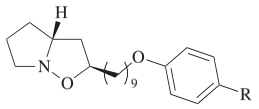
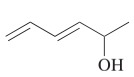
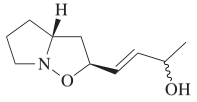
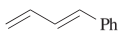
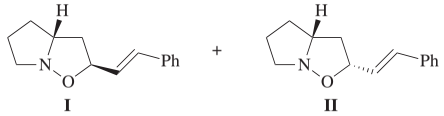
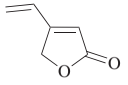
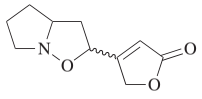
	Alkene (xs), sealed tube, benzene, 110°, 12 h		(63)		494
	Alkene (0.58 eq), toluene, 95°, 3 d		(72)		71
	Alkene (*x* eq), toluene, reflux, 6 h			R *x* H 0.47 (87) MeO 0.43 (83)	495
	Alkene (1.06 eq), benzene, reflux, 3 h		(70)		288
	Toluene	 **I** + **II**		Temp Time (d) **I+ II** **I/II** rt 10 (50) 81:19 110° — (91) 57:43	287
	Alkene (0.5 eq), Et_2O/toluene, 60°, 48 h		(58)		496

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

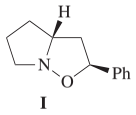
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_4



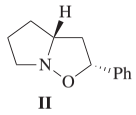


Alkene (5 eq), toluene, 110°, 5 h



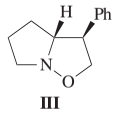
I

+



II

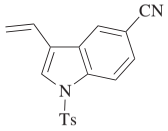
+



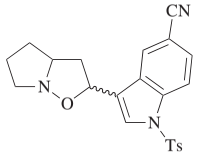
III

493

I + II + III (81), **I/II/III** = 91:8:1

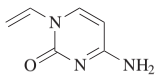


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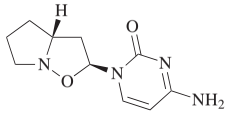


(36)

497

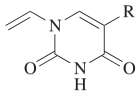


Alkene (0.33 eq), toluene, reflux, 20 h

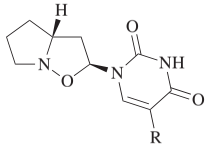


(80) dr 98:2

498

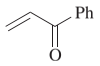


Alkene (0.33 eq), toluene, reflux

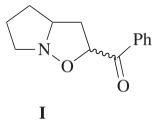


R	Time (h)		dr
H	17	(65)	90:10
Me	6	(95)	98:2

498

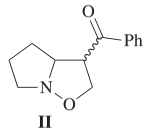


Alkene (1 eq), CH_2Cl_2, rt, 12 h



I

+



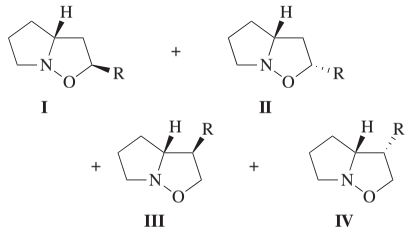
II

499, 500

I + II (68), **I/II** = 6:1, dr **I** 1.4:1

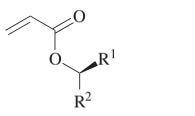


Alkene (*x* eq),
CH_2Cl_2, rt



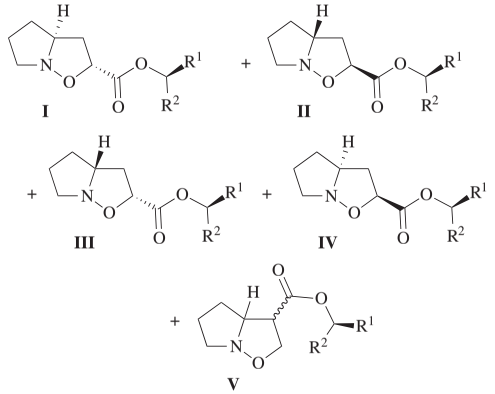
493

R	*x*	Time (h)	**I + II + III + IV**	**I/II/III/IV**
CHO	3	0.5	(58)	5:62:8:25
NC–	5	4	(83)	49:24:21:6
MeO_2C	5.5	2	(89)	43:37:11:9



non-racemic

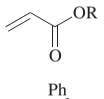
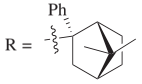
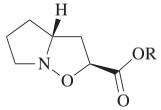
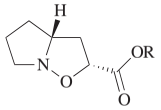
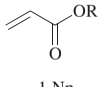
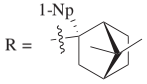
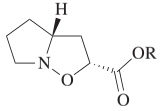
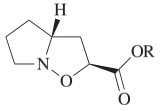
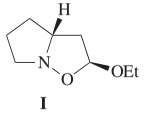
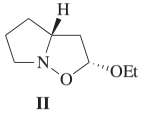
Alkene (0.9 eq),
CH_2Cl_2 or $CHCl_3$, rt



269

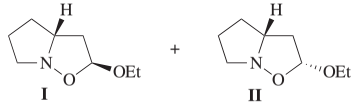
R^1	Time (d)	**I + II + III + IV + V**	**I/II/III/IV**	**(I + II + III + IV)/V**
Me	5	(66)	41:7:38:14	79:21
CF_3	1	(56)	34:15:34:17	59:41
t-Bu	3	(59)	70:11:15:4	88:12

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_4				
	  R = non-racemic	Alkene (0.22 eq), CH_2Cl_2, rt, 8 h	 +  (37) dr 57:43 (32) dr 70:30	268
	  R = non-racemic	Alkene (0.22 eq), CH_2Cl_2, rt, 8 h	 +  (36) dr 95:5 (20) dr >98.5:1.5	268
		Alkene (3 eq), CH_2Cl_2, 60°, 8 h	 +  **I** **II** **I + II** (70), **I/II** = 92:8	493, 501



Alkene (2 eq), catalyst (0.2 eq), solvent, 50°

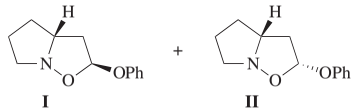


I + **II**

343

Catalyst	Solvent	Time (h)	**I**	**I/II**
$Ti(O\textit{i}\text{-}Pr)_4$	benzene	96	(46)[c]	10:1
$Ti(O\textit{i}\text{-}Pr)_4$	$CHCl_3$	120	(—)	10:1
$Ti(O\textit{i}\text{-}Pr)_2Cl_2$	benzene	21	(15)[c]	2:1
$Ti(O\textit{i}\text{-}Pr)_2Cl_2$	$CHCl_3$	21	(—)	1:1
$Ti(Cp)_2Cl_2$	benzene	35	(25)[c]	10:1
$Ti(Cp)_2Cl_2$	$CHCl_3$	84	(—)	2:1
$TiCl_4$	benzene	7.5	(—)	2:1

Alkene (2 eq), TCE, 50°, 16 h



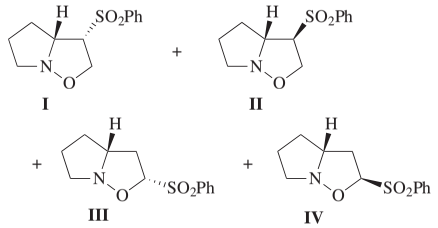
I + **II**

I + **II** (45), **I/II** = 90:10

502



Alkene (1.25 eq), benzene, rt, 6 h



I + **II** + **III** + **IV**

I + **II** + **III** + **IV** (38), **I/II/III/IV** = 1.3:1.1:1.1:1

267

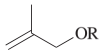
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

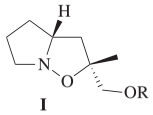
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_4



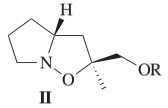


Alkene (*x* eq), solvent



I

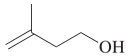
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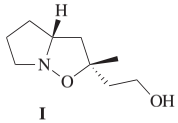
II

493

R	*x*	Solvent	Temp (°)	Time (h)	**I** + **II**	**I/II**
H	6.8	neat	115	2	(70)	85:15
THP	4	toluene	110	2	(50)	70:30
TBS	2.5	toluene	100	2	(53)	64:36
Ac	4	toluene	110	2.5	(72)	78:22

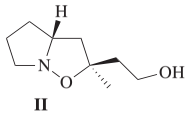


Alkene (10 eq), neat, 90°, 10 h



I

+



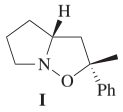
II

275

I + **II** (88), **I/II** = 60:40

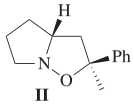


Alkene (4 eq), toluene, 110°, 2 h



I

+



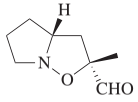
II

493

I + **II** (68), **I/II** = 54:46



Alkene (4 eq), CH_2Cl_2, rt, 4 h

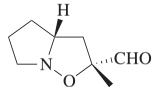


(95)

493



Alkene (*x* eq),
catalyst (0.05 eq),
CH_2Cl_2, 4 Å MS[d]



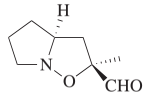
non-racemic

259

x	Catalyst	Temp (°)	Time (h)		er
1.4	**9a**	–25	15	(50)	90.0:10.0
1.4	**9b**	–25	16	(75)	88.0:12.0
7	**9a**	–25	15	(100)	93.0:7.0
7	**9b**	–25	15	(100)	93.0:7.0
7	**9b**	–35	24	(55)	95.5:4.5



Alkene (*x* eq),
catalyst (*y* eq),
2,6-lutidine,
CH_2Cl_2, –20°



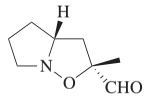
non-racemic

x	Catalyst	*y*		er
0.2	**11**	0.1	(87)	56.0:44.0
1.2	—	—	(45)	—
1.2	**11**	0.05	(92)	98.0:2.0
1.2	**12**	0.05	(61)	72.0:28.0
1.2	**12**	0.05	(88)	84.0:16.0
1.2	**11**	0.1	(84)	63.0:37.0
5.0	**11**	0.1	(85)	77.0:23.0

82

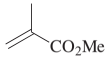


Alkene (1.4 eq),
13 (0.05 eq),
CH_2Cl_2, 4 Å MS,
–25°, 16 h

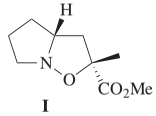


(92) er 69.5:30.5

348

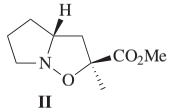


Alkene (7 eq),
CH_2Cl_2, 40°, 3 h



I

+



II

I + II (84), **I/II** = 95:5

493

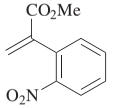
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

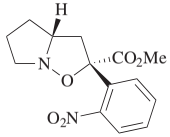
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

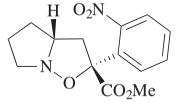
C_4

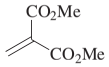




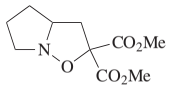
Alkene (0.5 eq), sealed vessel, dry toluene, MW, 150°, 0.5 h



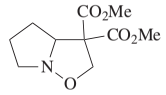
(40) +  (6) 503



Alkene (1.1 eq), CH_2Cl_2, –18°, 1 h



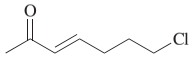
I

\+ 

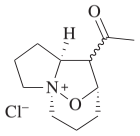
II

493

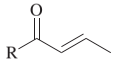
I + II (74), **I/II** = 22:78

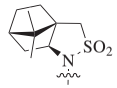


Alkene (0.7 eq), $CHCl_3$, reflux, 48 h



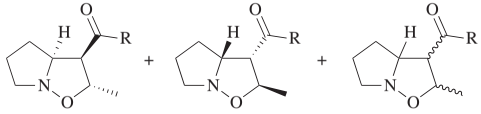
(—) 296



R = 

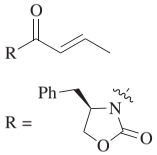
non-racemic

Additive (1.5 eq), CH_2Cl_2, 35°



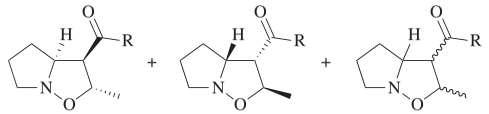
I **II** **III** 255

Additive	Pressure	Time (h)	**I + II + III**	**I/II/III**
—	—	24	(99)	54:27:19
ZnI_2	—	96	(30)	78:4:18
ZnI_2, 4 Å MS	10 Kbar	24	(74)	71:18:11



non-racemic

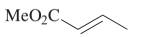
Additive (1.5 eq), CH_2Cl_2, 35°



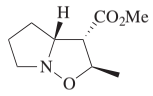
I + **II** + **III**

255

Additive	Time (h)	**I + II + III**	**I/II/III**
—	24	(84)	45:50:5
ZnI_2	48	(53)	82:13:5

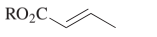


Toluene, 100°

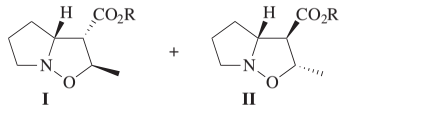


(82)

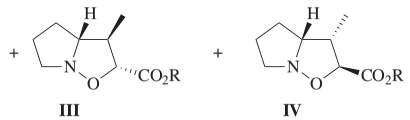
141, 277



Alkene (3 eq), solvent



I + **II**



III + **IV**

275, 504, 505, 506

R	Solvent	Temp (°)	Time (h)	**I + II + III + IV**	**I/II/III/IV**
Me	CH_2Cl_2	40	2	(72)	95:2:3:0
Me	C_6D_6	128	8	(—)	65:35:0:0
i-Pr	CH_2Cl_2	50	48	(79)	90:6:4:0
t-Bu	CH_2Cl_2	50	48	(73)	78:11:10:1
t-Bu	C_6D_6	128	8	(—)	55:36:8:1

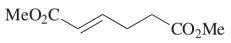
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

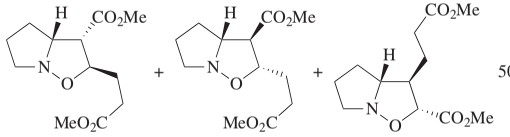
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_4





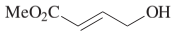
Alkene (0.59 eq), toluene, reflux, 4 h



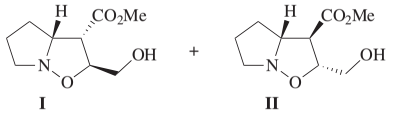
I (71) **II** **III**

I/II/III = 33:3:1

507



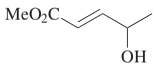
Alkene (0.5 eq), CH_2Cl_2, rt, 36 h



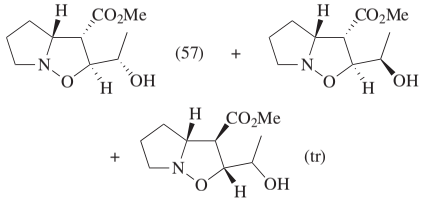
I **II**

I + **II** (95), **I/II** = 85:15

506

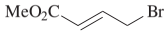


Alkene (0.3 eq), $CHCl_3$, reflux, 40 h



(57) + (28) + (tr)

508

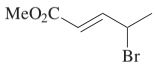


Alkene (0.4 eq) toluene, 100°, 14 h

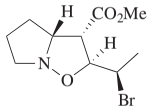


(54) + (10)

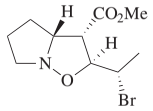
509



Alkene (0.4 eq), toluene, 100°, 24 h

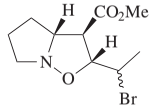


(51) +

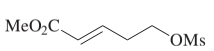


(14) 509

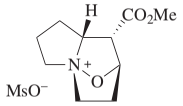
+



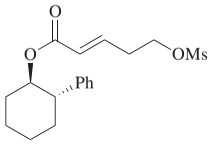
(11)



Alkene (0.66 eq), toluene, 0°, 3 h; then rt, 12 h

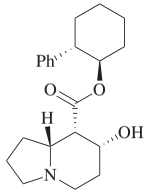


(48)[e] 297



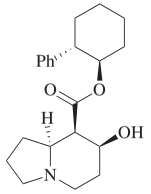
non-racemic

1. Alkene (0.5 eq), toluene, rt, 4 d
2. H_2, Pd/C



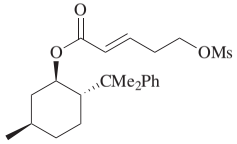
I

+



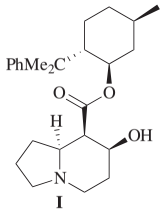
II 256

I + **II** (60)[e], **I/II** = 2.3:1



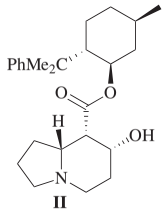
non-racemic

1. Alkene (0.5 eq), toluene, rt, 15 d
2. H_2, Pd/C



I

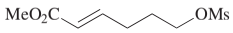
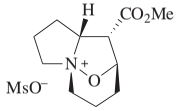
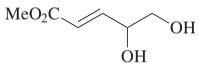
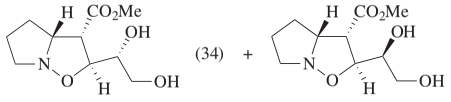
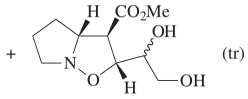
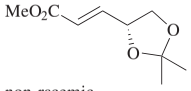
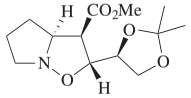
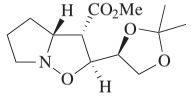
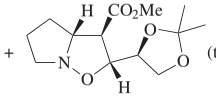
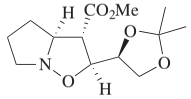
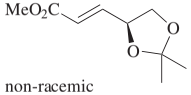
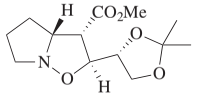
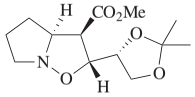
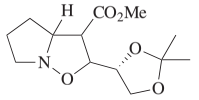
+



II 256

I + **II** (53)[e], **I/II** = 3.7:1

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_4				
		Alkene (0.4 eq), $CHCl_3$, reflux, 24 h	 (—)[e]	296
		Alkene (0.66 eq), $CHCl_3$, reflux, 24 h	 (34) + (49) +  (tr)	508
non-racemic		Alkene (0.5 eq), $CHCl_3$, reflux, 48 h	 (70) +  (14) +  (tr) +  (tr)	508
non-racemic		Alkene (0.5 eq), $CHCl_3$, reflux, 48 h	 (70) +  (14) +  (2) both *exo*-CO_2Me isomers	510

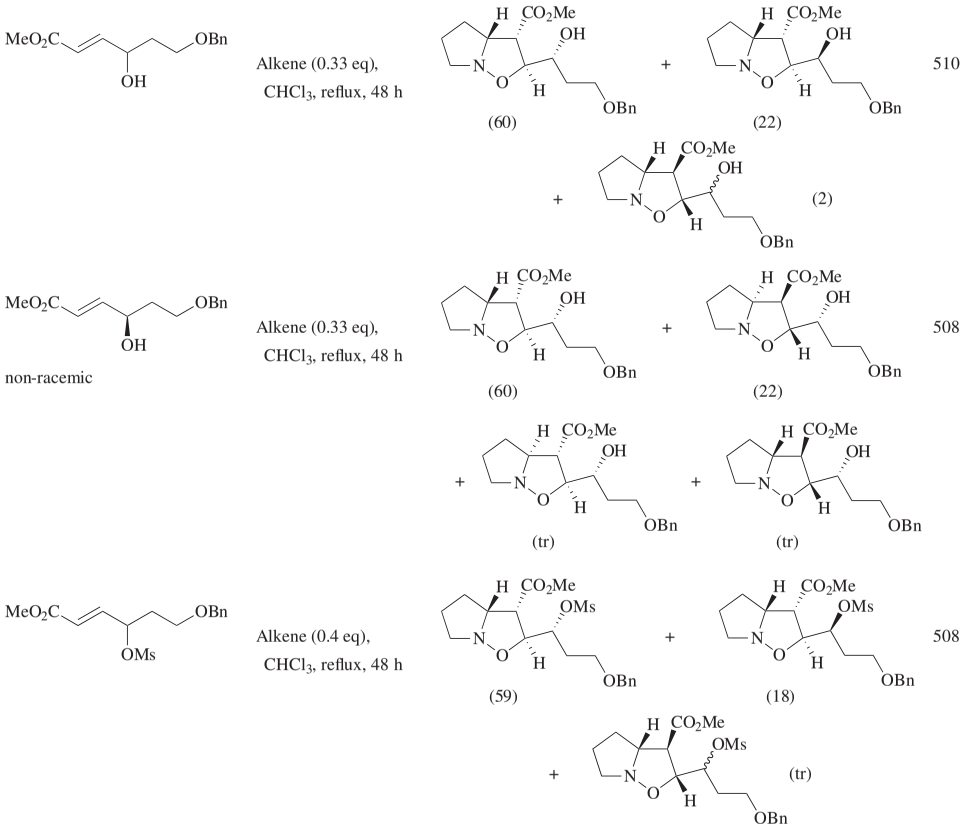
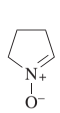

MeO2C
OBn
OH
Alkene (0.33 eq),
CHCl3, reflux, 48 h
H
CO2Me
OH
N
O
H
OBn
(60)
(22)
(2)
510
non-racemic
508
OMs
(59)
(18)
(tr)

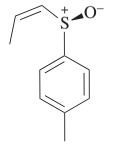
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

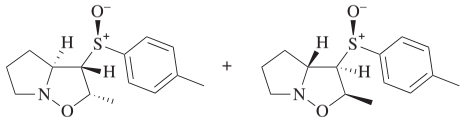
C_4





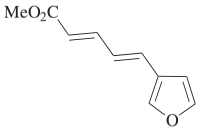
non-racemic

Alkene (0.2–0.3 eq), Et_2O, rt, 7–10 d

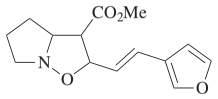


I + **II** (72), **I**/**II** = 87:13

683

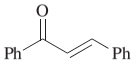


Alkene (2 eq), benzene, reflux

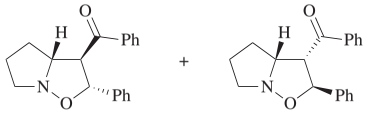


(73)

291

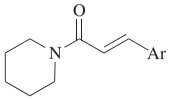


Alkene (15 eq), N_2, dry toluene, 82°

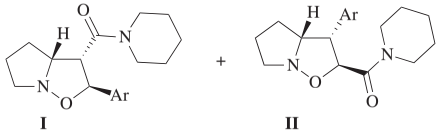


Time (h)	**I**	**II**	**I** + **II**	**I**/**II**
4	(—)	(—)	(30)	64:36
14	(34)	(20)	—	—

511

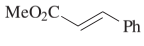


Alkene (1 eq), toluene, 110°, 12 h

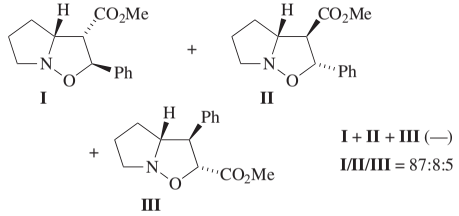


Ar	**I**	**II**
Ph	(30)	(22)
4-ClC_6H_4	(28)	(16)

512

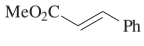


EtOH, reflux, 4 h

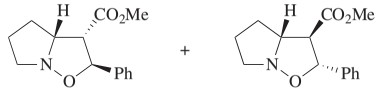


I + **II** + **III** (—)
I/II/III = 87:8:5

275

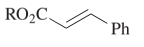


Alkene (15 eq), N_2, dry toluene, 82°

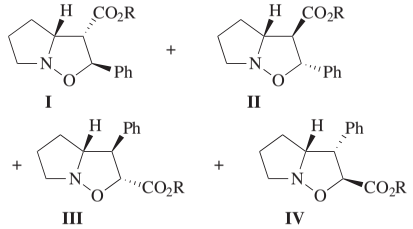


Time (h)	**I**	**I + II**	**I/II**
4	(—)	(20)	89:11
8	(—)	(19)	87:13
14	(11)	(19)	65:35

511



Alkene (2 eq), solvent



R	Solvent	Temp (°)	Time (h)	**I + II + III + IV**	**I/II/III/IV**
Me	benzene	80	4	(73)	87:8:5:0
i-Pr	toluene	80	6	(81)	79:10:9:2
t-Bu	toluene	80	6	(75)	71:10:15:4
t-Bu	C_6D_6	128	8	(—)	25:75:0:0

275, 504, 505, 506

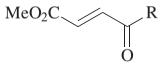
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

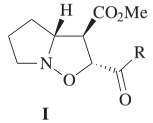
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_4



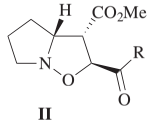


Alkene (0.5 eq), solvent



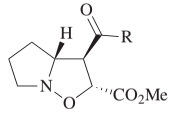
I

+



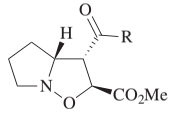
II

+



III

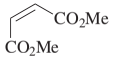
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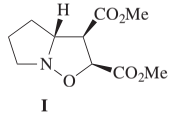
IV

R	Solvent	Temp	Time (h)	**I**	**II**	**III**	**IV**
Me	CH_2Cl_2	rt	72	(56)	(27)	(4)	(—)
Me	toluene	110°	10	(40)	(35)	(5)	(—)
i-Pr	CH_2Cl_2	rt	72	(60)	(21)	(—)	(—)
$BnO(CH_2)_2$	CH_2Cl_2	rt	48	(65)	(22)	(tr)	(—)

282

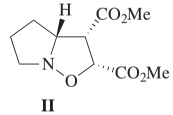


$CHCl_3$, 50°, 4 h



I

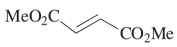
+



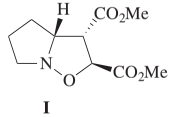
II

I + **II** (88), **I**/**II** = 83:17

506

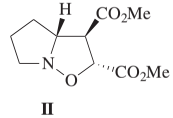


Alkene (1.4 eq), CH_2Cl_2, 40°, 1 h



I

+



II

I + **II** (79), **I**/**II** = 45:55

506, 513

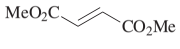
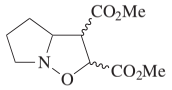
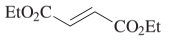
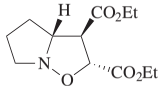
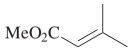
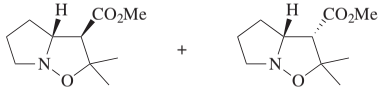
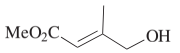
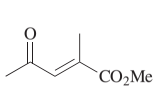
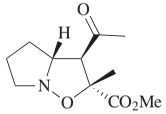
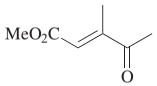
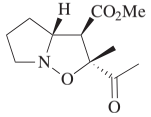
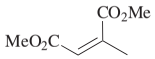
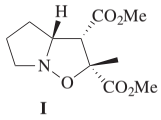
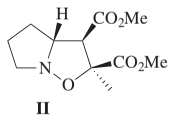
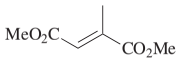
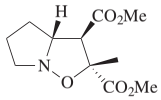
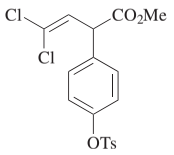
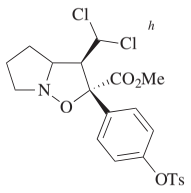
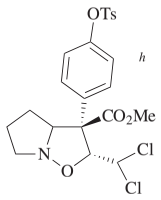
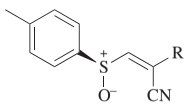
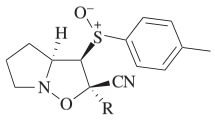
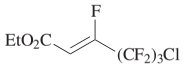
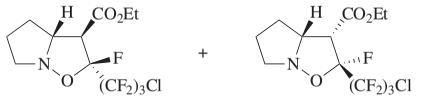
f 		Alkene (1 eq), Ar, $MeCN/H_2O$, reflux, 2 h		(76)	247
g 		CH_2Cl_2, rt, 14 h		(84)	514
		Alkene (0.75 eq), toluene, 80°, 6 h	 **I** + **II** (77), **I/II** = 50:50		515
		—	 **I** + **II** (75), **I/II** = 60:40		515
		Alkene (0.5 eq), CH_2Cl_2, rt, 18 d		(87)	282

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_4 		Alkene (0.5 eq), CH_2Cl_2, rt, 14 d	 (86)	282
		Alkene (1.2 eq), toluene, 85°, 6 h	 +  **I** **II** **I** + **II** (74), **I**/**II** = 70:30	515
		Alkene (0.9 eq), $CHCl_3$, reflux, 2 h	 (86)	515
		Alkene (1 eq), toluene, reflux, 4 h	 (52)[i] +  (10)[i]	492
		81°, 1–3 d	 R: *n*-Bu (61); *t*-Bu (61)	518

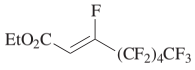


Alkene (0.5 eq),
CH_2Cl_2, rt, 3 d

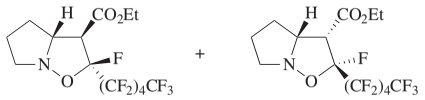


I + **II** (78), **I/II** = 96:4

516, 517

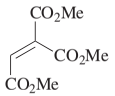


Alkene (0.5 eq),
CH_2Cl_2, rt, 3 d

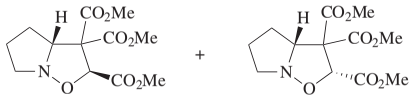


I + **II** (78), **I/II** = 80:20

516

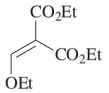


Alkene (1 eq),
CH_2Cl_2, –15°, 0.5 h



I + **II** (—), **I/II** = 66:34

275



Alkene (1.4 eq),
CH_2Cl_2, 20°, 48 h



I + **II** (81), **I/II** = 72:28

515

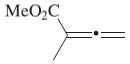
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

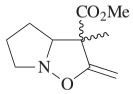
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_4



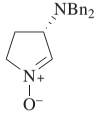


Alkene (1 eq), benzene, 50°, 2 h

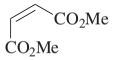


(70)

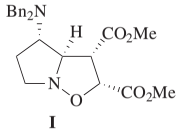
293



non-racemic

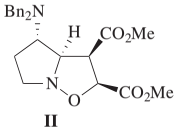


Alkene (1.2 eq), benzene, 40°, 3 d



I

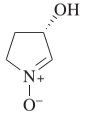
\+



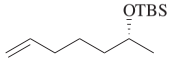
II

I + **II** (63), **I**/**II** = 4:1

301

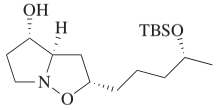


non-racemic



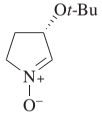
non-racemic

Alkene (1.8 eq), toluene, 110°, 24 h

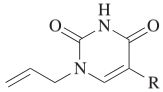


(67)

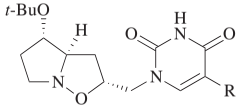
519



non-racemic

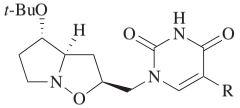


Alkene (1.1 eq), toluene, 80°, 72 h



I

\+



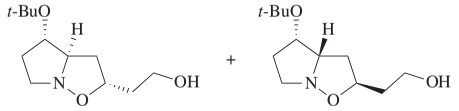
II

469

R	Time (h)	**I** + **II**	**I**/**II**
Me	72	(97)	84:16
F	56	(95)	80:20



Alkene (xs),
neat, rt, 10 d



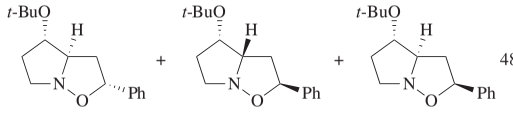
I **II**

I + **II** (71), **I**/**II** = 8:1

124



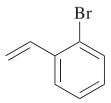
Alkene (1.5 eq),
benzene, 60°, 1 d



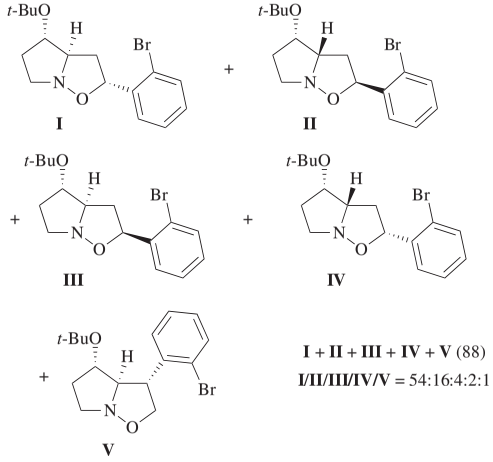
I **II** **III**

I + **II** + **III** (88), **I**/**II**/**III** = 15:3:1

480



Alkene (1.5 eq),
toluene, MW (100 W),
85°, 3 h



I **II** **III** **IV** **V**

I + **II** + **III** + **IV** + **V** (88)
I/**II**/**III**/**IV**/**V** = 54:16:4:2:1

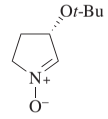
520

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

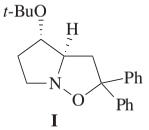
C_4

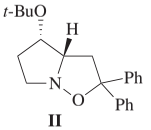


non-racemic



Alkene (1.5 eq), benzene, 60°, 2 d

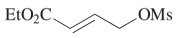


I + 

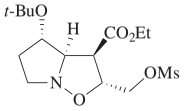
II

479

I + **II** (41), **I**/**II** = 3:1

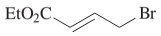


Toluene, rt, 7 d

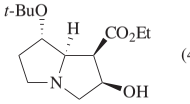


(—)

474

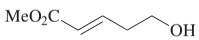


1. Alkene (0.9 eq), toluene, rt, 3 h
2. Raney/Ni, H_2
3. Ambersep 900

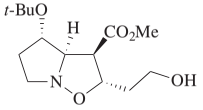


(46)

521

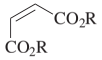


Alkene (1 eq), toluene, 60°, 1 d

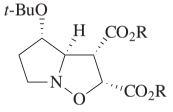


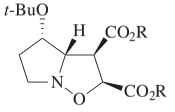
(77)

60



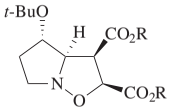
Alkene (1.2 eq), benzene, rt



I + 

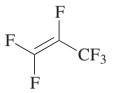
II

301

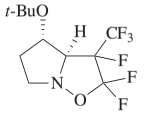


III

R	Time (d)	**I + II + III**	**I/II/III**
Me	3	(89)	5:1:1
i-Pr	2	(97)	5:1:1

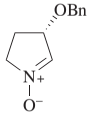


Alkene (4.2 eq), pressure vial, MeCN, rt, 25 h

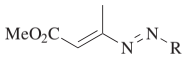


(81) dr 3.8:1

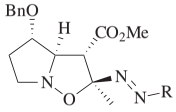
283



non-racemic



Alkene (*x* eq), solvent



522

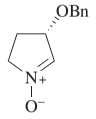
R	*x*	Solvent	Temp (°)	Time (h)	
PhHNCO	1	neat	60	3	(50)
PhHNCO	1	MeCN	60	7	(68)
PhHNCO	1	THF	60	9	(46)
PhHNCO	2	neat	60	3	(71)
PhHNCO	2	$CHCl_3$	60	17	(44)
PhHNCO	2	MeOH	60	24	(—)
PhHNCO	2	EtOAc	75	4	(53)
t-BuO_2C	2	neat	60	3	(69)
MeO_2C	2	neat	60	2	(54)

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

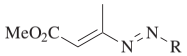
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

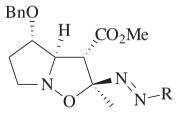
C_4



non-racemic

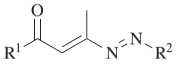


Alkene (1 eq), MW (300 W), neat, 70°

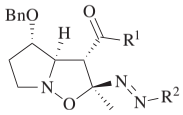


R	Time (s)		dr
PhHNCO	60	(80)	9:1[j]
t-BuO_2C	60	(73)	5:1[j]
MeO_2C	42	(69)	—

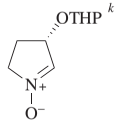
522



Alkene (2 eq), sealed vial, MeCN, 60°



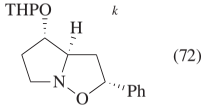
R^1	R^2	Time (h)		
Me_2N	PhHNCO	9	(74)	522
MeO	H_2NCO	5	(52)	
MeO	PhHNCO	9	(91)	
MeO	*t*-BuO_2C	9	(78)	
MeO	MeO_2C	2	(68)	
MeO	4-$O_2NC_6H_4$	9	(86)	
EtO	H_2NCO	5	(54)	

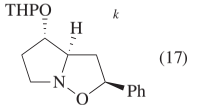


non-racemic



Alkene (2 eq), toluene, 80°, 11 h

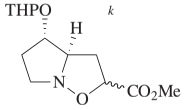


(72) +  (17)

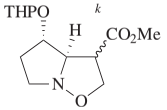
60, 219, 220



Alkene (1.3 eq), CH_2Cl_2, rt, 12 h



I

+ 

II

354

I + **II** (78)

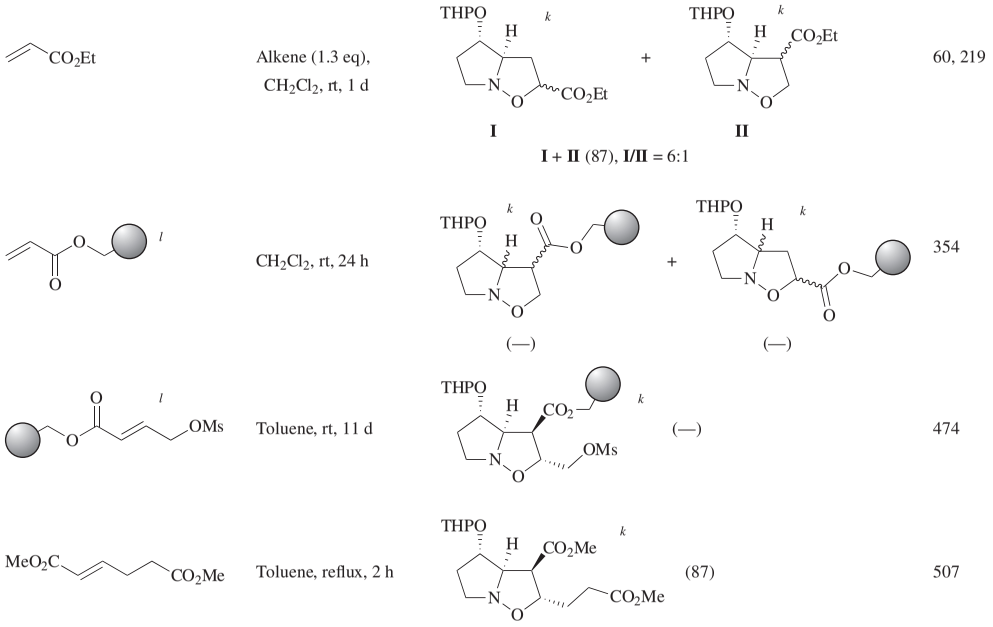
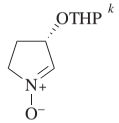
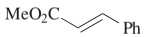
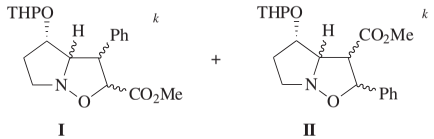
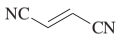
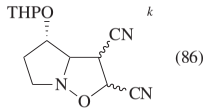
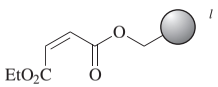
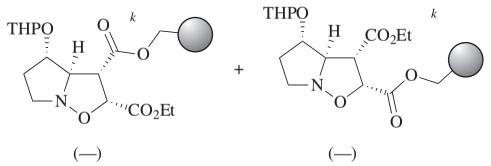
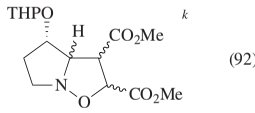
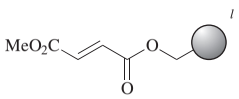
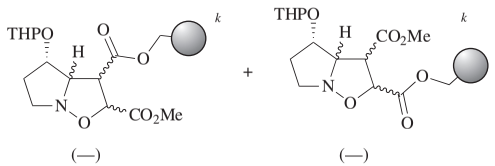
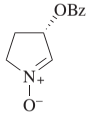
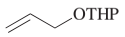

CO2Et
Alkene (1.3 eq),
CH2Cl2, rt, 1 d
THPO
H
k
N
O
CO2Et
+
I
II
I + II (87), I/II = 6:1
60, 219
l
CH2Cl2, rt, 24 h
(—)
354
OMs
Toluene, rt, 11 d
CO2
474
MeO2C
CO2Me
Toluene, reflux, 2 h
(87)
507

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

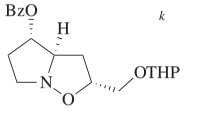
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*				
C_4  non-racemic		Alkene (1.1 eq), toluene, 110°, 48 h	 **I** + **II** (51)	354
		Alkene (1.3 eq), CH_2Cl_2, rt, 1 d	 (86)	60, 356
		CH_2Cl_2, rt, 14 d	 (—) (—)	474
		Alkene (1.2 eq), toluene, 60°, 2.5 h	 (92)	354
		Toluene, 60°, 2.5 h	 (—) (—)	354



non-racemic

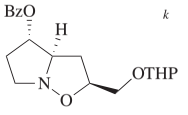


Alkene (2.2 eq),
toluene, rt, 8 h



I

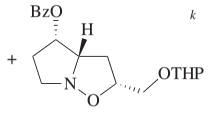
+



II

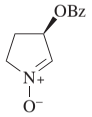
523

+

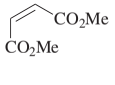


III

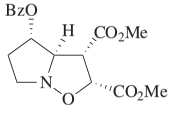
I + **II** + **III** (quantitative)
I/II/III = 65:22:13



non-racemic

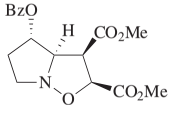


Alkene (1.2 eq),
benzene, rt, 3 d



I

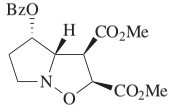
+



II

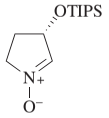
301, 479

+

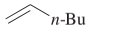


III

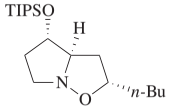
I + **II** + **III** (88)
I/II/III = 4:1.5:1



non-racemic



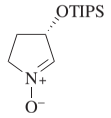
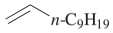
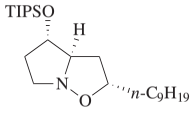
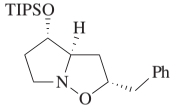
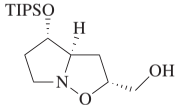
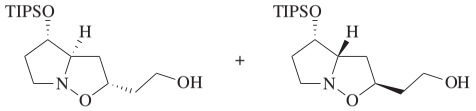
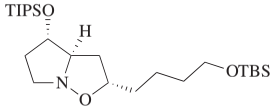
Toluene

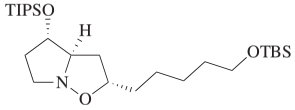
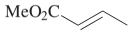
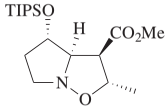
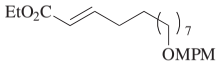
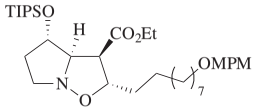
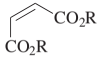
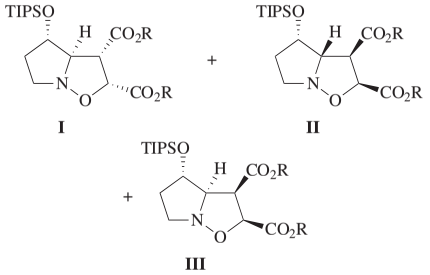


(83)

524

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

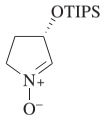
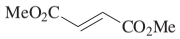
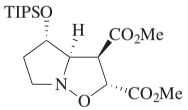
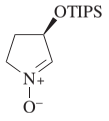
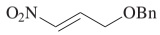
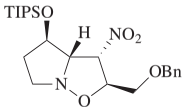
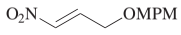
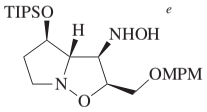
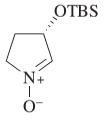
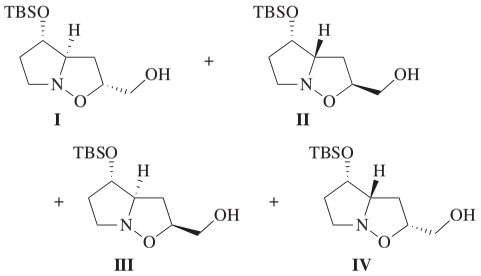
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_4				
 non-racemic		Alkene (5 eq), toluene, 90°, 9 h	 (75)	141, 394
		Toluene, 90°	 (79)	525
		Alkene (xs), neat, 90°, 30 h	 (77)	395, 524
		Benzene, rt, 15 d	 **I** **I** (63), **I/II** = 7.5:1 **II**	526
		Alkene (2 eq), toluene, 100°, 12 h	 (88)	527

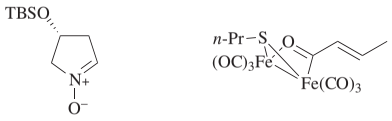
	Alkene (2 eq), toluene, 100°, 12 h		(78)	527
	Alkene (2 eq), toluene, 80°, 4 h		(93)	524, 528
	Alkene (1.17 eq), toluene, 90°, 19 h		(102)[m]	141, 394
	Alkene (1.2 eq), benzene, rt			

I **II** **III**

R	Time (d)	**I + II + III**	**I/II/III**	
Me	3	(100)	5.5:1.4:1	301
i-Pr	5	(91)	6:1.6:1	301, 526

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

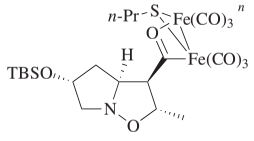
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*				
C_4  non-racemic		Toluene, 80°	 (89)	524
 non-racemic		Alkene (1 eq), neat, 40°, 0.5 h	 (95)	529
		1. Alkene (1.05 eq), neat, 40°, 0.5 h 2. DBU, CH_2Cl_2, –50°, 1 h 3. Zn, AcOH, 0°, 5 h	 [e] (72)	302, 530
 non-racemic		Alkene (xs), neat, 96°, 3 d	 **I** + **II** + **III** + **IV** (76), **I/II/III/IV** = 23:5:4:1	67



non-racemic

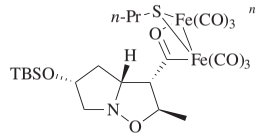
Alkene (0.83 eq), EtOAc, rt

Time (h)	**I**	dr **I**	**II**
3[a]	(50)	>20:1[j]	(—)
6	(—)	—	(21)



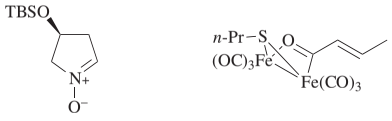
I

+



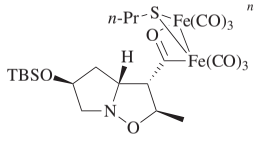
II

308



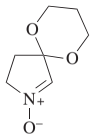
non-racemic

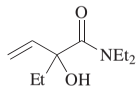
EtOAc, rt



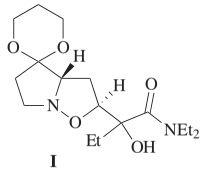
(—)[j]

308



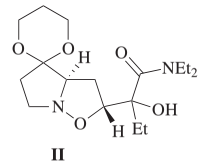


THF, 80°, 2 h



I

+

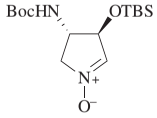
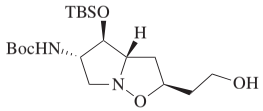
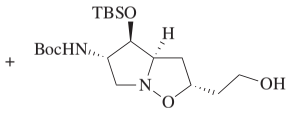
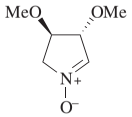
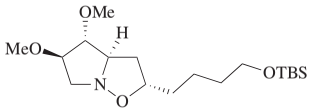
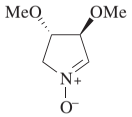
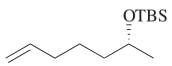
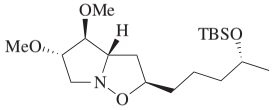
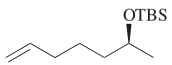
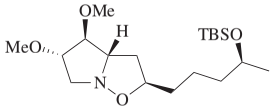


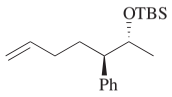
II

I + **II** (60), **I**/**II** = 1:1

531

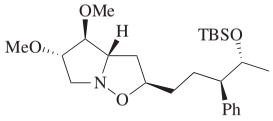
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_4				
 non-racemic		Benzene, 60°, 2 d	 **I** +  **II**	**I + II** (89) **I/II** = 10.7:1	532
 non-racemic		Toluene, 100°		(—)	71
 non-racemic	 non-racemic	Alkene (2 eq), toluene, 95°, 24 h		(48)	533
	 non-racemic	Alkene (2 eq), toluene, 95°, 24 h		(71)	533



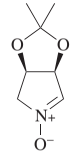
non-racemic

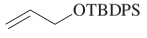
Toluene, 95°



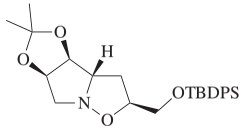
(—)

533



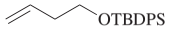


Alkene (2 eq),
toluene, reflux, 10 h

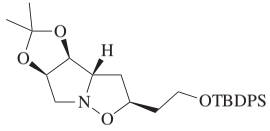


(95)

534, 535

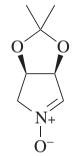


Alkene (1.1 eq),
toluene, reflux, 36 h



(92)

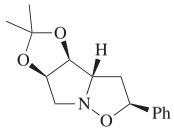
534, 535



non-racemic

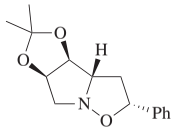


Toluene, reflux, 3 h



I

+



II

I + **II** (89), **I**/**II** = 20:1

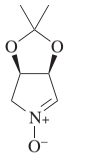
179

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

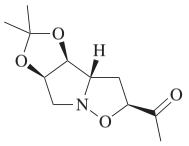
Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

C_4

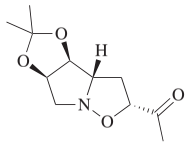




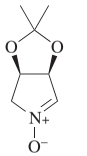
Alkene (1.5 eq), CH_2Cl_2, reflux, 2 d



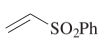
(57) +



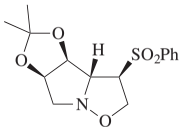
(35) 536



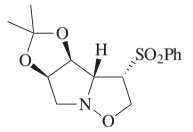
non-racemic



Alkene (1.2 eq), solvent



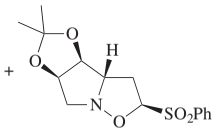
+



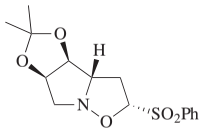
267, 537

I **II**

+



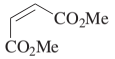
+



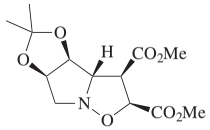
III **IV**

Solvent	Temp (°)	Time (h)	**I + II + III + IV**	**I/II/III/IV**
THF	–78	7	(27)	27:26:16:31
THF	rt	16	(76)	35:32:19:14
CH_2Cl_2	–78	6	(30)	32:32:11:26
CH_2Cl_2	rt	4	(77)	33:33:11:24
toluene	–78	7	(26)	24:23:13:41
toluene	rt	6	(98)	38:38:13:13
toluene	rt	24	(80)[p]	23:27:31:19
toluene	85	12	(89)	23:47:17:12

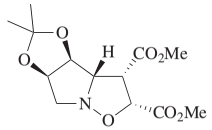




Alkene (2 eq), benzene, rt, 1 d



+

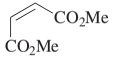


301

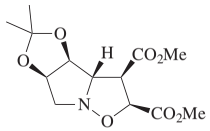
I **I + II** (85), **I/II** = 1.6:1 **II**



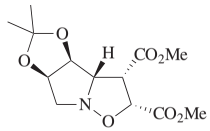
non-racemic



Alkene (1.1 eq), toluene, 70°, 5 h

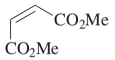


+

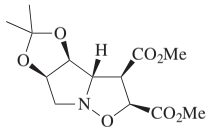


538

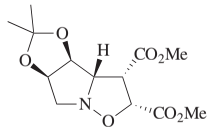
(49) (42)



Alkene (2 eq), CH_2Cl_2, 20°, 15 h



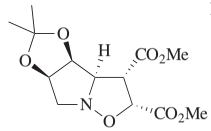
+



181

I **II**

+



III

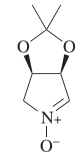
I + II + III (92), **I/II/III** = 9.6:6:1

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

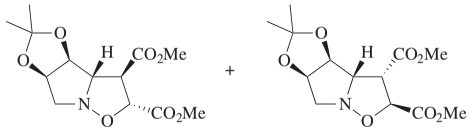
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_4



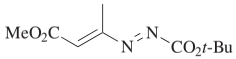
non-racemic

Alkene (1.1 eq), toluene, 70°, 2 h

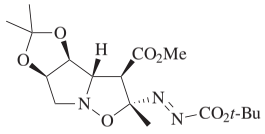


I **I + II** (93), **I/II** = 1:1 **II**

538

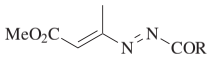


Alkene (2 eq), neat, 60°, 3 h

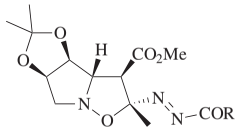


(61)

522

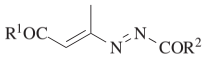


Alkene (1 eq), MW (300 W), neat, 70°

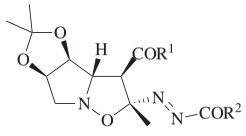


R	Time (s)	
PhHN	62	(68)
t-BuO	80	(82)
MeO	100	(80)

522

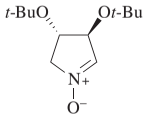


Alkene (2 eq), sealed vial, MeCN, 60°, 3 h

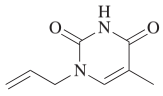


R^1	R^2	
MeO	PhHN	(66)
MeO	*t*-BuO	(72)
MeO	MeO	(67)
EtO	H_2N	(78)

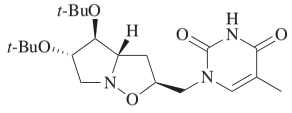
522



non-racemic

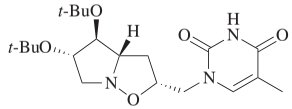


Alkene (1.1 eq), sealed tube, toluene



I

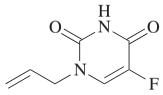
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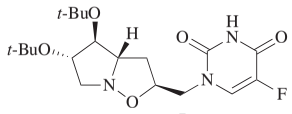
II

	Temp (°)	Time (h)	**I + II**	**I/II**
—	80	72	(71)	88:12
MW	80	5	(52)	88:12
MW	120	2	(50)	88:12

469

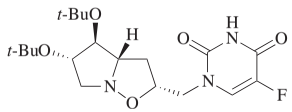


Alkene (1.1 eq), toluene, 80°, 66 h



I

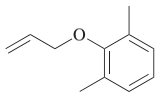
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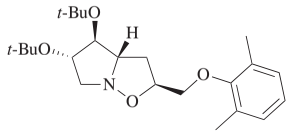
II

I + II (76), **I/II** = 91:9

469



Toluene, rt, 3 d



(48)

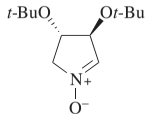
78

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

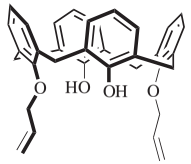
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

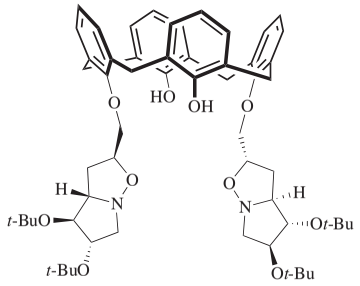
C_4



non-racemic



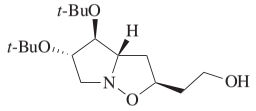
Alkene (1 eq), toluene, 60°, 3 d



(29) 78

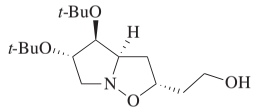


Alkene (5 eq), sealed vessel, solvent



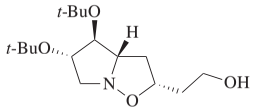
I

+



II

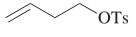
+



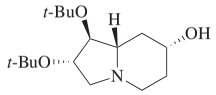
III

539, 303, 540, 77

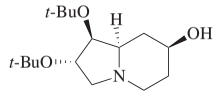
Solvent		Temp (°)	Time (h)	**I + II + III**	**I/II/III**
benzene	—	60	48	(100)	10:2:1
benzene	—	100	1.5	(75)	5:1:0
toluene	MW (150 W)	130	0.33	(88)	10:1:0



1. Alkene (4 eq), neat, rt, 3 d
2. Zn (15 eq), AcOH, Et_2O, rt, 24 h

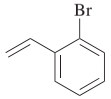


(60)[e]

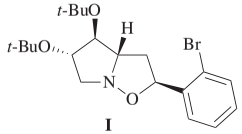


(14)[e] dr 6:1

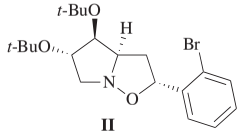
540



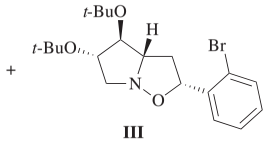
Alkene (1.5 eq), MW (100 W), toluene, 70°, 5 h



I



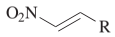
II



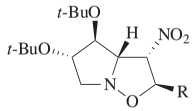
III

I + **II** + **III** (99), **I/II/III** = 12:3.5:1

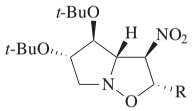
467



Alkene (1 eq), toluene, rt, 12 h



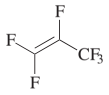
I



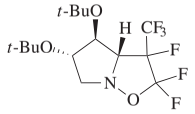
II

R	**I** + **II**	**I**/**II**
CF_3	(94)	85:15
CF_2Cl	(93)	92:8

541



Alkene (4.2 eq), pressure vial, MeCN, rt, 25 h



(71) dr 3.4:1

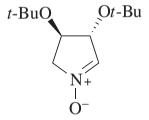
283

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

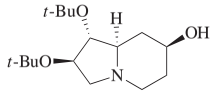
C_4

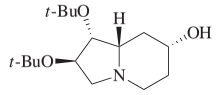


non-racemic



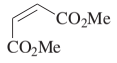
1. Alkene (4 eq), neat, rt, 3 d
2. Zn (15 eq), AcOH, Et_2O, rt, 24 h



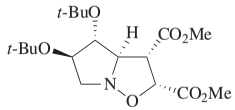
(60)[e] + 

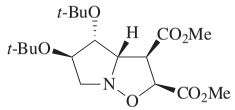
(14)[e]

540

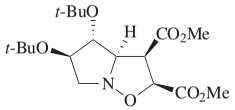


Alkene (1.2 eq), benzene, rt, 3 d



I + 

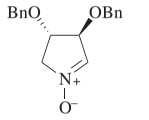
II

+ 

III

I + **II** + **III** (94), **I/II/III** = 13:1.4:1

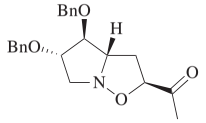
301



non-racemic

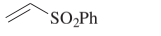


Alkene (1.5 eq), CH_2Cl_2, reflux, 2 d

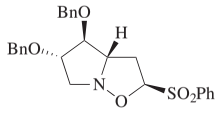


(85)

536

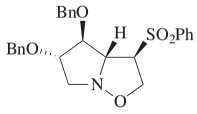


Alkene (1.25 eq), benzene, rt, 6 h



I

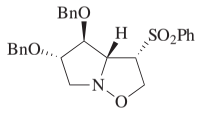
+



II

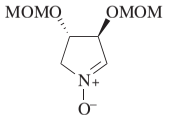
267

+



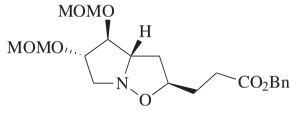
III

I + **II** + **III** (45), **I**/**II**/**III** = 2.5:1.2:1



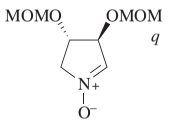
non-racemic

Alkene (1 eq), toluene, reflux, 4 d



(44)

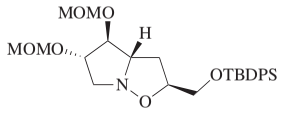
534



q

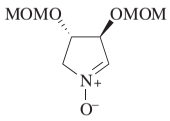
non-racemic

Alkene (1.1 eq), $CHCl_3$, reflux, 2 d



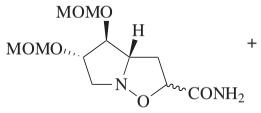
(35)

534, 535





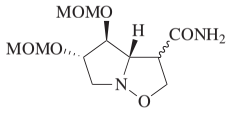
Alkene (1.5 eq), toluene, 90°, 0.5 h



I

I + **II** (91)

+



II

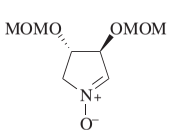
542

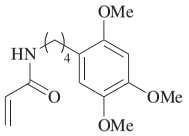
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

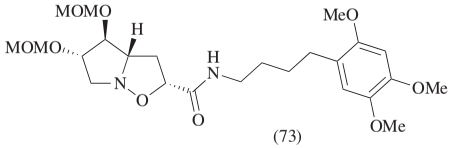
Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

C_4



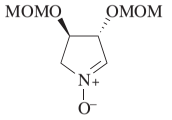


Alkene (0.95 eq), toluene, 90°, 2 h

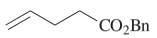


(73)

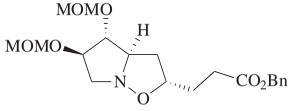
542



non-racemic

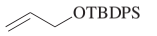


Alkene (1 eq), toluene, reflux, 4 d

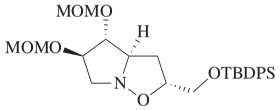


(52)

534

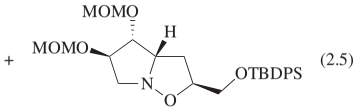


Alkene (1 eq), toluene, reflux, 4 d



(47)

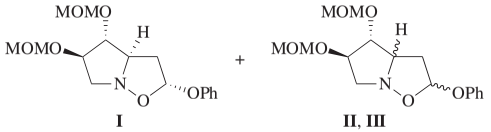
534



(2.5)



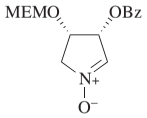
Alkene (2 eq), TCE, 50°, 16 h



I **II**, **III**

I + **II** + **III** (80), **I**/**II**/**III** = 80:13:7

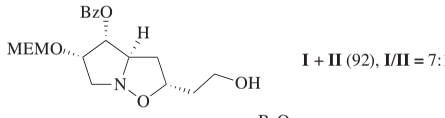
502



non-racemic

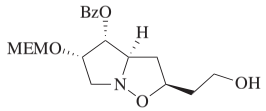


Benzene, 60°, 43 h



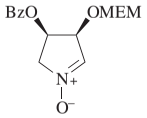
I

\+



II

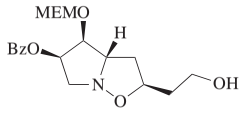
I + II (92), **I/II** = 7:1 543



non-racemic

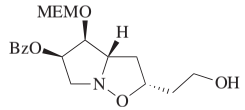


Benzene, 60°, 43 h



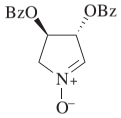
I

\+



II

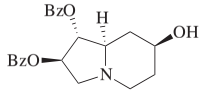
I + II (97), **I/II** = 7:1 543



non-racemic

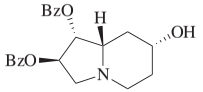


1. Alkene (5 eq), sealed vial, toluene, 100°, 1.5 h
2. MsCl (1 eq), Et_3N (1.3 eq), CH_2Cl_2, 0°, 1 h
3. H_2 (1 atm), 10% Pd/C, MeOH, rt, 15 h



(44)[e]

\+



(14)[e]

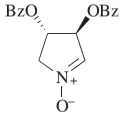
544

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

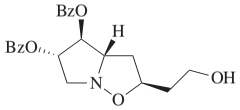
C_4



non-racemic

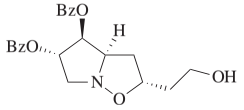


Alkene (5 eq), toluene, 100°, 1.25 h



I

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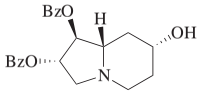


II

I + II (85), **I/II** = 76:24 — 545

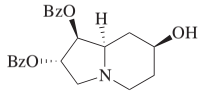
1. Alkene (5 eq), sealed vial, toluene, 100°, 1.5 h
2. MsCl (1 eq), Et_3N (1.3 eq), CH_2Cl_2, 0°, 1 h
3. H_2 (1 atm), 10% Pd/C, MeOH, rt, 15 h





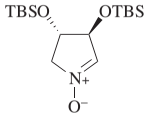
(44)[e]

\+



(11)[e]

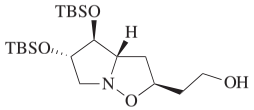
544



non-racemic

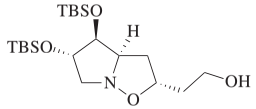


Alkene (5 eq), sealed vessel, benzene, 60°, 3 d



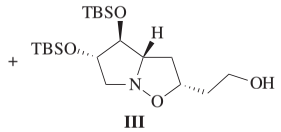
I

\+

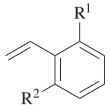


II

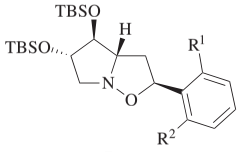
I + II + III (74), **I/II/III** = 6:2:1 — 303, 539



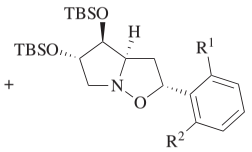
III



Alkene (*x* eq), MW (100 W), toluene, 70°



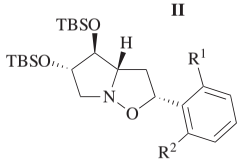
I



II

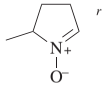
467

R^1	R^2	*x*	Time (h)	**I + II + III**	**I/II/III**
Cl	Cl	0.8	1.75	(94)	6.8:6.4:1
Br	H	1	2	(92)	18.4:11.6:1



III

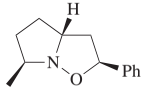
C_5



r



Alkene (2.2 eq), toluene, 55–60°, 48 h



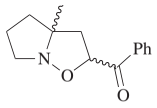
(66)

139, 546



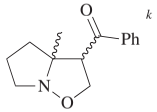


Alkene (1 eq), benzene, rt, 48 h



I

+



k

II

I (—) dr 5.6:1
I + II (71)
I/II = 3:1

500

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

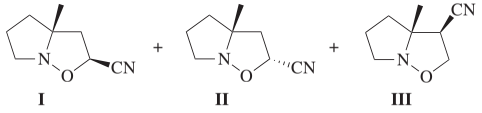
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_5

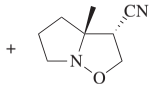




Alkene (5 eq), rt, 3 d



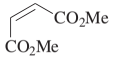
I + **II** + **III**



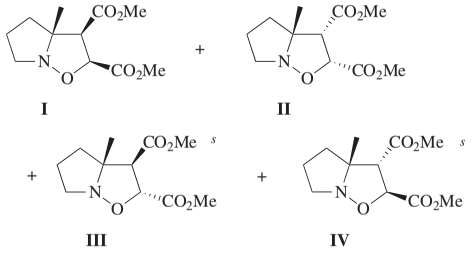
IV

I + **II** + **III** + **IV** (85)
I/II/III/IV = 56:16:5:23

547



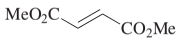
Alkene (1 eq), $CHCl_3$, reflux, 14 d



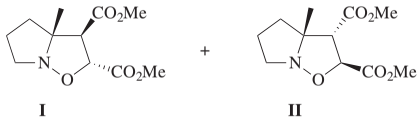
I + **II** + **III** + **IV**

I + **II** (62), **I/II/III/IV** = 38:53:3:6

548



Alkene (1 eq), $CHCl_3$, reflux, 14 d



I + **II**

I + **II** (42), **I/II** = 32:68

548

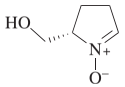
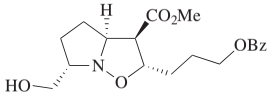
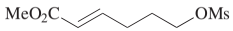
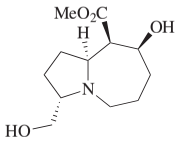
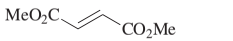
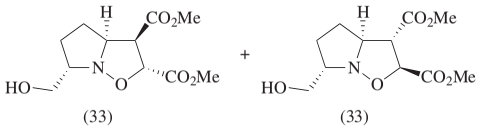
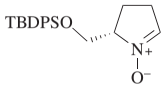
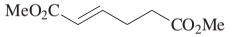
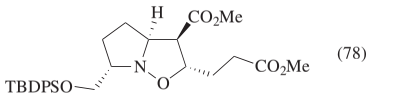
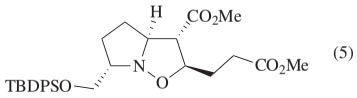
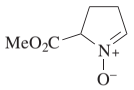
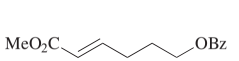
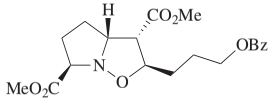
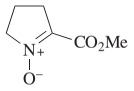
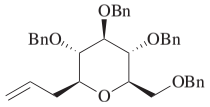
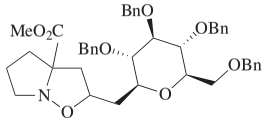
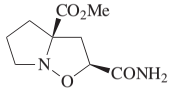
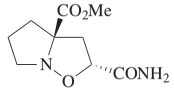
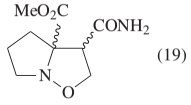
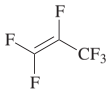
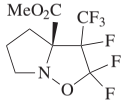
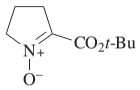
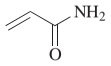
 non-racemic		Alkene (0.9 eq), $CHCl_3$, 61°, 5 d		(45)	482
		1. Alkene (1 eq), $CHCl_3$, reflux, 2 d 2. Removal of solvent, activated Zn, 10% aq. HCl, sonication, 0.5 h		(42)[e]	507
		Alkene (1.2 eq), $CHCl_3$, 61°, 3 h	 (33) + (33)		482
 non-racemic		Alkene (1.1 eq), toluene, reflux, 10 h	 + 	(78) (5)	421

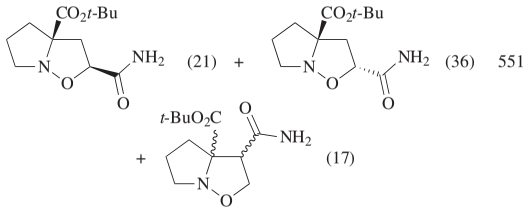
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*				
C_5				
		Alkene (0.69 eq), toluene, 110°, 70 h	 (81)	290
	 non-racemic	Toluene, reflux	 (—) dr 1:1	24
		Alkene (2 eq), H_2O, 60°, 14 h	 (42) +  (30) +  (19)	549, 550
		Alkene (4.2 eq), pressure vial, MeCN, 80°, 24 h	 (31) dr 4.5:1	283

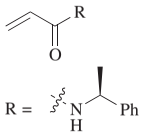




Alkene (2 eq),
H_2O, 60°, 15 h

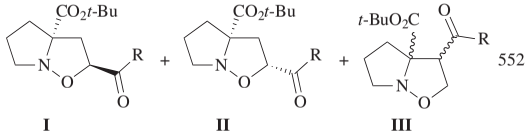


551



non-racemic

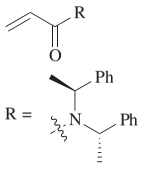
CH_2Cl_2, 40°, 10 h



I **II** **III**

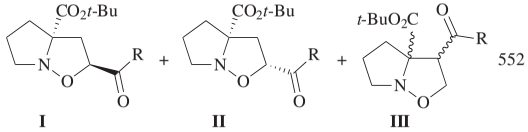
552

I + **II** + **III** (85), (**I** + **II**)/**III** = 77:23, **I**/**II** = 64:36



non-racemic

CH_2Cl_2, rt, 3 d



I **II** **III**

552

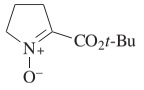
I + **II** + **III** (87), (**I** + **II**)/**III** = 86:14, **I**/**II** = 66:34

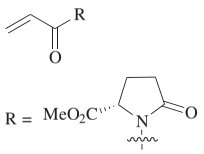
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

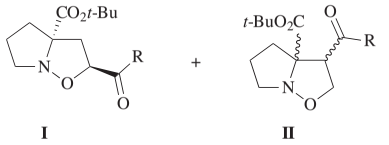
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_5





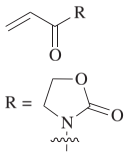
CH_2Cl_2, rt, 4 d



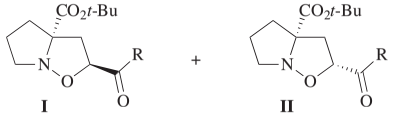
I **II**

I + II (47), **I /II**= 69:31

552



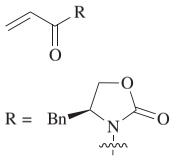
Additive (1 eq), CH_2Cl_2, rt, 1 d



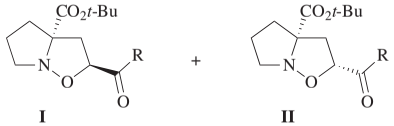
I **II**

Additive	**I + II**	**I/II**
—	(59)	67:33
$MgCl_2$	(56)	55:45

552



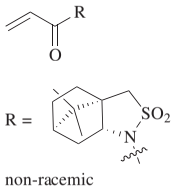
Catalyst (10 mol %), additive (1 eq), solvent



I **II**

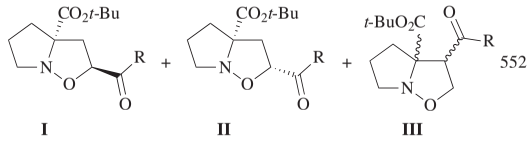
Catalyst	Additive	Solvent	Conditions	Temp	Time (h)	**I + II**	**I/II**
—	—	CH_2Cl_2	—	rt	120	(34)	63:37
—	—	CH_2Cl_2	MW (150 W)	60°	1	(49)	75:25
3	4 Å MS	CH_2Cl_2	—	rt	168	(60)	75:25
—	$MgCl_2$	CH_2Cl_2/MeOH	—	rt	120	(34)	50:50
—	—	H_2O	—	64°	14	(36)	73:27

552



non-racemic

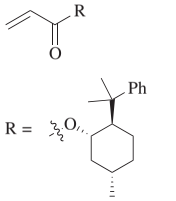
CH_2Cl_2, MW (150 W), 60°, 10 h



I **II** **III**

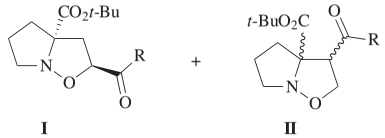
552

I + **II** + **III** (74), (**I** + **II**)/**III** = 67:33, **I**/**II** = 87:13



non-racemic

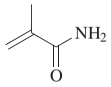
CH_2Cl_2, rt, 4 d



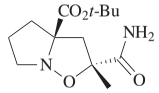
I **II**

552

I + **II** (68), **I**/**II** = 73:27

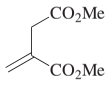


Alkene (2 eq), H_2O, 60°, 12 h

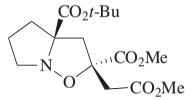


(79)

551



Alkene (1.1 eq), neat, 42°, 2.5 h



(73)

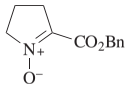
551

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

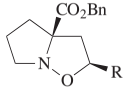
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_5



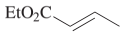


Alkene (*x* eq), toluene

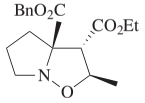


R	*x*	Temp (°)	Time (h)	
n-C_4H_9	xs	65	24	(65)
4-$MeOC_6H_4CH_2$	2	110	7	(80)
Ph	4	110	21	(65)

553

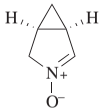


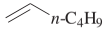
Alkene (6 eq), toluene, 110°, 3 h



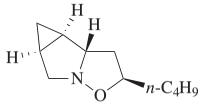
(83)

553





Sealed tube, benzene, 80°

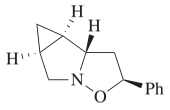


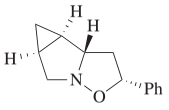
(65)

554



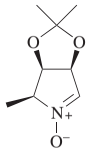
Benzene, 80°



(69) + 

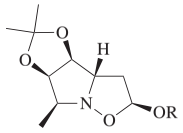
(6)

554





Alkene (*x* eq), TCE, 50°, 16 h



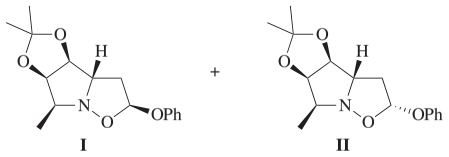
R	*x*	
Et	5	(100)
Ph	2	(85)

555

non-racemic



C_2Cl_4, 50°



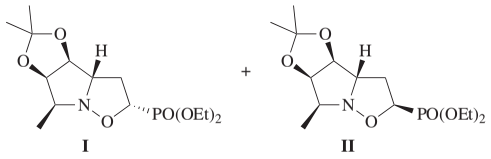
I **II**

556

I (85), **I/II** = 85:15

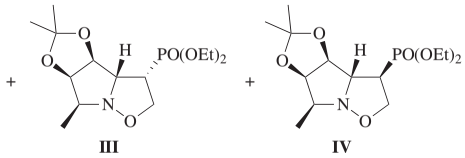


Alkene (2 eq),
C_2Cl_4, 50°, 16 h



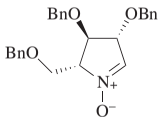
I **II**

556, 557

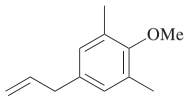


III **IV**

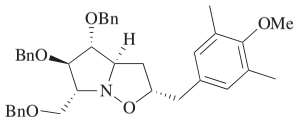
I + II + III + IV (100), **I/II/III/IV** = 52:30:16:12



non-racemic



Alkene (2 eq),
toluene, 60°, 3 d



(65)

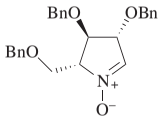
78

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

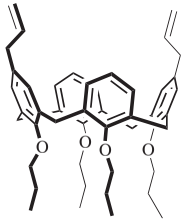
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

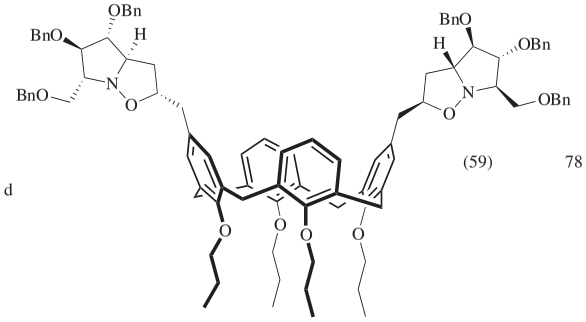
C_5



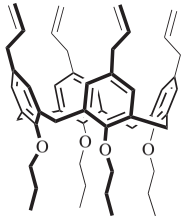
non-racemic



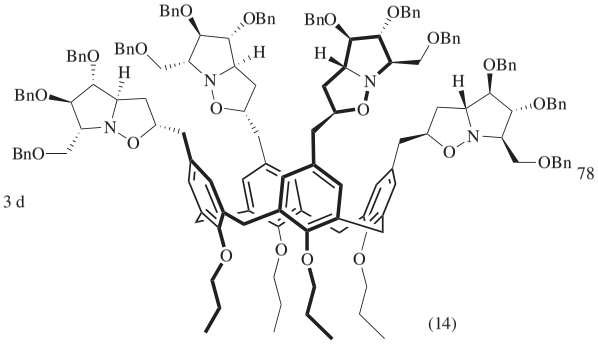
Alkene (1 eq), toluene, 60°, 3 d



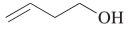
(59) 78



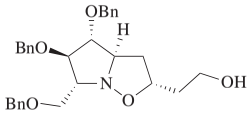
Alkene (1 eq), toluene, 60°, 3 d



(14) 78



Alkene (5 eq), toluene, 60°, 48 h



(89) 468

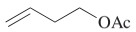
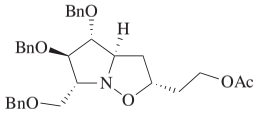
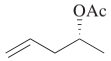
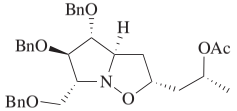
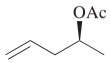
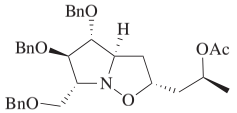
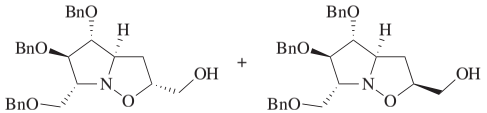
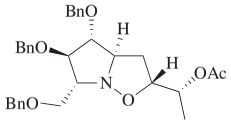
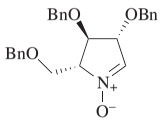
	Alkene (10 eq), sealed tube, MW, toluene, 120°, 2 h		(81)	468
 non-racemic	Alkene (10 eq), sealed tube, MW, toluene, 120°, 3 h		(74)	468
 non-racemic	Alkene (10 eq), sealed tube, MW, toluene, 120°, 3 h		(51)	468
	Alkene (3 eq), toluene, reflux, 3 h	 (73) + (20)		558
 non-racemic	Alkene (5 eq), sealed tube, MW, toluene, 120°, 3 h		(61)	468

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

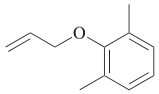
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

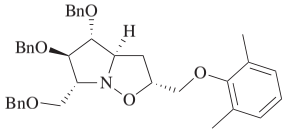
C_5



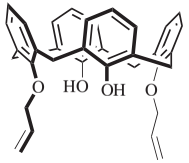
non-racemic



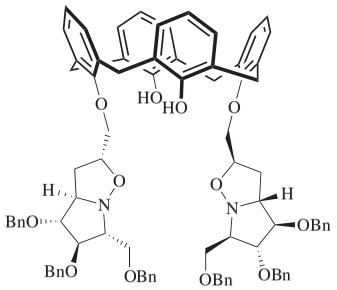
Alkene (2 eq), toluene, 60°, 24 h



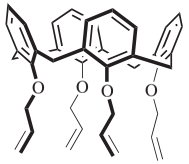
(52) 78



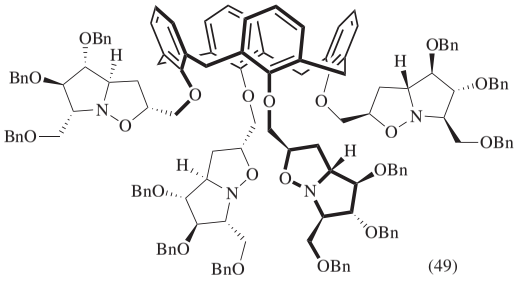
Alkene (1 eq), toluene, 60°, 3 d



(52) 78

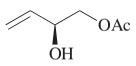


Alkene (1 eq), toluene, 60°, 3 d



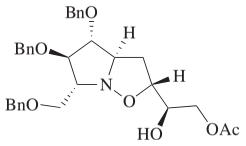
78

(49)



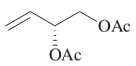
non-racemic
(er 80.5:19.5)

Alkene (2.1 eq),
MW (2450 MHz),
CH_2Cl_2, 70°, 2.5 h



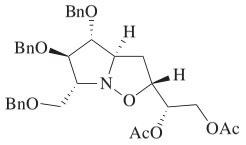
(70)

304



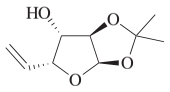
non-racemic
(er 82.0:18.0)

Alkene (3.5 eq),
MW (2450 MHz),
CH_2Cl_2, 70°, 4 h



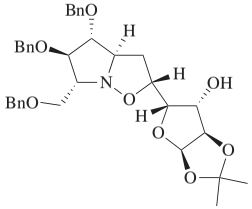
(74)

304



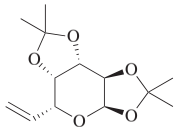
non-racemic

Alkene (1 eq)
CH_2Cl_2,
reflux, 3–4 d



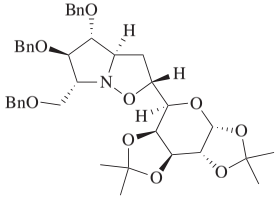
(80)

559



non-racemic

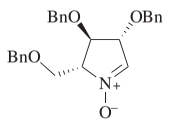
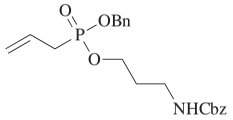
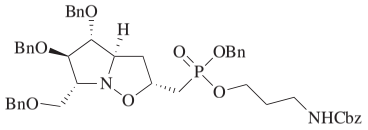
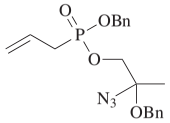
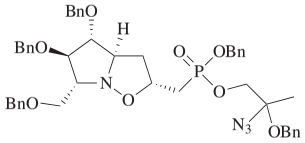
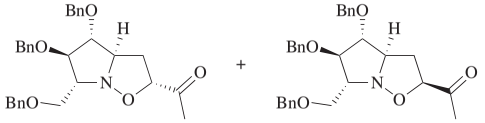
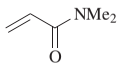
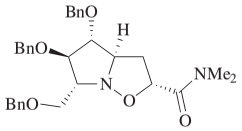
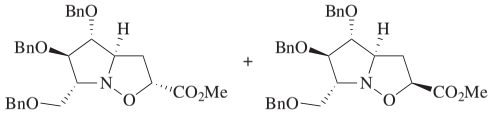
Alkene (1 eq)
CH_2Cl_2,
reflux, 3–4 d

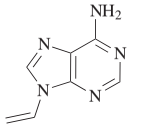


(82)

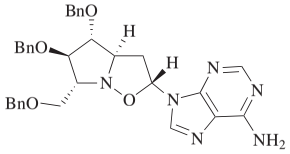
559

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

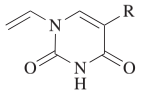
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_5				
 non-racemic		TCE, 80°		(42) 560
		TCE, 80°		(—) 560
		Alkene (1.5 eq), CH_2Cl_2, reflux, 2 d	 (59) + (31)	536
		Alkene (1.5 eq), CH_2Cl_2, rt, 3 d		(83) 72, 561
		CH_2Cl_2, rt	 (56) + (23)	72



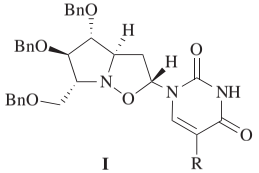
Alkene (1 eq), toluene, reflux, 8–10 h



(60) 562



Alkene (1 eq), toluene, reflux, 8–10 h

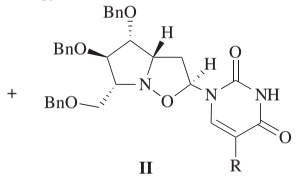


I

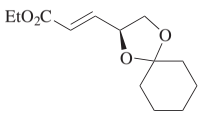
R	**I**	**II**
H	(68)	(7)
Me	(73)	(7)

562

+

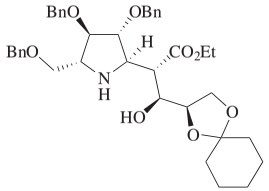


II



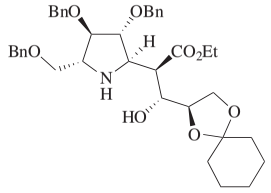
non-racemic

1. Alkene (1 eq), toluene, reflux, 1 h
2. Purification, dried Zn, 70% aq. AcOH, rt, 1 h



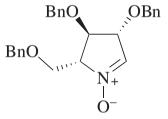
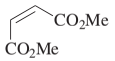
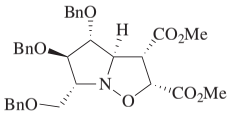
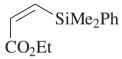
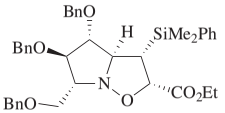
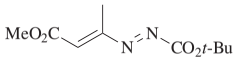
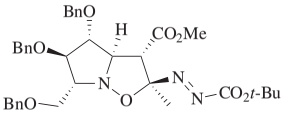
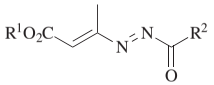
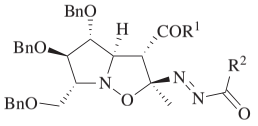
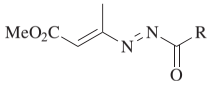
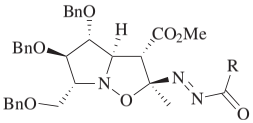
(47) 563

+



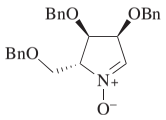
(24)

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_5  non-racemic		CH_2Cl_2, rt	 (78)	72
		Alkene (2.2 eq), CH_2Cl_2, rt, 36 h	 (93)	74
		Alkene (2 eq), neat, 60°, 3 h	 (80)	522
		Alkene (2 eq), sealed vial, MeCN, 60°, 3 h		522
		Alkene (2 eq), MW (300 W), neat, 70°		522

R^1	R^2		
Me	PhHN	(76)	
Me	MeO	(80)	
Me	*t*-BuO	(82)	
Et	H_2N	(74)	

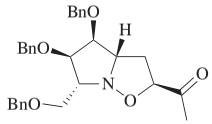
R	Time (s)		dr[j]
PhHN	72	(88)	9:1
MeO	118	(90)	9:1
t-BuO	72	(86)	5:1



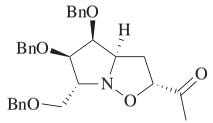
non-racemic



Alkene (1.5 eq), CH_2Cl_2, reflux, 2 d



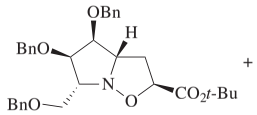
(64) +



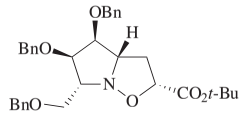
(32) 536



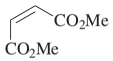
Alkene (1.5 eq), CH_2Cl_2, rt, 3 d



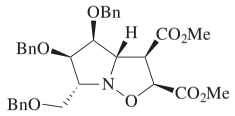
I +



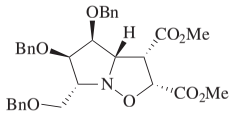
I + II (88), **I/II** 1.5:1 **II** 403



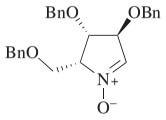
Alkene (2 eq), benzene, 60°, 3 h



I +



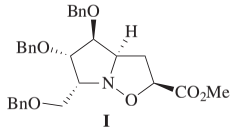
I + II (86), **I/II** = 80:20 **II** 178



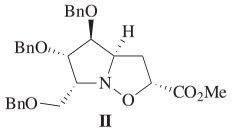
non-racemic



Alkene (4 eq), THF, rt, 48 h

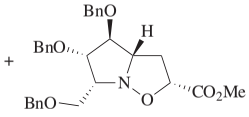


I +



II 564

+



III

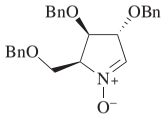
I + II + III (—)
I/II/III = —

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

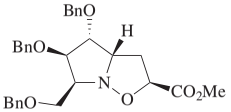
C_5



non-racemic

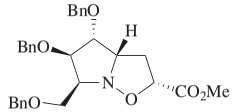


Alkene (4 eq), THF, rt, 48 h



I

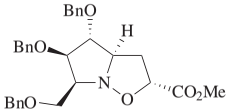
+



II

564

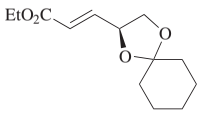
+



III

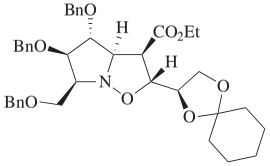
I + II + III (—)

I/II/III = —



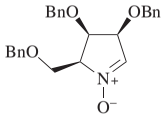
non-racemic

Alkene (1 eq), toluene, reflux, 1 h



(78)[f]

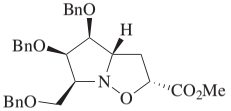
563



non-racemic



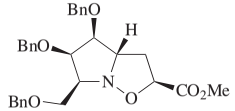
Alkene (4 eq), THF, rt, 48 h



I

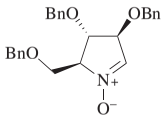
I + II (—), **I > II**

+



II

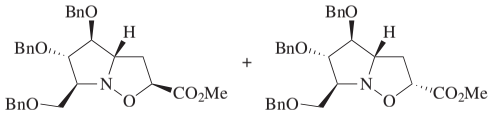
564



non-racemic

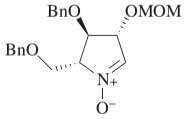


Alkene (4 eq), THF, rt, 24 h



564

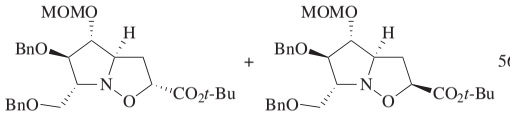
I **I + II** (88), **I/II** = 80:20 **II**



non-racemic

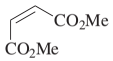


Alkene (5 eq), benzene, rt, 15 h

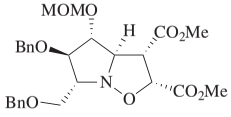


565

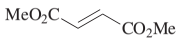
(64) (31)



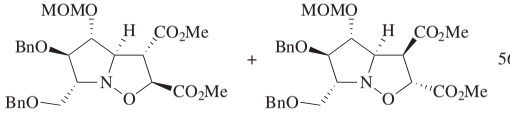
Alkene (5 eq), benzene, rt, 15 h



(78) 565



Alkene (5 eq), benzene, rt, 15 h



565

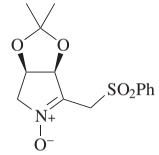
(74) (26)

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

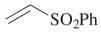
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

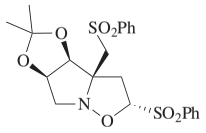
C_5



non-racemic

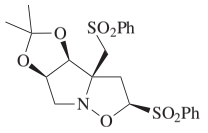


Alkene (1.25 eq), toluene, 110°, 24 h



I

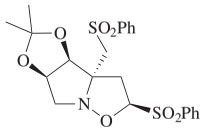
+



II

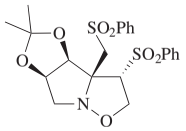
566

+



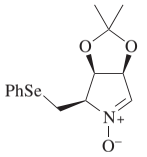
III

+

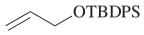


IV

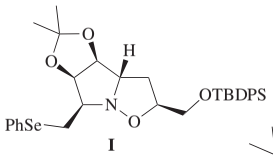
I + **II** + **III** + **IV** (70), **I/II/III/IV** = 3.5:1.4:1:1



non-racemic

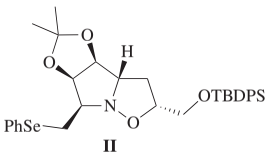


Toluene, 110°, 2 h



I

+



II

I + **II** (80), **I/II** = 9:1

200

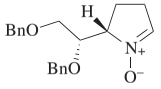
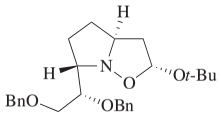
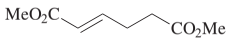
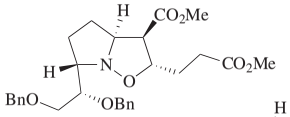
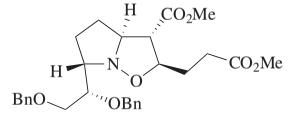
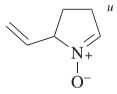
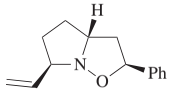
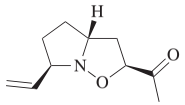
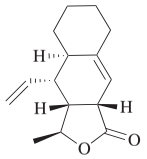
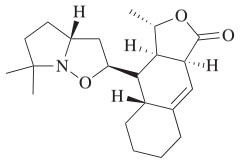
C_6					
 non-racemic		Alkene (1.1 eq), $CHCl_3$, reflux, 4–6 h		(89)	507, 567
		Alkene (1.1 eq), toluene, reflux, 2 h	 + 	(83) (7)	507, 567
		Alkene (2–4 eq), DCE 70°, 2 h		(42)	207, 568
		Alkene (2–4 eq), DCE, 70°, 2 h		(36)	568
	 non-racemic	Toluene, 135°		(45)	569

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

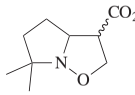
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_6





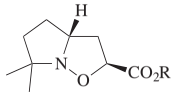
Alkene (1 eq), MW (2450 MHz), neat, 0.5 h



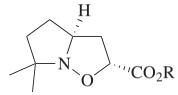
(80) 491



Alkene (0.5 eq), CH_2Cl_2, rt, 24 h

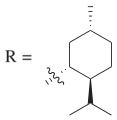


I (42) +



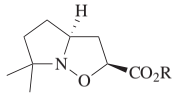
II (33) 570

R =

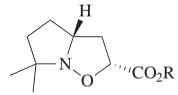


non-racemic

+

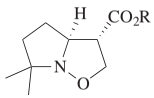


III +

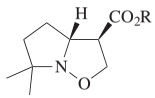


IV

+



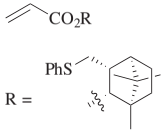
V +



VI

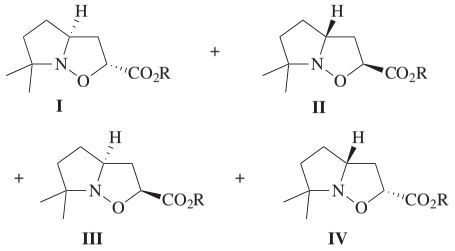
III + **IV** (15), **V** + **VI** (5)

III/**IV** = 1:1, **V**/**VI** = 1:1



non-racemic

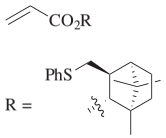
Alkene (*x* eq),
additive (0.1 M)
solvent, rt



I **II** **III** **IV**

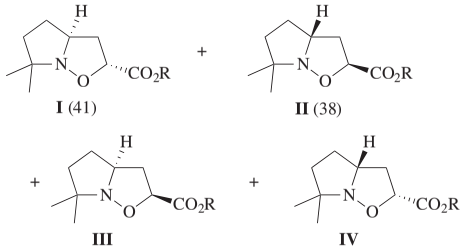
570

x	Additive	Solvent	Time (d)	**I + II**	**III + IV**	**I/II**
0.1	—	H_2O	15	(66)	(19)	2.1:1
0.1	SDS	H_2O	15	(51)	(9)	1.8:1
0.5	—	CH_2Cl_2	1	(80)	(18)	1.5:1



non-racemic

Alkene (0.5 eq),
CH_2Cl_2, rt, 24 h



I (41) **II** (38) **III** + **IV** (14)

570

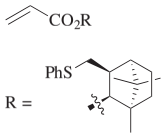
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

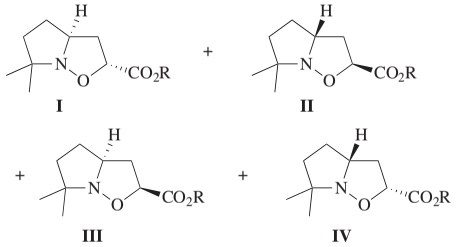
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_6





Alkene (*x* eq), additive (0.1 M), solvent, rt

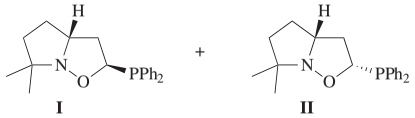


x	Additive	Solvent	Time (d)	**I + II**	**III + IV**	**I/II**
0.1	SDS	H_2O	15	(79)	(15)	1.8:1
0.5	—	CH_2Cl_2	1	(82)	(16)	1.3:1

570



Alkene (0.83 eq), dry benzene, rt, 6 d

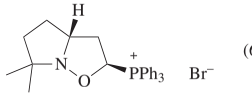


I (62), **I/II** = 6:1

571, 572, 573

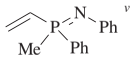


Alkene (0.9 eq), $CHCl_3$, rt, 6 h

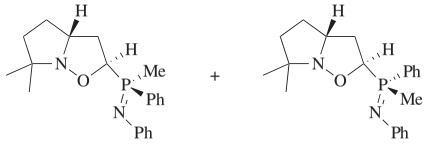


(63)

574

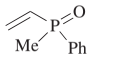


Alkene (0.67 eq), toluene, rt, 2 d

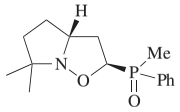


I **I + II** (85)[w], **I/II** = 76:24 **II**

575

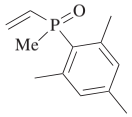


Alkene (1 eq), CH_2Cl_2, rt, 7 d

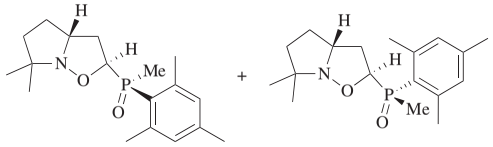


(91) dr 72:28

576

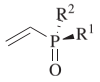


Alkene (0.8 eq), $CHCl_3$, rt, 10 d



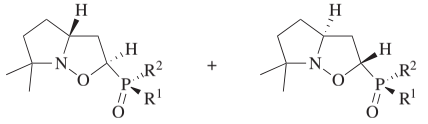
I **I + II** (73), **I/II** = 90:10 **II**

575



non-racemic

Alkene (0.9 eq), solvent, rt



I **II**

575

R^1	R^2	Solvent	Time (d)	**I + II**	**I/II**
Ph	Me	$CHCl_3$	20	(87)	71:29
Ph	CH_2CO_2-L-menthyl	CH_2Cl_2	7	(89)	50:50
CH_2CO_2-L-menthyl	Ph	CH_2Cl_2	7	(85)	67:33

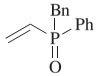
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

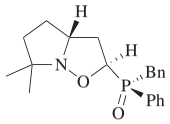
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_6

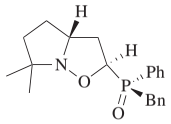




Alkene (0.9 eq), CH_2Cl_2, rt, 7 d

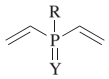


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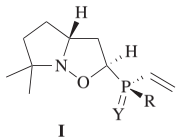


575

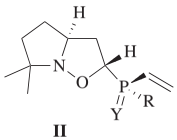
I **I + II** (84), **I/II** = 56:44 **II**



Alkene (*x* eq), $CHCl_3$, rt



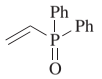
+



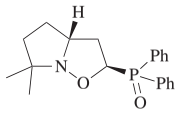
575

I **II**

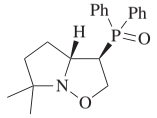
Y	R	*x*	Time (d)	**I + II**	**I/II**^{x}
O	Ph	1	17	(47)	60:40
O	*t*-Bu	0.8	15	(84)	92:8
S	Ph	1	17	(68)	73:27
S	*t*-Bu	0.7	15	(80)	96:4



Alkene (0.9 eq), $CHCl_3$, rt, 7 d

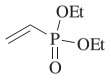


+

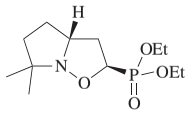


574, 577

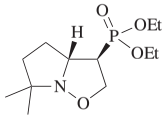
I **I + II** (90), **I/II** = 86:14 **II**



Alkene (0.9 eq), $CHCl_3$, rt, 14 h

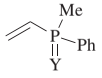


+

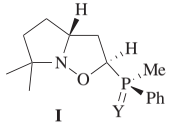


574

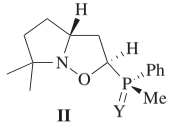
I **I + II** (84), **I/II** = 72:28 **II**



Alkene (*x* eq), $CHCl_3$, rt



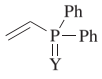
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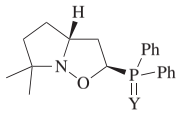
575

I **II**

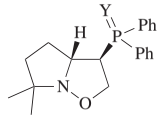
Y	*x*	Time (d)	**I + II**	**I/II**
S	0.5	4	(96)	80:20
Se	0.8	12	(89)	80:20



Alkene (0.9 eq), C_6D_6, rt, 4 d



+



574

I **II**

Y	**I + II**	**I/II**
S	(84)	86:14
Se	(86)	88:12

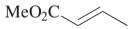
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

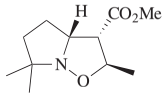
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_6



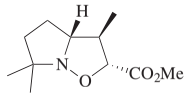


Alkene (0.7 eq), benzene, reflux, 36 h



I

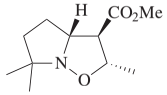
+



II

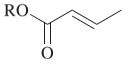
570

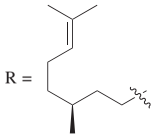
+



III

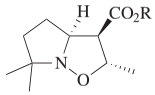
I + **II** + **III** (70)
I/II/III = 22:2:1





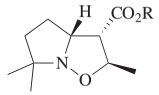
non-racemic

Benzene, reflux, 110 h



I

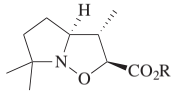
or



I

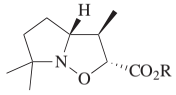
578

+



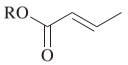
II

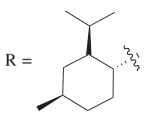
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II

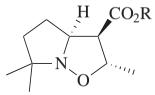
I + **II** (72), **I/II** = 1.8:1





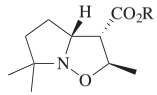
non-racemic

Benzene, reflux, 110 h



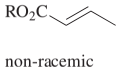
(64)

or



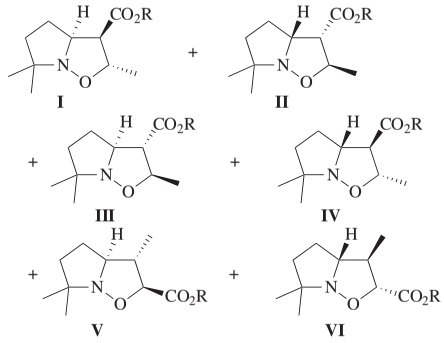
(64)

578



non-racemic

Alkene (0.5 eq),
benzene,
reflux, 36 h



570

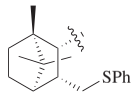
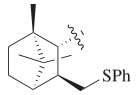
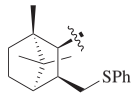
R	I + II + V + VI	III + IV	I/II	III/IV	V/VI	(I + II)/(V + VI)
	(73)	(7)	1.6:1	1.1:1	1.4:1	2.6:1
	(77)	(7)	—	1.1:1	1.2:1	6.5:1
	(64)	(6)	2.3:1	—	1.3:1	3.6:1

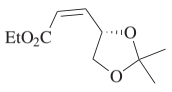
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

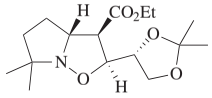
C_6





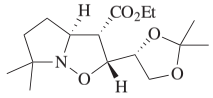
non-racemic

Alkene (0.67 eq), $CHCl_3$, reflux, 65 h



I

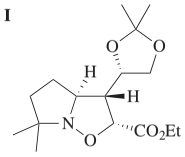
+



II

579

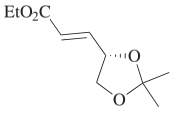
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III

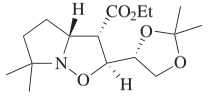
I + II + III (76)

I/II/III = 4:2:1



non-racemic

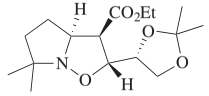
Alkene (0.67 eq), toluene, reflux, 200 h



I

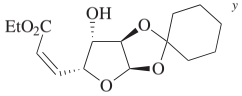
I + II (55), **I/II** = 1:1

+



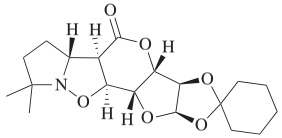
II

580



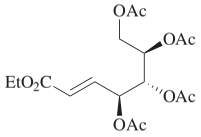
non-racemic

Alkene (1.5 eq), $CHCl_3$, reflux, 3 d



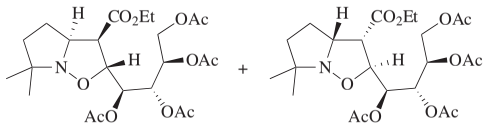
(71)

579



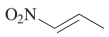
non-racemic

Alkene (0.83 eq), benzene, reflux, 100 h

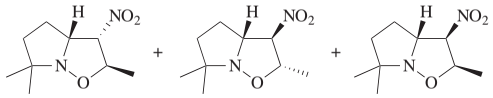


I **I** + **II** (85), **I**/**II** = 1.5:1 **II**

580

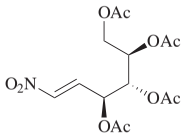


Alkene (2.3 eq), benzene, rt



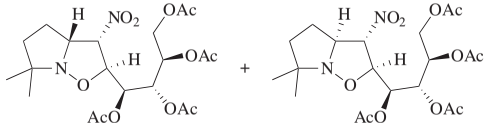
I[z] (87) **II** (6) **III**

581



non-racemic

Alkene (1 eq), benzene, reflux, 100 h

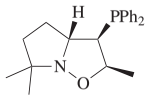


I **I** + **II** (81), **I**/**II** = 2:1 **II**

580

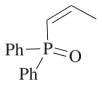


Alkene (0.88 eq), degassed toluene, reflux, 36 h

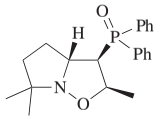


(51)

571, 572



Alkene (0.9 eq), C_6D_6, 80°, 30 h



(70)

574

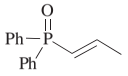
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

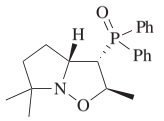
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_6

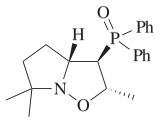




Alkene (0.9 eq), toluene, 110°, 16 h

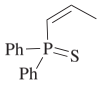


+

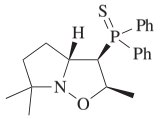


I **I + II** (80), **I/II** 1.3:1 **II**

574



Alkene (0.9 eq), C_6D_6, 60°, 30 h

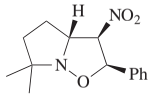


(86)

574

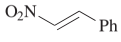


Alkene (0.5 eq), $CDCl_3$, 2 h, dark

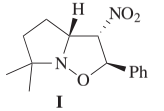


(—)

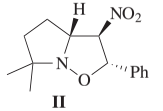
581



Alkene (1.5 eq), benzene, dark



+

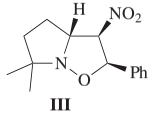


I **II**

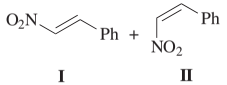
581

Temp	Time (d)	**I**	**II**	**I + II**	**III**	**I/II**
rt	7	(72)	(0)	(—)	(10)	—
reflux	3	—	—	(78)	(9)	6:94

+

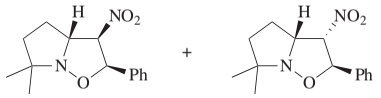


III



I **II**

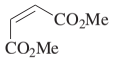
Alkenes (xs), solvent, dark



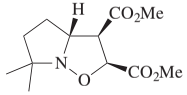
III **IV**

I/II	Solvent	Temp (°)	Time (h)	**III**	**IV**
1:1	benzene	21	8	(67)	(6)
1:3	C_6D_6	33	24	(90)	(0)

581

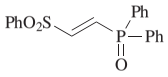


Alkene (1 eq), $CHCl_3$, reflux, 2 d

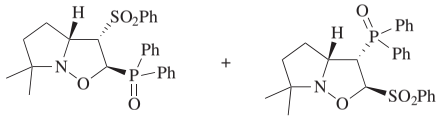


(98)

548

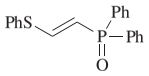


Alkene (0.9 eq), toluene, 110°, 5 h

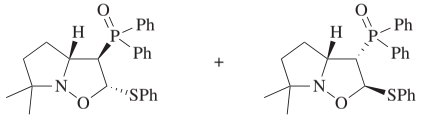


I **I + II** (80), **I/II** 58:42 **II**

574

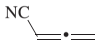


Alkene (0.9 eq), toluene, 110°, 24 h

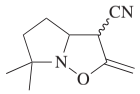


I **I + II** (37), **I/II** 1.6:1 **II**

574



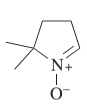
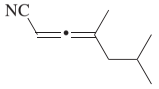
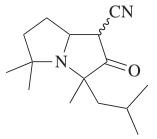
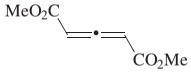
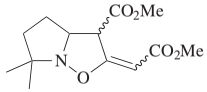
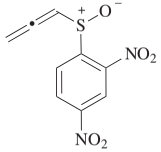
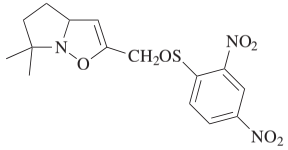
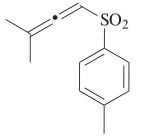
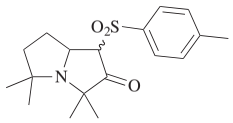
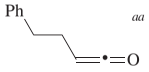
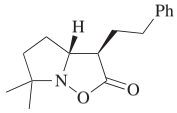
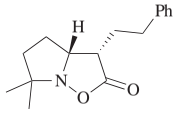
Alkene (1 eq), benzene, 30°, 3.5 h

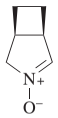


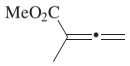
(95)

582

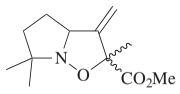
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

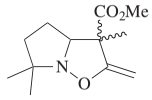
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_6 		Alkene (1 eq), benzene, reflux, 36 h	 (64)[e]	293
		Alkene (1 eq), benzene, 40°, 3.5 h	 (94)	582
		—	 (95)[e]	583
		Alkene (1 eq), benzene, 40°, 12 h	 (84)[e]	293
		Dry THF, 0°, 15 h, Ar	 +  **I** **I + II** (60), **I/II** = 4:1 **II**	295





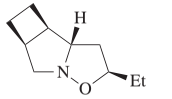
Alkene (1 eq), benzene, 50°, 20 h



(42) +  (14) 293



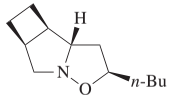
Sealed tube, toluene, 110°



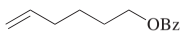
(77) 554



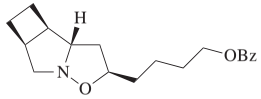
Toluene, 110°



(82) 554



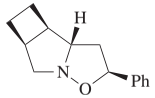
Toluene, 80°, 45,000 psi

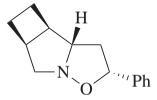


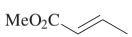
(64) 554



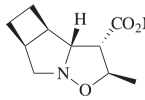
Toluene, 110°



(82) +  (2) 554



Benzene, rt



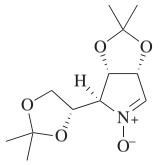
(85) 554

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

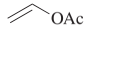
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

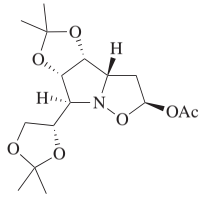
C_6



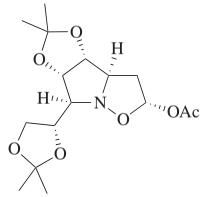
non-racemic



Alkene (xs), sealed tube, neat, 75°, 18 h

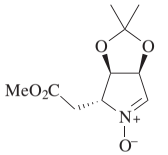


+

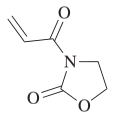


584

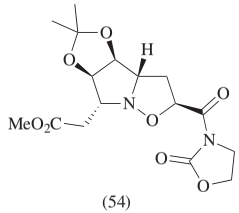
I (78) **I/II** = 87:13 **II**



non-racemic

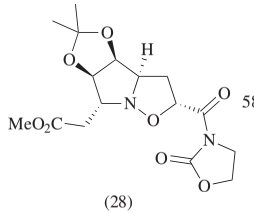


Alkene (2 eq), Ar, dry $CHCl_3$, reflux, 15 h



(54)

+

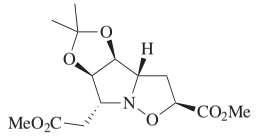


(28)

585



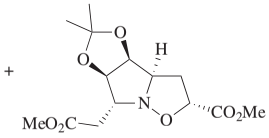
Alkene (xs), Ar, neat, reflux, 5 h



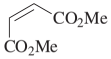
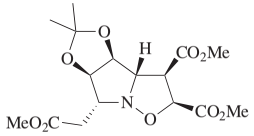
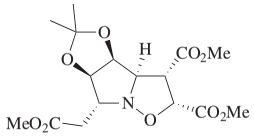
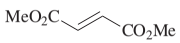
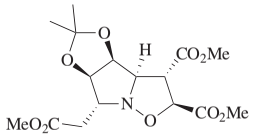
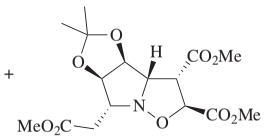
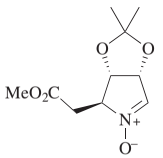
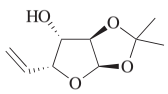
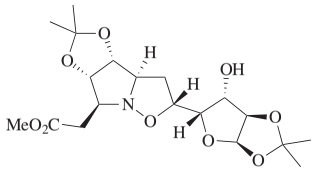
(66)

585

+



(22)

		Alkene (2 eq), Ar, dry $CHCl_3$, reflux, 15 h	 + 	(39) (31)[bb]	585
		Alkene (2 eq), Ar, dry $CHCl_3$, reflux, 15 h	 + 	(51) (22)[bb]	585
		Alkene (1 eq), CH_2Cl_2, reflux, 3–4 d		(85)	559

non-racemic

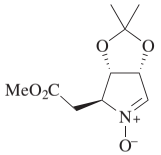
non-racemic

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

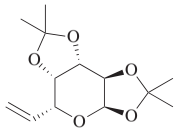
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_6

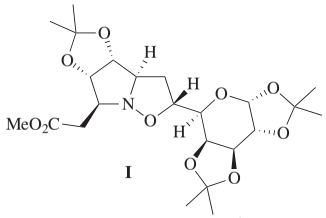


non-racemic



non-racemic

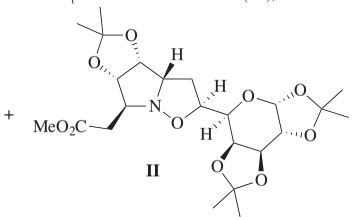
Alkene (1 eq), CH_2Cl_2, reflux, 3–4 d



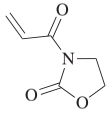
I

559

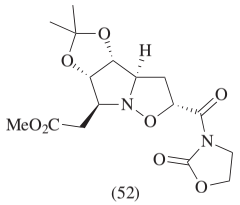
I + II (85), **I/II** = 3:2



II

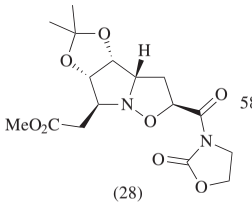


Alkene (2 eq), Ar, dry $CHCl_3$, reflux, 15 h



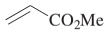
(52)

+

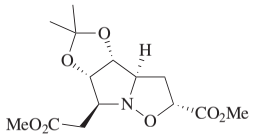


(28)

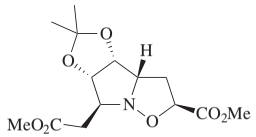
585



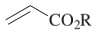
Alkene (xs), Ar, neat, reflux, 5 h



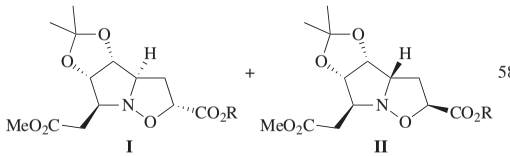
(65) 585



(23)



Alkene (5 eq), additive (3 M), solvent, rt



586

I **II**

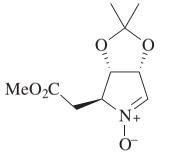
R	Additive	Solvent	Time (h)	**I + II**	**I/II**
Me	—	CH_2Cl_2	12	(95)	67:33
Me	—	H_2O	5	(98)	75:25
Me	LiCl	H_2O	3	(98)	78:22
n-$C_{12}H_{25}$	—	CH_2Cl_2	60	(80)	58:42
n-$C_{12}H_{25}$	—	H_2O	5	(89)	62:38
n-$C_{12}H_{25}$	LiCl	H_2O	5	(95)	64:36

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

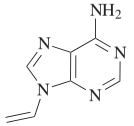
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

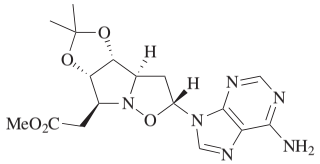
C_6



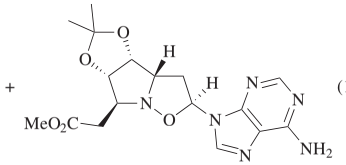
non-racemic



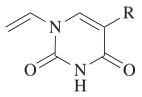
Alkene (1 eq), toluene, reflux, 2 d



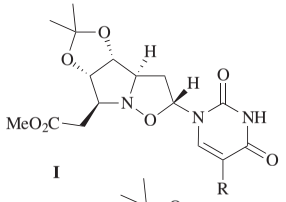
(81) 562



(18)

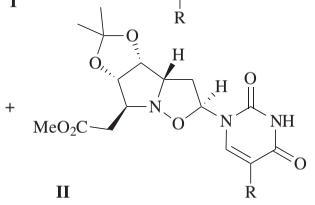


Alkene (1 eq), toluene, reflux, 2 d



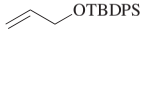
R	**I**	**II**	Refs.
H	(67)	(29)	562
Me	(68)	(30)	

I

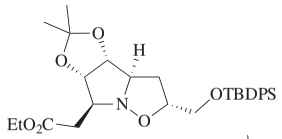


II

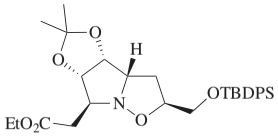
non-racemic



Toluene, 110°

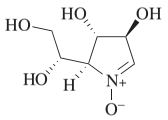

I

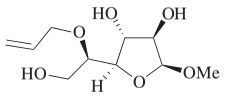
+


II

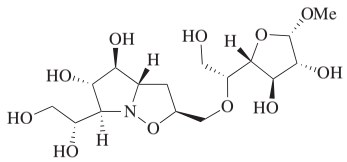
I + **II** (83), **I/II** = 3:1

200


non-racemic

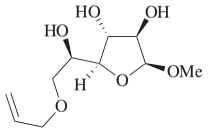

non-racemic

Alkene (1.6 eq)
H_2O, 60°, 5 d

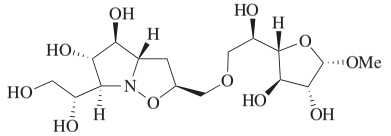


(72)

300


non-racemic

Alkene (1.6 eq),
H_2O, 60°, 10 d



(51)

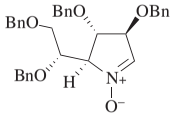
300

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

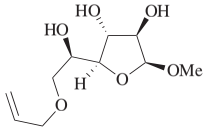
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

C_6

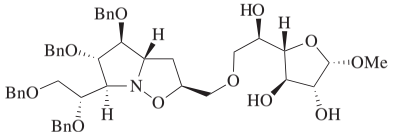


non-racemic

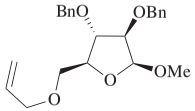


non-racemic

Toluene, 110°, 14 h

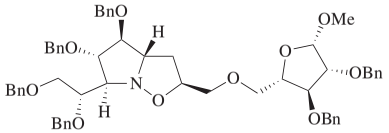


(35) 300

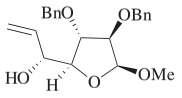


non-racemic

Toluene, 110°, 12–14 h

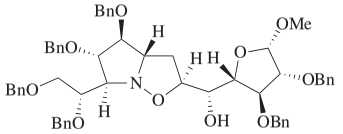


(49) dr 96:4 300

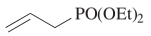


non-racemic

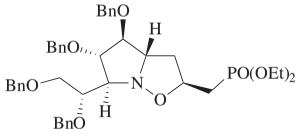
Toluene, 110°, 14 h



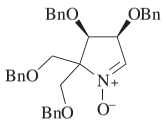
(64) 300

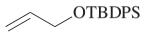


CH_2Cl_2, 50°, overnight

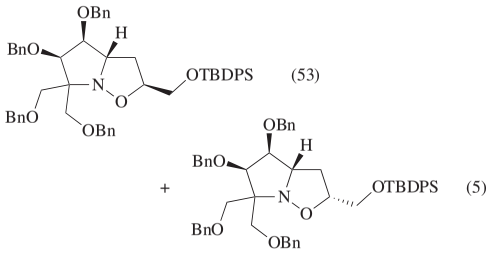


(88) 73





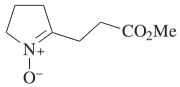
Alkene (1.6 eq), toluene, reflux, 18 h



(53) + (5)

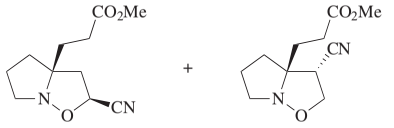
587

C_7

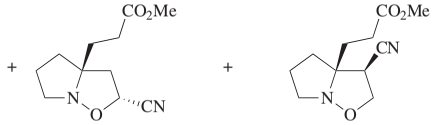




Alkene (5 eq), rt, 24 h



I **II**



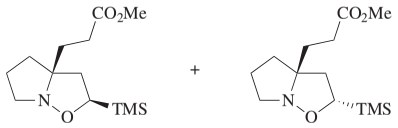
III **IV**

I + **II** + **III** + **IV** (67), **I/II/III/IV** = 50:30:15:5

547



Alkene (10 eq), toluene, reflux, 3 d



I **I** + **II** (72), **I/II** = 60:40 **II**

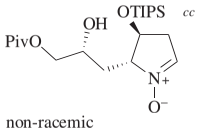
547

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

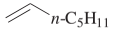
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

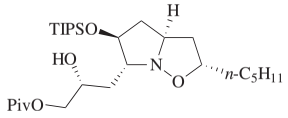
C_7



non-racemic

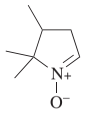


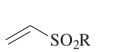
Toluene, 50°, 30 h



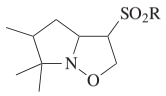
(63)

395



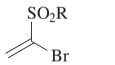


Alkene (1 eq), benzene, reflux

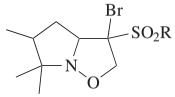


R	Time (d)	
Et_2N	1	(62)
F	4	(67)

588

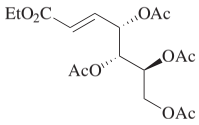


Alkene (1 eq), benzene, reflux



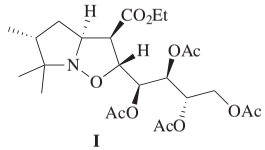
R	Time (d)	
Et_2N	4	(41)
F	1	(50)

588



non-racemic

Dry benzene, reflux, 12 h

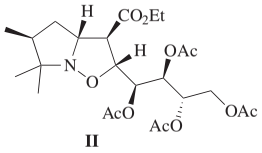


I

I + **II** (80), **I**/**II** = 60:40

589

\+



II

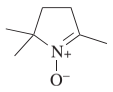
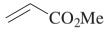
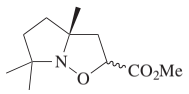
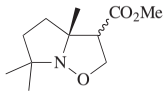
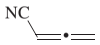
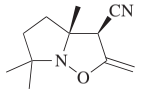
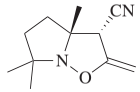
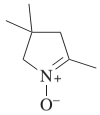
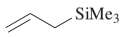
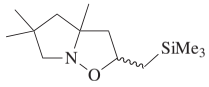
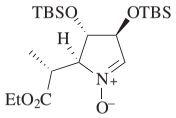
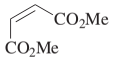
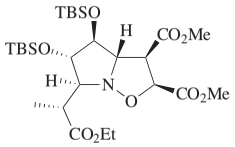
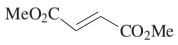
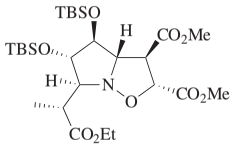
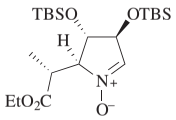
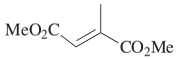
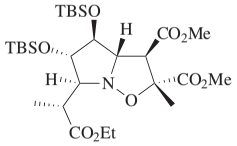
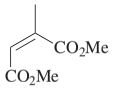
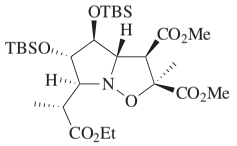
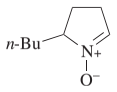
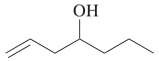
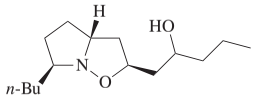
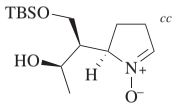
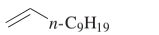
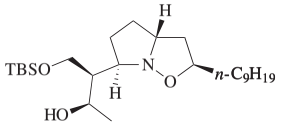
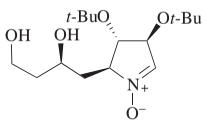
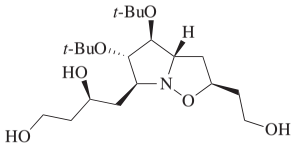
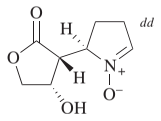
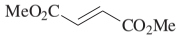
		Alkene (2 eq), benzene, 80°, 12 h	 +  **I** **I + II** (76), **I/II** = 83:17 **II**	590
		Alkene (0.9 eq), benzene, 35°, 3 h	 (87) +  (7)	582
		Sealed tube, neat, 120°, 40 h	 (88)	591
 non-racemic		Alkene (3 eq), benzene, 70°, 24 h	 (85)	70
		Alkene (3 eq), benzene, 70°, 12 h	 (82)	70

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

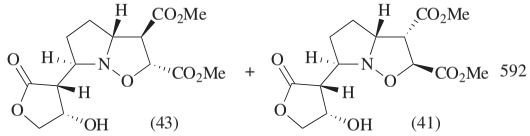
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*				
C_7  non-racemic		Alkene (4 eq), benzene, 70°, 12 h	 (62)	70
		Alkene (4 eq), benzene, 70°, 18 h	 (60)	70
C_8 		Alkene (2 eq), toluene, 110°, 46 h	 (61) dr 1:1	146
		Toluene, 110°	 (76)	141, 277
 non-racemic		Alkene (4.3 eq), sealed tube, MW (150 W), toluene, 130°, 0.67 h	 (78)	77



dd

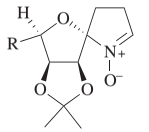


Alkene (1.1 eq),
CH_2Cl_2, 20°, 19 h



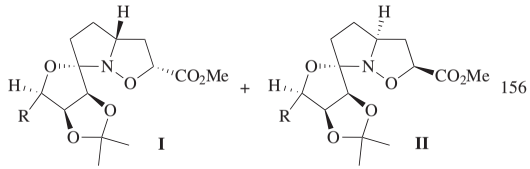
592

C_9



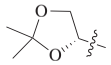


Alkene (65 eq),
$CHCl_3$, 70°, 0.5 h

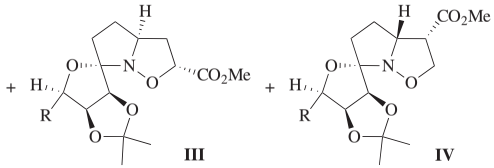


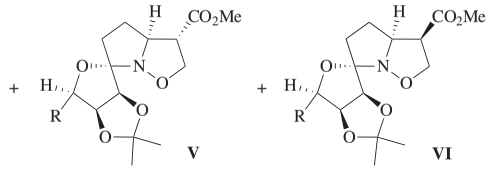
156

R =



non-racemic





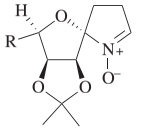
I + II + III + IV + V + VI (87), **I/II/III/IV/V/VI** = 54:27:10:6:2:1

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

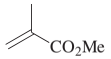
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

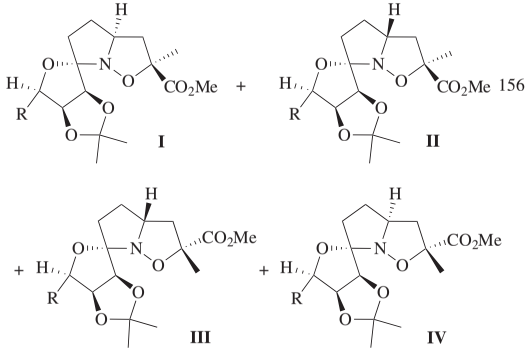
C_9



non-racemic



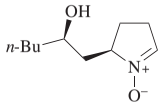
Alkene (13.4 eq), $CHCl_3$, 70°, 0.5 h



156

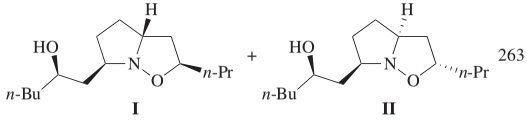
I + **II** (69), **III** + **IV** (12), **I/II/III/IV** = 83:7.5:7.5:2

C_{10}



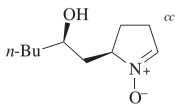


Sealed tube, toluene, 100°



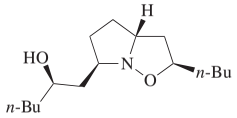
263

I + **II** (—), **I/II** = 84:16





Alkene (*x* eq), solvent

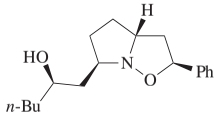


x	Solvent	Temp (°)	Time (h)	
—	benzene	75	12	(70)
—	toluene	100	—	(65)
5	toluene	65–70	48	(71)

139, 488, 546

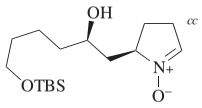


Alkene (18.4 eq), toluene, 60–65°, 48 h



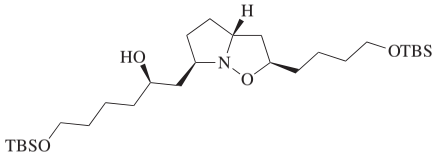
(66)

139



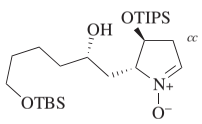


Alkene (1.1 eq), toluene, 100°, 2 d



(60)

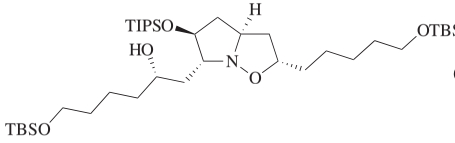
71



non-racemic



Alkene (2 eq), toluene, 100°, 12 h



(60)

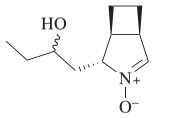
527

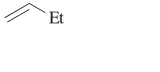
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

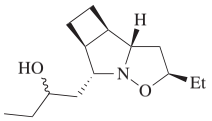
Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

C_{10}



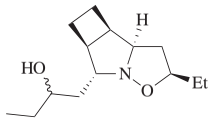


—



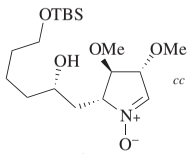
(58)

+

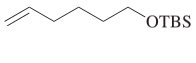


(19)

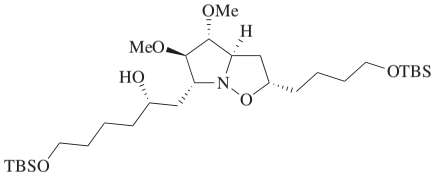
593



non-racemic



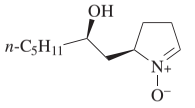
Toluene, 100°



(42)

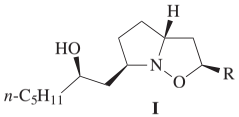
71

C_{11}



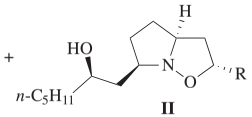


Sealed tube, toluene, 100°



I

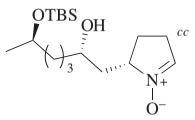
+



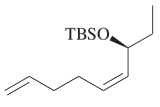
II

263

R	**I + II**	**I/II**
Et	(66)	87:12
CH_2=CH	(—)	93:7

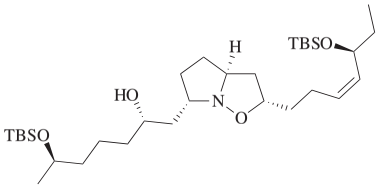


non-racemic



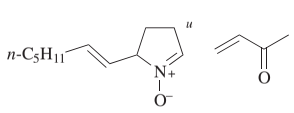
non-racemic

Toluene, 110°, 2 d

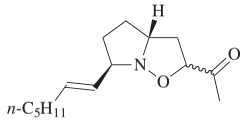


(65)

519

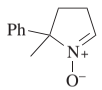


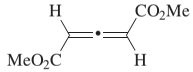
Alkene (2.9 eq),
THF, rt, 15 h



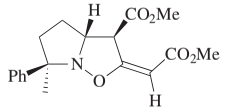
(48) dr 1:1

568, 594



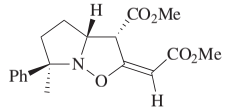


Benzene, 40°, 24 h



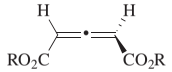
(30)

+



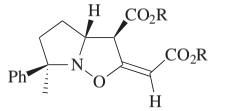
(24)

595



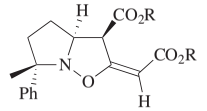
R = (–)-menthyl
non-racemic

Benzene, 40°, 24 h



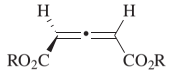
(41)

+



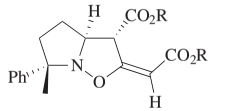
(26)

595



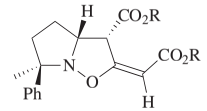
R = (+)-menthyl
non-racemic

Benzene, 40°, 24 h



(38)

+



(25)

595

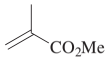
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

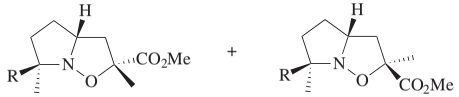
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_{11}





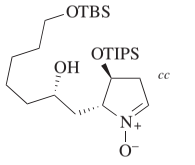
Alkene (2 eq), sealed vial, MeCN, 40°, 24 h



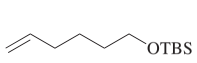
I + **II**

R	I + II	I/II
2-$MeOC_6H_4$	(82)	94:6
4-$MeOC_6H_4$	(80)	94:6

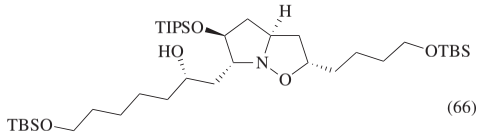
151



non-racemic

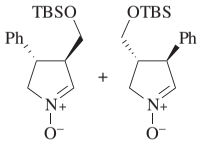


Alkene (2 eq), toluene, 100°, 12 h



(66)

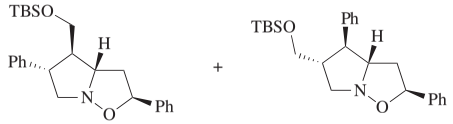
527



non-racemic non-racemic

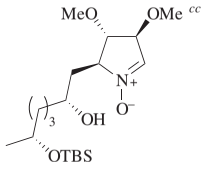


Toluene, reflux

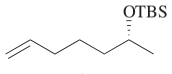


I **I** + **II** (55) **II**

596

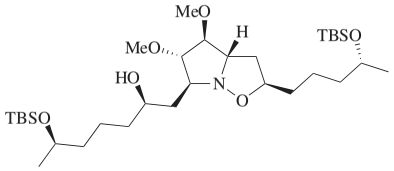


non-racemic

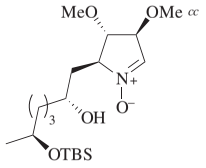


non-racemic

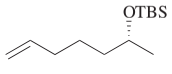
Alkene (3 eq),
toluene, 100°, 24 h



(41) 533

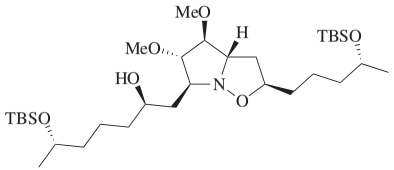


non-racemic

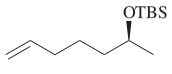


non-racemic

Alkene (3 eq),
toluene, 100°, 24 h

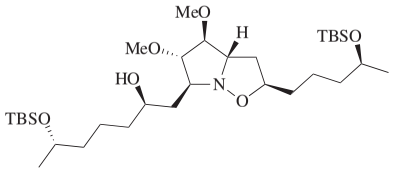


(51) 533



non-racemic

Alkene (3 eq),
toluene, 100°, 24 h



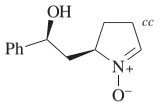
(57) 533

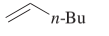
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

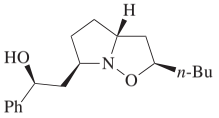
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_{12}

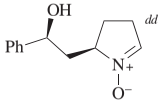


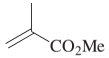


Alkene (18.9 eq), toluene, 60–65°, 48 h

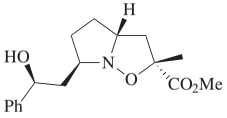


(69) 139

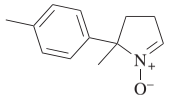


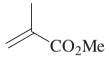


Alkene (13.6 eq), CH_2Cl_2, 35–40°, 48 h

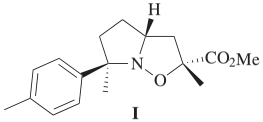


(80) 139





Alkene (2 eq), MeCN

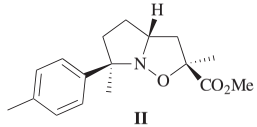


I

151

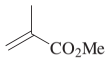
Temp	Time (h)	**I + II**	**I/II**
rt	41.5	(73)	96:4
reflux	5	(80)	90:10

\+

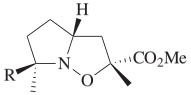


II



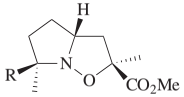


Alkene (2 eq), sealed vial, MeCN, 40 °, 24 h



I

\+



II

151

R	**I + II**	**I/II**
3-MeC_6H_4	(80)	95:5
4-MeC_6H_4	(78)	95:5

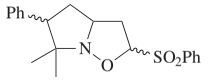
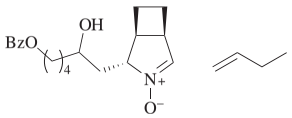
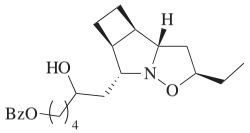
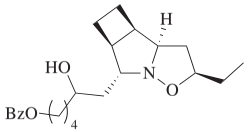
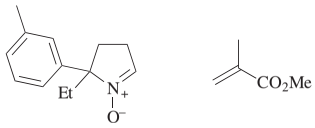
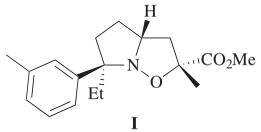
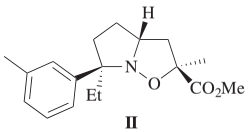
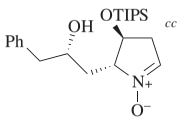
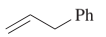
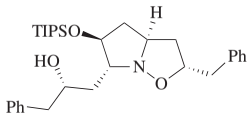
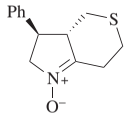
		Alkene (1 eq), benzene, reflux, 8 h	 (87)	597
		—	 (54) +  (23)	593
		Alkene (2 eq), sealed vial, MeCN, 40°, 24 h	 **I** +  **II**	**I** + **II** (87), **I/II** = 95:5	151
 non-racemic		Toluene, 90°		(60)	525

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

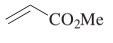
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

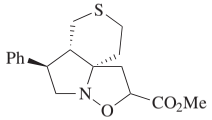
C_{13}



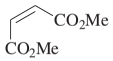
non-racemic



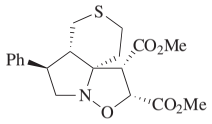
Alkene (10 eq), toluene, reflux

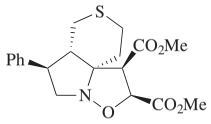


(64) dr 1:1 598



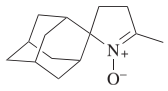
Alkene (10 eq), toluene, reflux



(41) + 

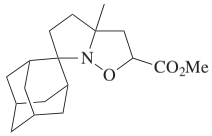
(30) 598

C_{14}

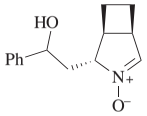


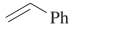


Alkene (1.5 eq), benzene, 80°, 3 h

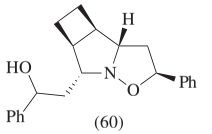


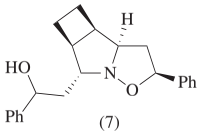
(76) 599



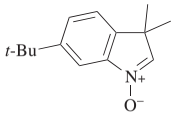


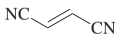
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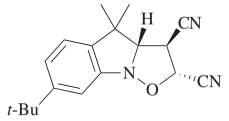
(60) + 

(7) 593



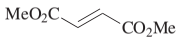


Alkene (1 eq), benzene, rt, 2 h

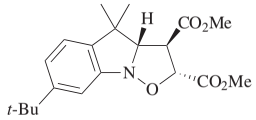


(79)

600

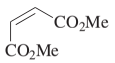


Alkene (1 eq), benzene, 65°, 0.25 h

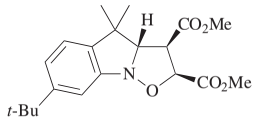


(90)

600

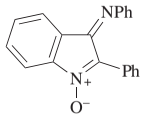


Alkene (1 eq), benzene, 75°, 0.25 h



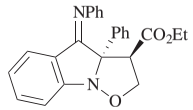
(85)

600



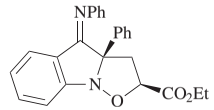


Alkene (xs), neat, 80°, 4 h



I

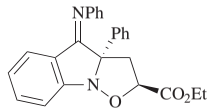
\+



II

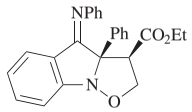
601

\+



III

\+



IV

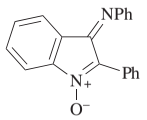
I + **II** + **III** + **IV** (94), **I/II/III/IV** = 38:33:17:12

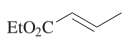
TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

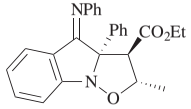
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_{14}

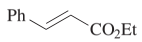




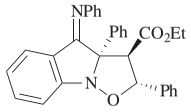
Alkene (xs), neat, 130°, 8 h



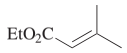
(90) 601



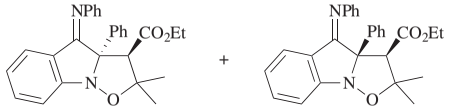
Alkene (xs), neat, 130°, 10 h



(43) 601

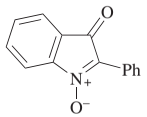


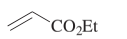
Alkene (xs), neat, 130°, 8 h



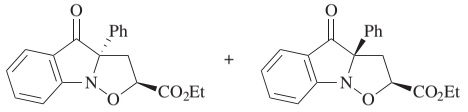
601

I **I + II** (40), **I/II** = 83:17 **II**



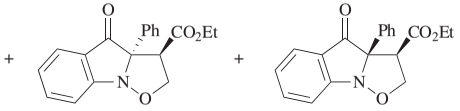


Alkene (xs), neat, 80°, 4 h



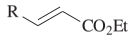
601

I **II**

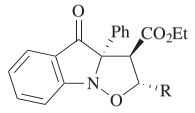


III **IV**

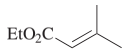
I + II + III + IV (98), **I/II/III/IV** = 49:24:17:10



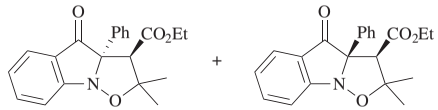
Alkene (xs), neat, 130°



R	Time (h)		
Me	8	(85)	601
Ph	10	(47)	



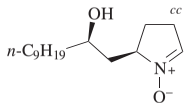
Alkene (xs), neat, 130°, 8 h

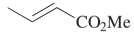


I **I + II** (45), **I/II** = 82:18 **II**

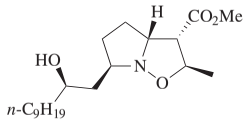
601

C_{15}



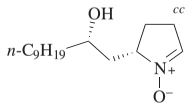


Toluene, 100°

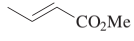


(62)

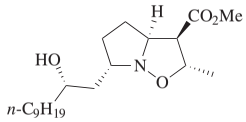
264



non-racemic



Alkene (5 eq), toluene, 100°, 1 h



(75)

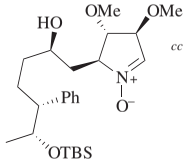
141

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

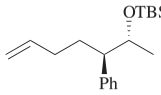
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_{17}

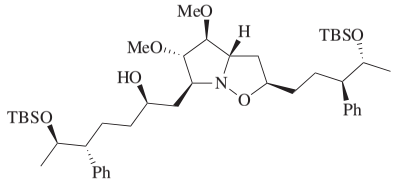


non-racemic



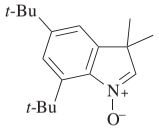
non-racemic

Toluene, 100°



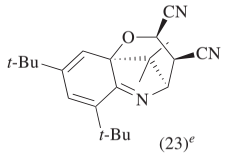
(—) 533

C_{18}

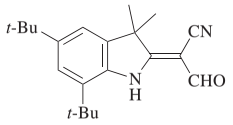




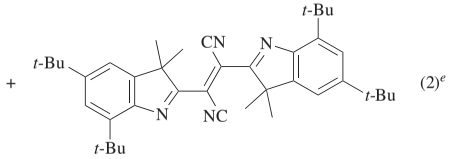
Alkene (1.1 eq), CH_2Cl_2, rt, 3 h



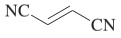
(23)[e] +



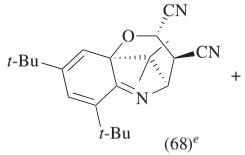
(9)[e] 600



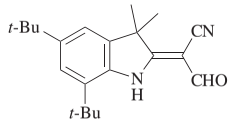
(2)[e]



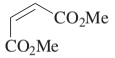
Alkene (1 eq), CH_2Cl_2, rt, 3 h



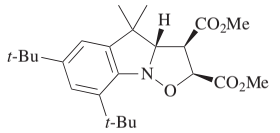
(68)[e] +



(12)[e] 600

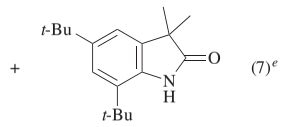


Alkene (1.07 eq),
CH_2Cl_2, 0°, 24 h

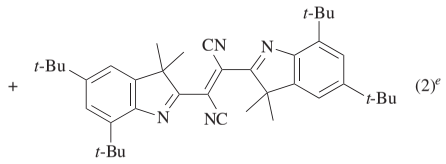


(52)

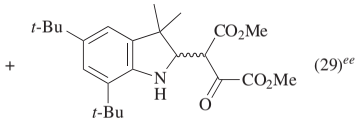
600



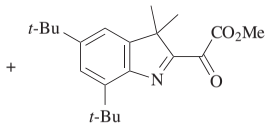
(7)[e]



(2)[e]

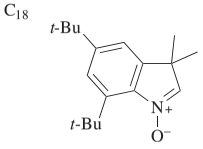
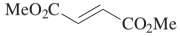
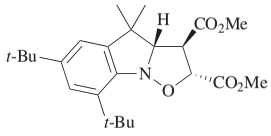


(29)[ee]



(3)[ee]

TABLE 2A. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*				
C_{18} 		Alkene (1.07 eq), CH_2Cl_2, 0°, 24 h	 (74)	600

[a] Formation of this adduct was postulated to occur through isomerization of the alkene to a mixture of methyl (*E*)- and (*Z*)-2-phenyl-2-butenoate.

[b] The starting nitrone was generated in situ by oxidation of pyrrolidine with SeO_2 and H_2O_2.

[c] The yield of the reaction refers to the synthesis of ethyl (benzyl-2-pyrrolidyl)acetate obtained by treatment of the cycloadduct mixture with benzyl bromide followed by heating at 50 ° for 10 h.

[d] The nitrone was added over a 10–15 h period.

[e] The primary adduct was not isolated.

[f] The starting nitrone was generated by photolysis of pyrrolidin-1-ol and then directly trapped with dimethyl fumarate.

[g] The nitrone was generated in situ by oxidation of *N*-hydroxypyrrolidine with polymer-supported perruthenate.

[h] Formation of this adduct was postulated to occur through isomerization of the alkene to methyl (*E*)-4,4-dichloro-2-[4-(*p*-toluenesulfonyloxy)phenyl]-2-butenoate.

[i] The yield was based on alkene conversion.

[j] A minor diastereoisomer was detected in low amounts; the relative configuration was not assigned.

[k] The compound was a mixture of diastereoisomers.

[l] Resin.

[m] This is the yield of crude material.

[n] Configuration at the metal stereocenters was assigned tentatively.

[o] The unreacted alkene was recovered highly enantioenriched (er and absolute configuration were not determined).

[p] HMPA was added to the reaction mixture in equimolar amount with the alkene.

[q] The starting nitrone was generated in situ by oxidation of (3*S*,4*S*)-1-benzyl-3,4-bis(methyloxymethoxy)pyrrolidine with 2-(phenylsulfonyl)-3-phenyloxaziridine.

[r] The starting nitrone was generated in situ by oxidation of 2-methylpyrrolidin-1-ol with HgO and was used in mixture together with the regioisomeric nitrone.

[s] Formation of this product was ascribed to a partial isomerization of the starting alkene to dimethyl fumarate.

[t] The crude product was obtained in 88% yield as a 9:1 mixture together with an unidentified stereoisomer.

[u] The starting nitrone was generated in situ by reaction of a (*Z*)/(*E*) mixture of the appropriate 4,5-dienal oxime precursor with silver tetrafluoroborate (0.5–1 eq).

[v] The alkene was generated in situ from methylphenylvinylphosphine and phenylazide.

[w] The primary cycloadducts were not isolated: they were characterized by ^{31}P NMR spectroscopy and then converted into the corresponding phosphine oxides for analysis.

[x] The reported **I/II** ratios were measured at low conversion; the ratio changed with time as double addition took partially place.

[y] The alkene contains 35% of the (*E*) isomer which does not react; cyclization to the lactone, identical to the product obtained starting from the lactone dipolarophile, occurred during the cycloaddition process.

[z] This product was contaminated with traces of **III** and converted completely into **III** on standing at rt; heating a solution of **I** and 1-nitro-1-propene (1.5 eq) in toluene (reflux, 30 h) afforded adducts **II** (43%) and **III** (13%).

[aa] The ketene was generated in situ from (*Z*)-1-chloro-4-phenylbut-1-enyl acetate and diethylaluminum ethoxide.

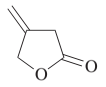
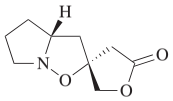
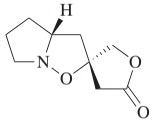
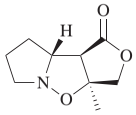
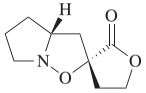
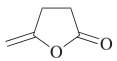
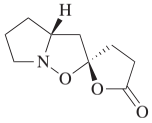
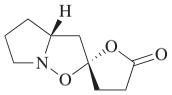
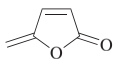
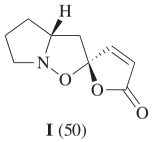
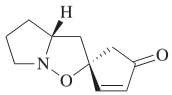
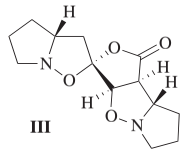
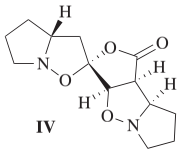
[bb] This product was the main component of an isomeric mixture.

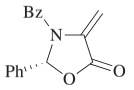
[cc] The starting nitrone was prepared by oxidation of the appropriate isoxazolidine precursor with *m*-CPBA in CH_2Cl_2 at 0° and used as the crude product after work-up; the yield refers to the two-step process.

[dd] The starting nitrone was generated in situ by oxidation of the appropriate isoxazolidine precursor with *m*-CPBA in CH_2Cl_2 at 0°.

[ee] The primary cycloadduct underwent partial transformation.

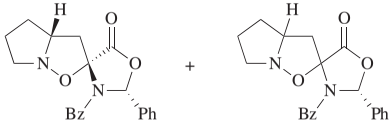
TABLE 2B. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH EXOCYCLIC ALKENES

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_4				
		Alkene (0.37 eq), $CHCl_3$, 70°, 16 h	 (16) +  (19) +  (18)	602
		Alkene (0.46 eq), $CHCl_3$, 70°, 1 h	 (96)	602
		Alkene (0.79 eq), $CHCl_3$, 70°, 14 d	 +  **I** **I** + **II** (69), **I/II** = 3:2 **II**	602
		Alkene (0.73 eq), $CHCl_3$, 70°, 4 h	 +  **I** (50) **II** (2) +  +  **III** **IV** **III** + **IV** (11), **III/IV** = 4:1	602



non-racemic

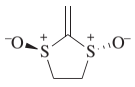
Alkene (0.9 eq), CH_2Cl_2, 2 d



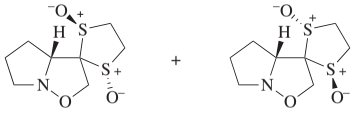
I **II**

Temp	**I + II**	**I/II**
rt	(27)	>98:2
40°	(33)	92:8

603

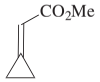


Alkene (0.2 eq), CH_2Cl_2, –78°, 1 h

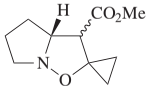


I **I + II** (84), **I/II** = 22:1 **II**

270

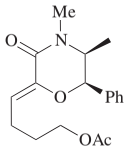


Alkene (0.4 eq), benzene, rt, 18 h



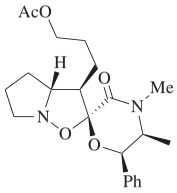
(64) dr 2.1:1

57



non-racemic

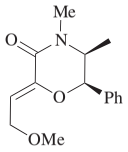
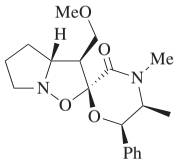
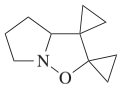
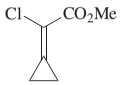
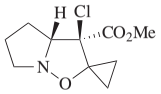
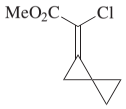
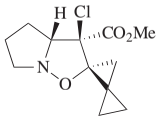
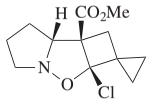
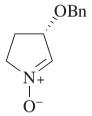
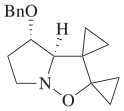
Alkene (0.5 eq), MW, toluene, 110°, 0.5 h

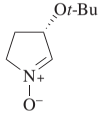


(71)

480

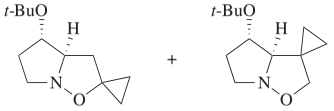
TABLE 2B. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH EXOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_4				
	 non-racemic	Alkene (0.5 eq), MW, toluene, 110°, 0.5 h	 (71)	480
		Alkene (0.6 eq), benzene, rt, 20 d	 (42)	604
		Alkene (0.82 eq), CH_2Cl_2, rt, 60 h	 (65)	286, 605
		Alkene (0.5 eq), CH_2Cl_2, rt, 60 h	 +  **I** **I** + **II** (70), **I**/**II** = 5:1 **II**[a]	286, 605
 non-racemic		Alkene (2.2 eq), sovirel tube, toluene, 60°, 2 d	 (78)	606


non-racemic



Alkene (10 eq), benzene, rt, 7 d


I + **II** (70), **I/II** = 6:1

124



Alkene (1.2 eq), benzene, 40°, 28 d


I **I** + **II** (83)[b], **I/II** = 2.3:1 **II**

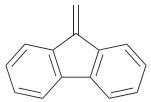
298



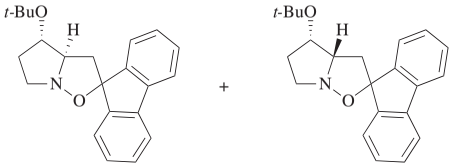
Alkene (1.5 eq), xylenes, 125°, 6 h


(46)[c] + (22)[c]

298

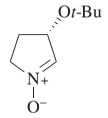
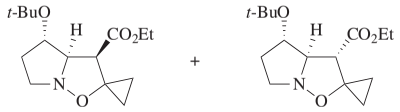
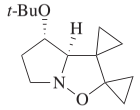
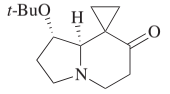
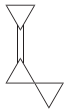
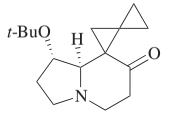
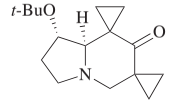
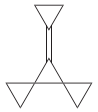
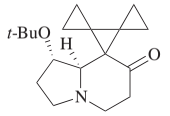
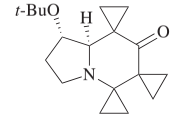


Alkene (1.5 eq), benzene, 60°, 2 d


I **I** + **II** (54), **I/II** = 2:1 **II**

479

TABLE 2B. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH EXOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_4  non-racemic		Alkene (*x* eq), toluene, rt, overnight	 **I** + **II**	
			x Temp **I + II** **I/II**: 1.3 rt (69) 5:1	356
			— 30° (81) 6:1	606
		Alkene (1.5 eq), benzene, 60° 2 d	 (80)	298
		Alkene (1.5 eq), xylenes, 120°, 8 h	 (64)[c]	298
		Alkene (1.25 eq), 2-xylene, 120°, 1 d	 +  **I**[b] **I + II** (80)[c], **I/II** = 66:33 **II**	607
		Alkene (1.25 eq), 2-xylene, 120°, 1 d	 +  **I** **I + II** (77)[c], **I/II** = 62:38 **II**	607

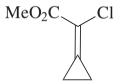
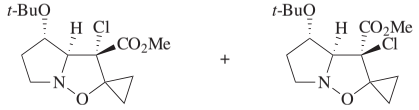
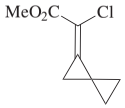
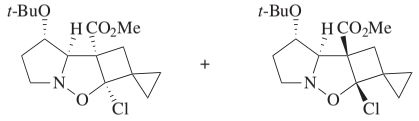
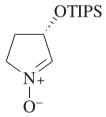
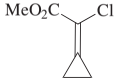
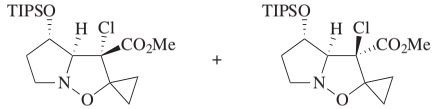
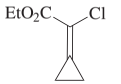
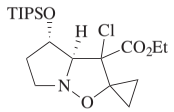
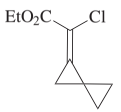
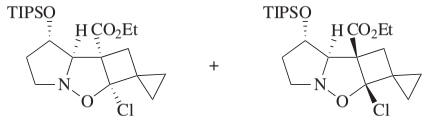
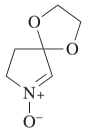
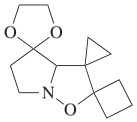
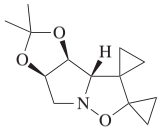
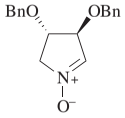
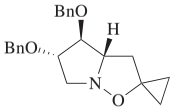
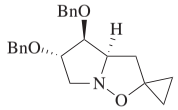
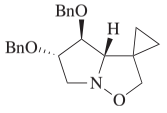
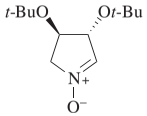
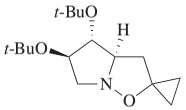
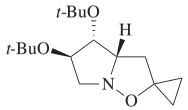
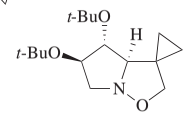
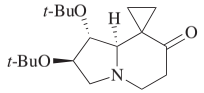
		Alkene (1.1 eq), CH_2Cl_2, rt, 6 d	 **I** **I + II** (100), **I/II** = 6:1 **II**	608
		Alkene (1.2 eq), CH_2Cl_2, rt, 6 d	 **I** **I + II** (80)[c], **I/II** = 6:1 **II**	608
 non-racemic		Alkene (1.2 eq), toluene, rt, 5 d	 **I** **I + II** (100), **I/II** = 7:1 **II**	608
		Alkene (1.2 eq), toluene, rt, 5 d	 (100) dr 5:1	608
		Alkene (1 eq), CH_2Cl_2, rt, 6 d	 **I** **I + II** (85)[c] **II**	608

TABLE 2B. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH EXOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_4				
		Alkene (1.69 eq), sealed tube, toluene, 100°, 6 d	 (48)	609
 non-racemic		Alkene (1.3 eq), toluene, 60°, 2 d	 (85)	610
 non-racemic		Alkene (xs), sealed tube, neat, 40°, 7 d	 +  **I** **II** +  **III** **I** + **II** + **III** (95) **I/II/III** = 10:2:1	273
 non-racemic		Alkene (3 eq), sealed vial, toluene, 42°, 7 d	 (64) +  (8) +  (4)	274



Alkene (1.49 eq), xylenes, 120°, 16 h

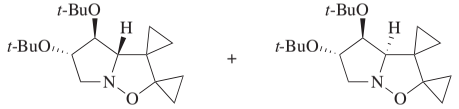


(62)[c]

298



Alkene (2 eq), closed vessel, toluene, 60°, 3 d

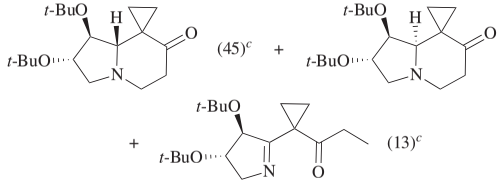


611

I **I + II** (90), **I/II** = 81:19 **II**

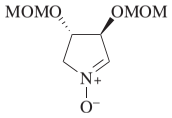


Alkene (1.1 eq), MW, xylenes, 120–125°, 1.5 h

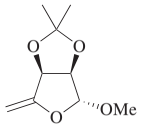


(45)[c] + (10)[c]

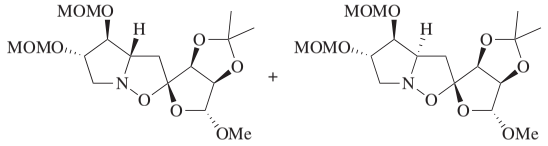
612



non-racemic



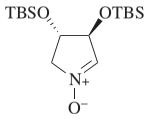
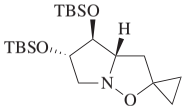
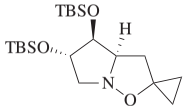
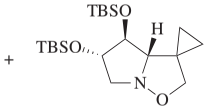
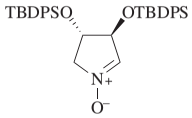
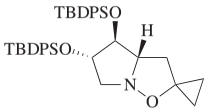
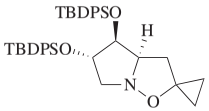
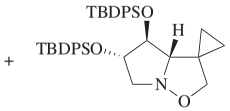
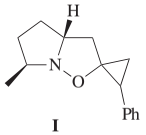
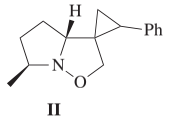
Toluene, reflux, 48 h



613

I **I + II** (96), **I/II** = 8.5:1 **II**

TABLE 2B. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH EXOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_4				
 non-racemic		Alkene (3.5 eq), sealed tube, benzene, 35°, 11 d	 **I** +  **II** +  **III** (tr) **I** + **II** (95), **I/II** = 6:1	614
 non-racemic		Alkene (xs), sealed tube, neat, 35°, 8 d	 **I** +  **II** +  **III** **I** + **II** + **III** (94) **I/II/III** = 12:1:1.5	273, 615
C_5				
		Alkene (0.9 eq), neat, rt, 15 d	 **I** +  **II** **I** + **II** (90)[b] **I/II** = 83:17	272

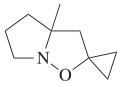
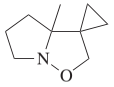
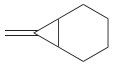
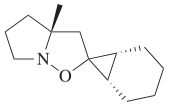
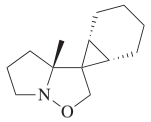
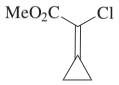
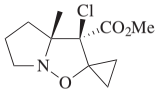
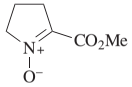
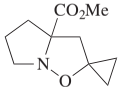
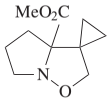
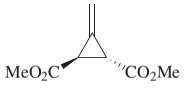
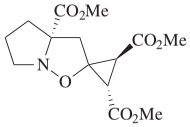
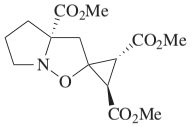
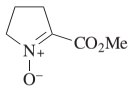
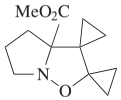
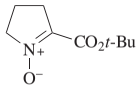
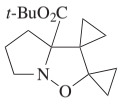
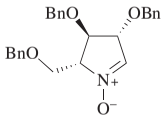
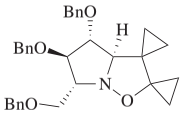
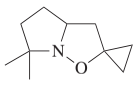
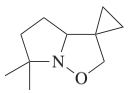
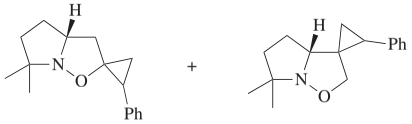
		Alkene (xs), sealed tube, benzene, 80°, 7 d	 **I** +  **II**	**I** + **II** (78), **I/II** = 5.5:1	616
		Alkene (1.2 eq), toluene, 80°, 7 d	 +  **I** **I** + **II** (41), **I/II** = 4:1 **II**		616
		Alkene (1.2 eq), sealed vial, toluene, 80°, 20 h		(73)	608
		Alkene (3 eq), sealed vial, toluene, 42°, 7 d		(61) +  (6)	274
		Alkene (0.9 eq), benzene, 80°, 60 h		(37) +  (34)	617

TABLE 2B. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH EXOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_5				
		Alkene (2 eq), closed vessel, toluene, 60°, 3 d	 (69)	611
		Alkene (2 eq), closed vessel, toluene, 20°, 5 d	 (84)	611
 non-racemic		Alkene (1.3 eq), toluene, 60°, 2 d	 (90)	610
C_6				
		Alkene (2 eq), sealed tube, neat, 60°, 2 d	 +  **I** + **II** (86), **I/II** = 65:35 **I** **II**	61
		Alkene (1 eq), neat, rt, 15 d	 **I** **I** + **II** (76)[b], **I/II** = 67:33 **II**	272

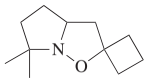
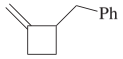
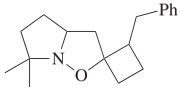
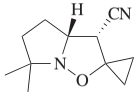
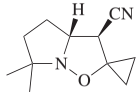
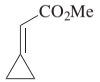
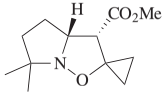
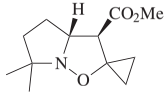
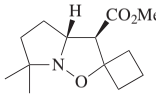
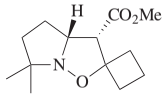
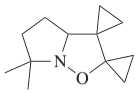
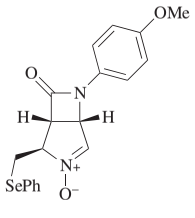
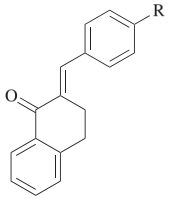
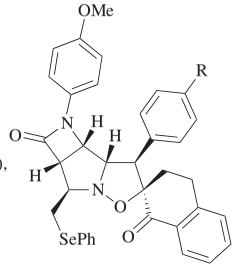
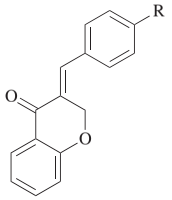
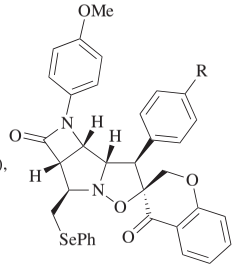
	Alkene (1.5 eq), sealed tube, neat, 100°, 4 d		(90)	65, 618
	Alkene (1 eq), sealed tube, toluene, 100°, 7 d		(80) dr 40:40:13:7	618
	Alkene (2 eq), toluene, 50°, 1 h	 **I** +  **II**	**I** + **II** (87) **I/II** = 80:20	619
	Alkene (2 eq), neat, 50°, 40 h	 **I** +  **II**	**I** + **II** (63), **I/II** = 33:67	619
	Alkene (0.7 eq), sealed tube, toluene, 100°, 7 d	 **I** +  **II**	**I** + **II** (81), **I/II** = 66:34	618
	Alkene (1 eq), benzene, rt, 7 d		(80)	604, 620

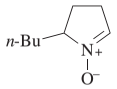
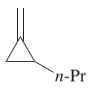
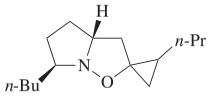
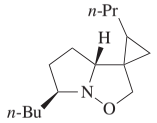
TABLE 2B. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH EXOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_6				
		**A**: MeCN, reflux, 4 h; or **B**: MeCN, MW (600 W), 10 min		466

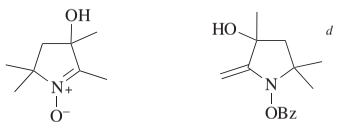
R	Conditions **A**	Conditions **B**
H	(62)	(90)
Cl	(64)	(92)
Br	(63)	(93)
MeO	(56)	(86)
Me	(60)	(82)

		**A**: MeCN, reflux, 4 h; or **B**: MeCN, MW (600 W), 10 min		466

R	Conditions **A**	Conditions **B**
H	(60)	(89)
Cl	(65)	(92)
Br	(64)	(94)
MeO	(55)	(88)
Me	(62)	(85)

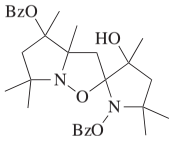
C_8				
		Alkene (1 eq), benzene, 50°, 15 d	 + 	272

I **I + II** (76)[b], **I/II** = 75:25 **II**



[d]

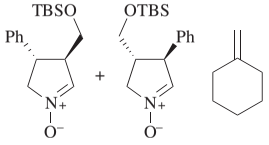
PhCOCl, pyridine, CH_2Cl_2, rt, 16 h



(—)[e]

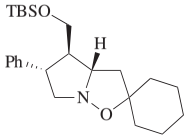
621

C_{10}



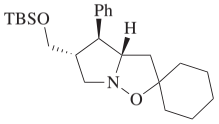
non-racemic

Toluene, reflux



I

I + **II** (23)



II

596

[a] The product was derived from rearrangement of the primary cycloadduct.

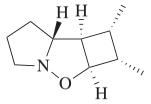
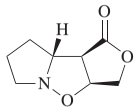
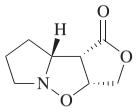
[b] Each product is a mixture of two diastereoisomers.

[c] The primary adduct was not isolated.

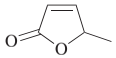
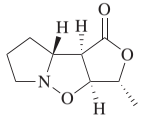
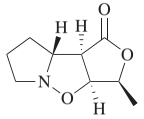
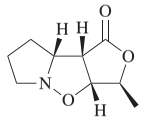
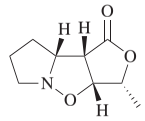
[d] The enamine dipolarophile was formed in situ by benzoylation of the nitrone with benzoyl chloride in pyridine.

[e] The product was generated by a dimerization of the nitrone, followed by selective benzoylation (tentatively assigned) of one of the two free hydroxy groups in the product.

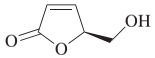
TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_4				
		Alkene (0.33 eq), sealed vial, benzene, rt, 5 d	 (75)	622
		Alkene (0.8 eq), solvent	 +  **I** **II**	623

Solvent	Temp	Time	**I**	**II**	**I + II**	**I/II**
$CHCl_3$	20°	40 d	(64)	(10)	(—)	—
$CHCl_3$	reflux	50 h	(63)	(13)	(—)	—
toluene	reflux	2 h	(—)	(—)	(84)	3:1

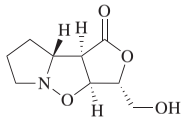
	Alkene (0.8 eq), solvent	 +  **I** **II** +  +  **III** **IV**	623

Solvent	Temp	Time	**I + II + III + IV**
$CHCl_3$	20°	40 d	(70)
$CHCl_3$	reflux	50 h	(76)
toluene	reflux	3 h	(85)



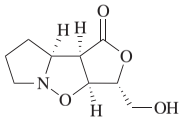
non-racemic

Alkene (0.77 eq), toluene



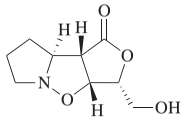
I

+



II

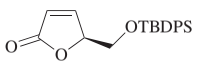
+



III

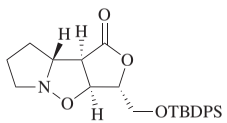
624, 625

Temp 1	Time 1 (h)	Temp 2	Time 2 (h)	**I** + **II** + **III**	**I**/**II**/**III**
rt	—	—	—	(70)	78:15:7
rt	50	reflux	1	(69)	70:0:30



non-racemic

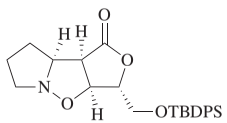
Alkene (0.77 eq), toluene, rt



I

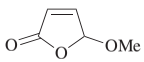
I + **II** (73), **I**/**II** = 94:6

+

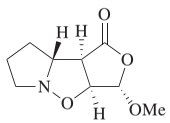


II

624



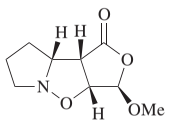
Alkene (1 eq), toluene, reflux, 16 h



I (75)

I + **II** (91), **I**/**II** = 7:1

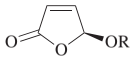
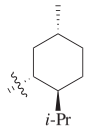
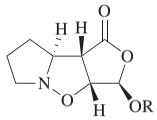
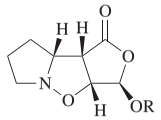
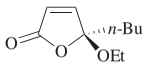
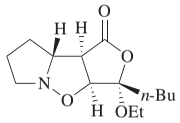
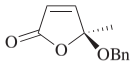
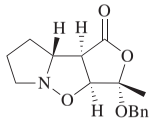
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II (—)

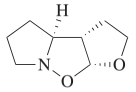
626

TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

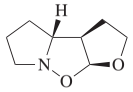
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_4				
	 R =  non-racemic	Alkene (0.91 eq), toluene, reflux, 16 h	 **I** (85) **I/II** = 7:1 +  **II** (—)	627, 628
	 non-racemic	Alkene (0.15 eq), toluene, reflux, 3 h	 (89)	629
	 non-racemic	Alkene (0.1 eq), toluene, reflux, 3 h	 (80)	629



Alkene (xs), optically pure catalyst (0.2 eq), neat, rt, 20 h



+



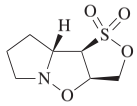
278

I **II**

Catalyst	Pressure		**I/II**
—	2 kbar	(65)	—
4a	1 bar	(65)	50:50
4a	2 kbar	(69)	52:48
4b	1 bar	(56)	69:31
4b	2 kbar	(61)	65:35
4c	1 bar	(58)	41:59
4d	1 bar	(54)	50:50
4f	1 bar	(74)	67:33

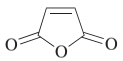


Alkene (0.45 eq), toluene, 40°, 12 h

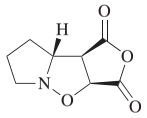


(78)

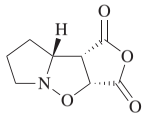
630



Alkene (1.3 eq), CH_2Cl_2, rt, 2 min

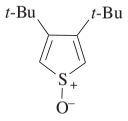


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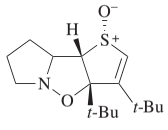


506

I **I + II** (74), **I/II** = 67:33 **II**



Alkene (1 eq), toluene, reflux



(73)

632

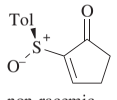
TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

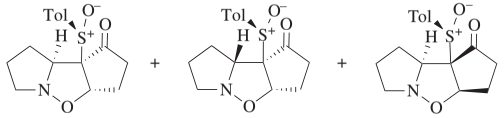
C_4





non-racemic

Alkene (0.66 eq), $CHCl_3$

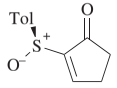


I + **II** + **III**

631

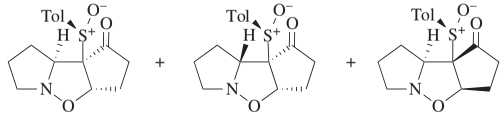
Temp	Time (h)	**I + II + III**	**I/II/III**
rt	15	(91)	86:11:3
rt	20	(92)	79:16:5
60°	15	(90)	49:39:12





non-racemic

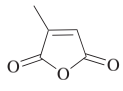
$CHCl_3$, 60°



I (—) + **II** (—) + **III** (—)

631

Time (h)	**I/II/III**
1	74:19:7
6	62:29:9
14	53:37:10

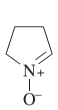


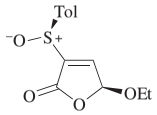
1. Alkene (1.5 eq), CH_2Cl_2, 20°, 8 h
2. MeOH/HCl



I **I + II** (79), **I/II** = 92:8 **II**

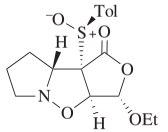
515





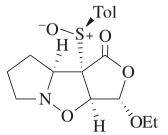
non-racemic

Alkene (0.66 eq),
solvent



I

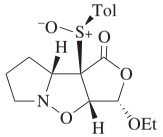
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II

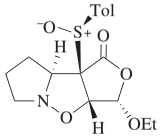
285

+



III

+



IV

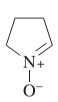
Solvent	Temp	Time (h)	**I-IV**	**I/II/III/IV**
$CHCl_3$	–40°	336	(—)	23:39:38:0
$CHCl_3$	0°	14	(—)	28:39:32:1
$CHCl_3$	rt	1	(86)	24:46:29:1
$CHCl_3$	rt	24	(—)	29:40:27:4
$CHCl_3$	rt	96	(—)	35:42:19:4
$CHCl_3$	60°	0.3	(—)	31:40:28:1
toluene	0°	2	(—)	33:36:30:1
toluene	rt	0.25	(—)	36:38:24:2
toluene	rt	648	(—)	43:46:7:4
toluene	110°	0.1	(—)	50:40:5:5
MeCN	0°	15.5	(—)	41:45:14:0
MeCN	rt	24	(—)	41:45:14:0
MeCN	80°	0.25	(—)	44:43:11:2

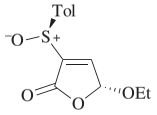
TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

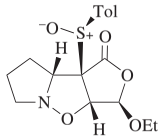
C_4





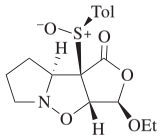
non-racemic

Alkene (0.66 eq), solvent



I

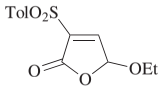
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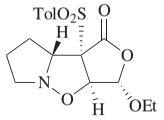
II

285

Solvent	Temp	Time	**I**	**II**	**I/II**
$CHCl_3$	–40°	48 h	(71)	(18)	80:20
$CHCl_3$	–22°	4 h	(—)	(—)	75:25
$CHCl_3$	0°	1 h	(—)	(—)	69:31
$CHCl_3$	rt	10 min	(58)	(29)	67:33
$CHCl_3$	rt	1 d	(—)	(—)	62:38
$CHCl_3$	rt	4 d	(—)	(—)	54:46
toluene	–40°	22 h	(—)	(—)	68:32
toluene	0°	10 min	(—)	(—)	58:42
toluene	rt	5 min	(—)	(—)	59:41
toluene	rt	1 d	(—)	(—)	53:47
toluene	rt	4 d	(—)	(—)	47:53
toluene	110°	5 min	(—)	(—)	18:82
toluene	110°	1 h	(11)	(71)	13:87
MeCN	–40°	48 h	(65)	(15)	80:20
MeCN	rt	10 min	(—)	(—)	72:28
MeCN	rt	4 d	(—)	(—)	59:41

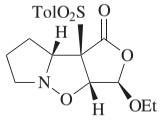


Alkene (0.66 eq), solvent, rt



I

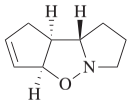
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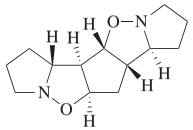
II

285

Solvent	Time	**I/II**
toluene	5 min	80:20
MeCN	5 min	66:34
MeCN	18 h	72:28



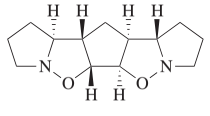
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I (—)

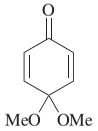
I/II = 3:1

+

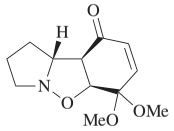


II (—)

494

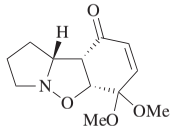


Alkene (2 eq)[a], toluene, 110°, 8 h



(21)

+



(12)

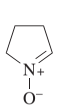
633, 634

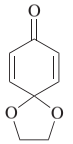
TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

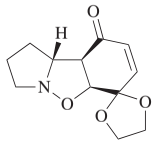
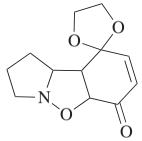
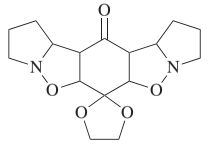
Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

C_4

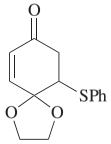




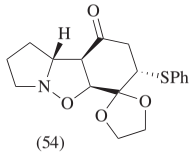
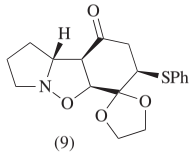
Alkene (1.7 eq), toluene, 110°, 4.5 h


(18) +

(16)
+

(24)

633, 634



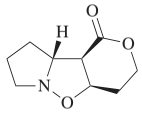
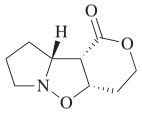
Alkene (0.46 eq), toluene, reflux, 6 h


(54) +

(9)

634



See table.


I +

II

623

Solvent	Temp	Time	**I**	**II**
CH_2Cl_2	20°	82 d	(73)	(—)
$CHCl_3$	reflux	7 d	(85)	(<1)
toluene	reflux	22 h	(86)	(1)

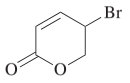
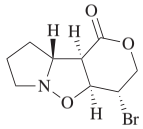
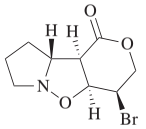
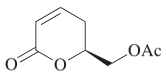
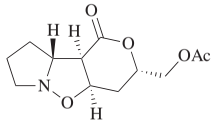
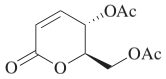
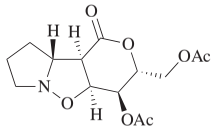
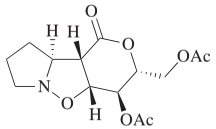
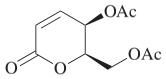
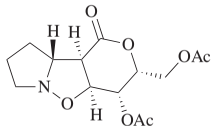
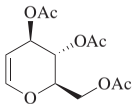
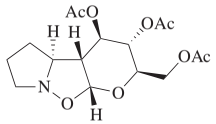
	Alkene (0.39 eq), toluene, 100°, 22 h	 (50) +  (6)		509
 non-racemic	Alkene (0.66 eq), toluene, rt, 48 h	 (81)		635
 non-racemic	Alkene (1 eq), toluene, rt, 48 h	 + 		635
		I	**I** + **II** (83), **I**/**II** = 74:26	**II**
 non-racemic	Alkene (1 eq), toluene, rt, 48 h	 (86)		635
 non-racemic	Alkene (3 eq), mesitylene, 152°, 40 min	 (12)		280, 636

TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

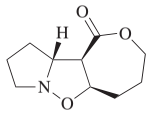
Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

C_4



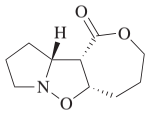


Alkene (0.66 eq), solvent



I

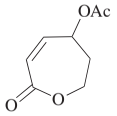
+



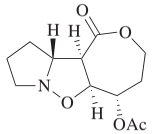
II

623

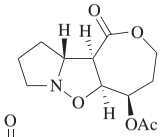
Solvent	Temp	Time	**I**	**II**
$CHCl_3$	20°	180 d	(22)	(—)
$CHCl_3$	reflux	11 d	(52)	(6)
toluene	reflux	4 h	(65)	(4)



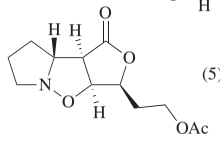
Alkene (0.5 eq), toluene, 110°, 4 d



(78) +

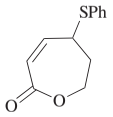


(13)

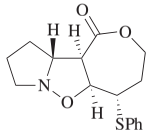


(5)

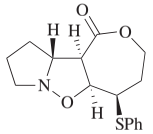
290



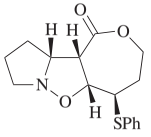
Alkene (0.5 eq), toluene, 110°, 19 h



(69) +



(7)



(1)

290

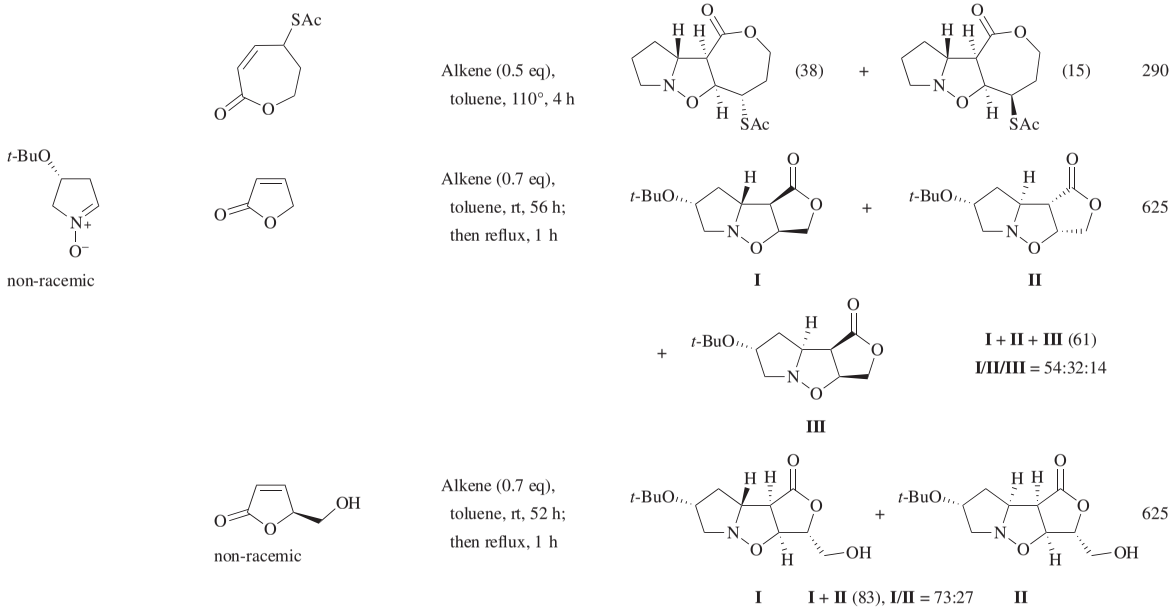
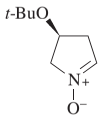

SAc
Alkene (0.5 eq),
toluene, 110°, 4 h
(38)
+
(15)
290
t-BuO
non-racemic
Alkene (0.7 eq),
toluene, rt, 56 h;
then reflux, 1 h
625
I
II
+
III
I + II + III (61)
I/II/III = 54:32:14
OH
non-racemic
Alkene (0.7 eq),
toluene, rt, 52 h;
then reflux, 1 h
625
I
I + II (83), I/II = 73:27
II

TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

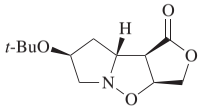
C_4



non-racemic

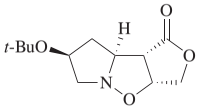


See table.



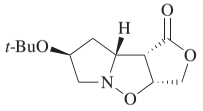
I

+



II

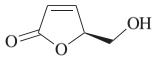
+



III

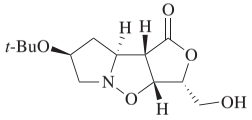
625

Solvent	Temp 1	Time 1	Temp 2	Time 2	**I** + **II** + **III**	**I/II/III**
MeCN	rt	10 d	—	—	(55)	50:38:12
toluene	rt	50 h	reflux	1 h	(82)	40:50:10
benzene	rt	49 h	—	—	(76)	36.4:49.5:14.1
THF	rt	7 d	—	—	(85)	43:45:12
CH_2Cl_2	rt	7 d	—	—	(66)	41:47:12
n-hexane	rt	14 d	—	—	(49)	48:40.5:11.5
DMF	rt	10 d	—	—	(71)	51:37.5:11.5
MeOH	rt	14 d	—	—	(64)	45:44.5:10.5



non-racemic

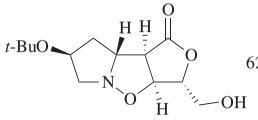
Alkene (0.7 eq), toluene, rt, 40 h; then reflux, 1 h



I

I + **II** (82), **I/II** = 21:79

+



II

625

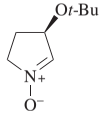
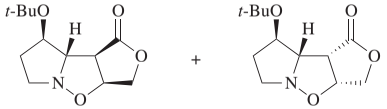
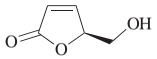
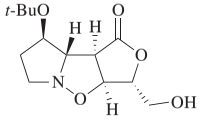
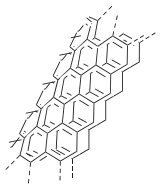
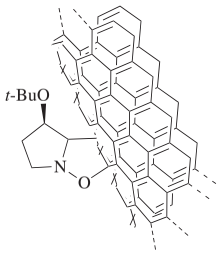
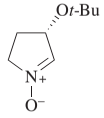
 non-racemic		Alkene (0.7 eq), toluene, rt, 72 h; then reflux, 1 h	 **I** **I** + **II** (85), **I**/**II** = 78:22 **II**	625
 non-racemic		Alkene (0.7 eq), toluene, rt, 47 h; then reflux, 1 h	 (86)	625
 MWCNT		Nitrone (1.56 mmol), MWCNT (120 mg), dry degassed DMF, 160°, 3 d	 (—)[c]	289

TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

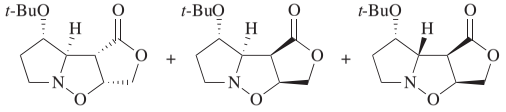
C_4



non-racemic



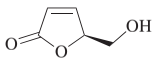
Toluene



I + **II** + **III**

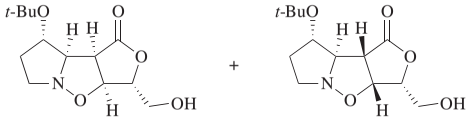
482, 625

Temp	Time (h)	**I + II + III**	**I/II/III**
rt	48	(75)	75:25:0
reflux	48	(73)	64:17:19
reflux	96	(67)	67:12:29
reflux	120	(65)	46:8:46
reflux	196	(56)	35:4:68

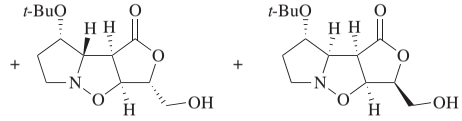


non-racemic

See table.



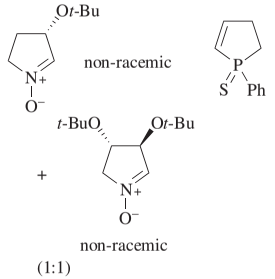
I + **II**



III + **IV**

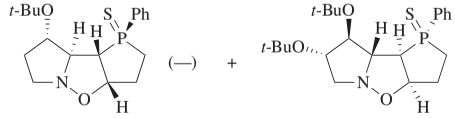
482, 625

Solvent	Temp 1	Time 1	Temp 2	Time 2	**I + II + III + IV**	**I/II/III/IV**
toluene	rt	47 h	reflux	1 h	(89)	52:27:21:0
toluene	reflux	48 h	—	—	(72)	48:23:23:6
Et_3N	rt	9 d	—	—	(90)	25:11:0:64

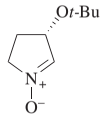


(1:1)

Benzene, 60°, 22 h

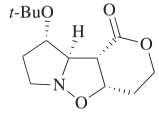


312



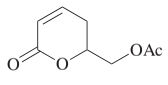


Alkene (1 eq), toluene, rt, 48 h

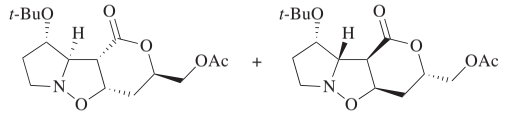


(89)

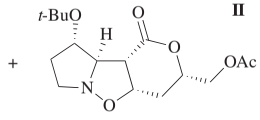
276



Alkene (*x* eq), toluene



I **II**



III

276, 635

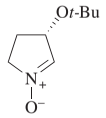
x	Temp 1	Time 1 (h)	Temp 2	Time 2 (h)	**I** + **II** + **III**	**I**/**II**/**III**
1	rt	24	reflux	1	(79)	51:21:28
2[d]	rt	48	—	—	(87)	**I** only

TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

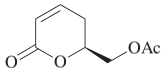
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

C_4

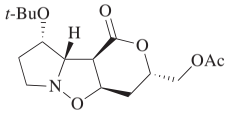


non-racemic

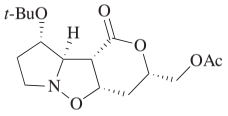


non-racemic

Alkene (1 eq), toluene, rt, 24 h; then reflux, 1 h

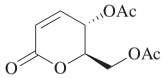


+



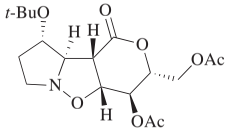
276, 635

I **I + II** (75), **I/II** = 42:58 **II**



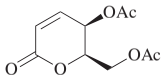
non-racemic

Alkene (0.66 eq), toluene, rt, 48 h



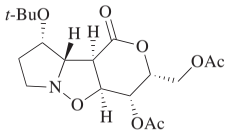
(62)

635



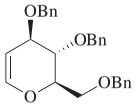
non-racemic

Alkene (1 eq), toluene, rt, 24 h; then reflux, 1 h



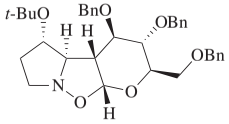
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276



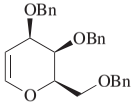
non-racemic

Alkene (*x* eq), toluene



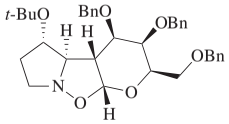
x	Pressure	Temp (°)	Time (d)	
2	10 kbar	60	3	(97)
3	1 atm	100	9	(35)

280, 470, 636



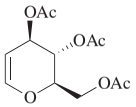
non-racemic

Alkene (*x* eq), toluene



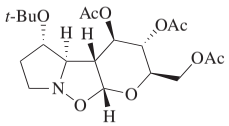
x	Pressure	Temp (°)	Time (d)	
2	10 kbar	60	3	(63)
3	1 atm	100	7	(27)

280, 636



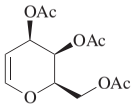
non-racemic

Alkene (*x* eq), toluene



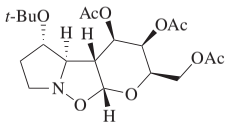
x	Pressure	Temp (°)	Time (d)	
2	10 kbar	60	3	(98)
3	1 atm	100	4	(68)

280, 470, 636



non-racemic

Alkene (*x* eq), toluene

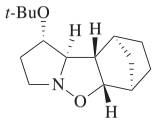


x	Pressure	Temp (°)	Time (d)	
2	10 kbar	60	3	(67)
3	1 atm	100	7	(42)

280, 470, 636



Alkene (1.5 eq), benzene, rt, 4 d



(89)

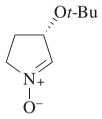
479

TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_4

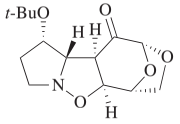


non-racemic

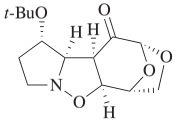


non-racemic

Alkene (1 eq), toluene, rt, 7 h



(36) + (17)

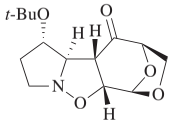


311



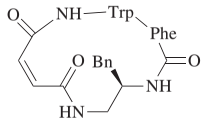
non-racemic

Alkene (1 eq), toluene, rt, 2.5 h

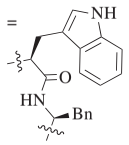


(89)

306

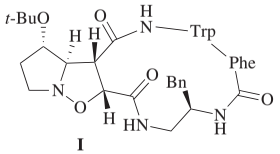


–Trp–Phe– =



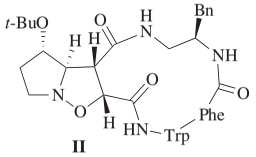
non-racemic

Alkene (0.8 eq), solvent



I

+

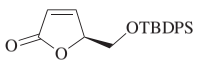


II

637

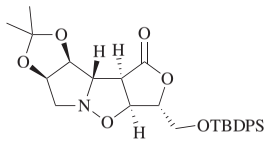
Solvent	Temp (°)	Time (h)	**I + II**	**I/II**
DMSO	84	8	(99)	4:1
toluene	87	27	(86)	25:1





non-racemic

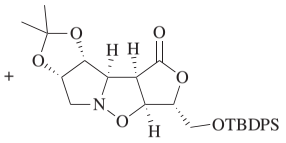
Alkene (x eq), N_2,
dry toluene, 7 d



I

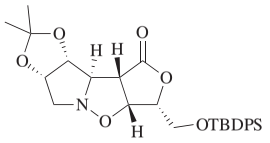
x	Temp	**I + II + III**	**I/II/III**
0.5	rt	(95)	76:24:0
0.5	reflux	(72)	58:28:14
1	rt	(68)	71:23:6

+



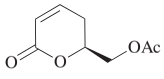
II

+



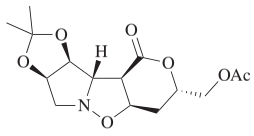
III

481



non-racemic

Alkene (0.5 eq), N_2,
dry toluene, rt, 5 d



(79)

+



(60) er 82:18

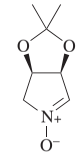
481

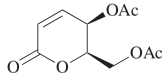
TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

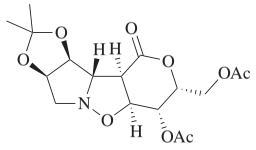
C_4



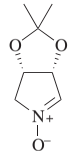


non-racemic

Alkene (0.5 eq), N_2, dry toluene, rt, 6 d

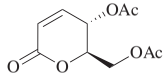


(82)



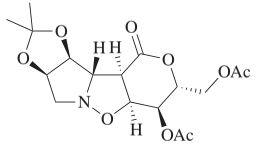
(53) non-racemic

481

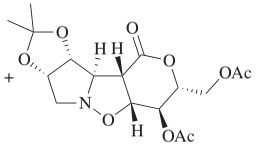


non-racemic

Alkene (*x* eq), N_2, dry toluene



I



II

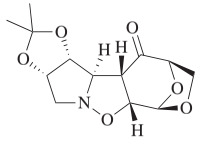
481

x	Temp	Time (d)	**I + II**	**I/II**
0.5	rt	7	(89)	95:5
1	rt	8	(36)	67:33
1	reflux	3	(51)	64:36

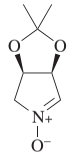


non-racemic

Alkene (0.5 eq), toluene, rt, 2.5 h

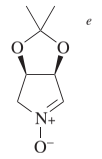


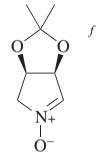
(64) +

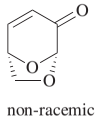


(50) er 77:23

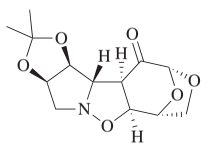
306, 311


e

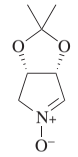

f


non-racemic

Alkene (0.5 eq), toluene, rt, 2 h


(44)

+


(50) er 71:29

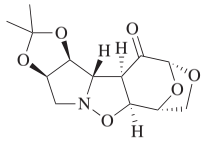
311


non-racemic

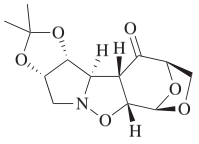
+


non-racemic

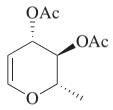
Alkene (0.5 eq each), toluene, rt, 2 h


(64)

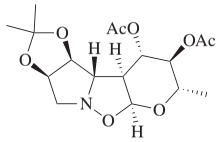
+


(88)

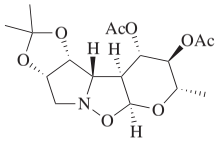
311


non-racemic

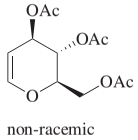
Alkene (3 eq), toluene, 100°, 1 d


(29)

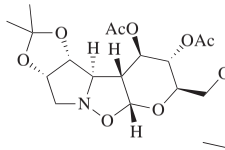
+


(7)

281


non-racemic

Alkene (3 eq), toluene, 100°, 1 d


(33)

281

+

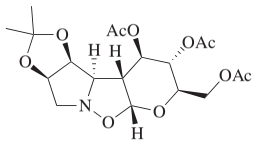

(10)

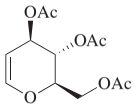
TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

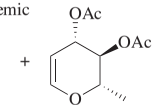
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_4



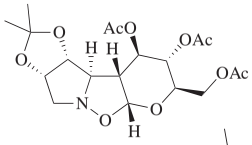


non-racemic

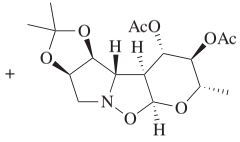


non-racemic

Alkenes (1.5 eq each), toluene, 90°, 3 d



(23)

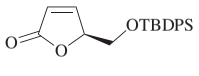


(24)

281

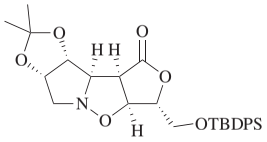


non-racemic



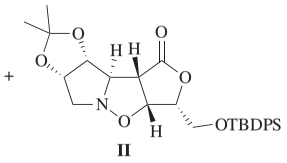
non-racemic

Alkene (1 eq), N_2, dry toluene, rt, 14 d



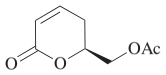
I

I + **II** (84), **I/II** = 80:20



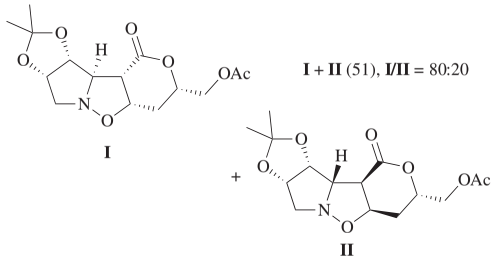
II

481

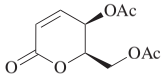


non-racemic

Alkene (1 eq), N_2, dry toluene, reflux, 5 d

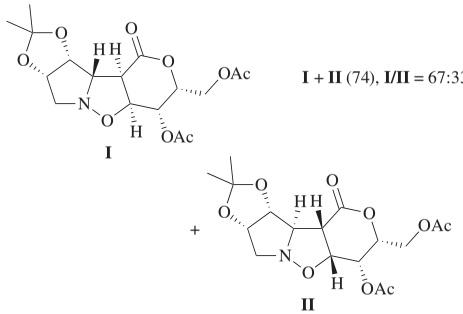


I + **II** (51), **I**/**II** = 80:20 481

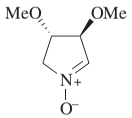


non-racemic

Alkene (1 eq), N_2, dry toluene, 1 kbar, 50°, 24 h



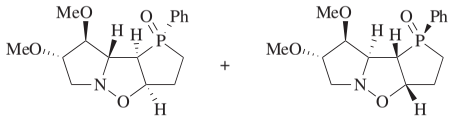
I + **II** (74), **I**/**II** = 67:33 481



non-racemic



Alkene (1.8 eq), benzene



Temp	Time (h)	**I** + **II**	**I**/**II**
rt	72	(75)	4:1
60°	8	(90)	3.3:1[g]

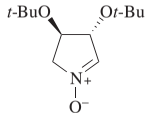
307

TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

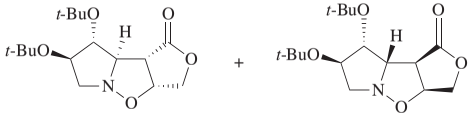
C_4



non-racemic

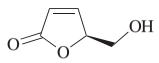


Alkene (0.7 eq), toluene, rt, 55 h; then reflux, 1 h



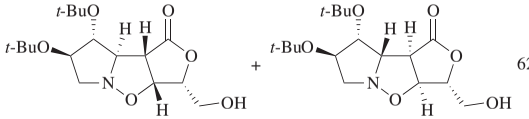
I **I + II** (62), **I/II** = 94:6 **II**

625

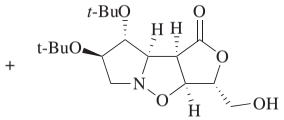


non-racemic

Alkene (0.7 eq), toluene, rt, 49 h; then reflux, 1 h



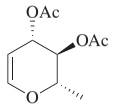
I **II**



III

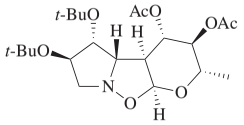
I + II + III (77), **I/II/III** = 45:32:23

625



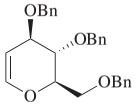
non-racemic

Alkene (*x* eq), toluene



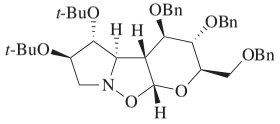
x	Pressure	Temp (°)	Time (d)	
2	10 kbar	60	3	(40)
3	1 atm	100	11	(22)

281, 470



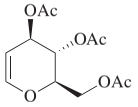
non-racemic

Alkene (2 eq),
toluene,
10 kbar, 60°, 3 d



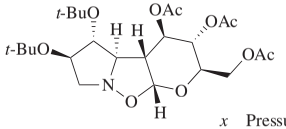
(96)

280, 470



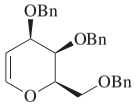
non-racemic

Alkene (*x* eq),
toluene, 3 d



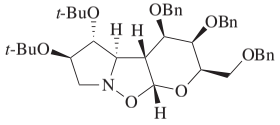
x	Pressure	Temp (°)	
2	10 kbar	60	(100)
3	1 atm	100	(61)

280, 281,
470, 636



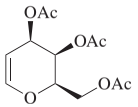
non-racemic

Alkene (2 eq),
toluene,
10 kbar, 60°, 3 d



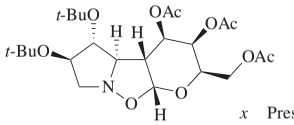
(80)

280, 470



non-racemic

Alkene (*x* eq),
toluene, 3 d



x	Pressure	Temp (°)	
2	10 kbar	60	(81)
3	1 atm	100	(28)

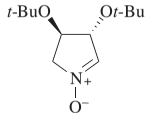
280, 470,
636

TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

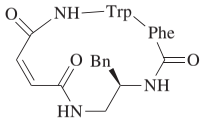
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

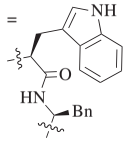
C_4



non-racemic

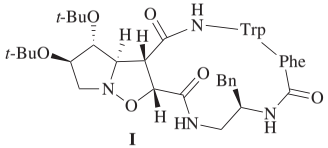


–Trp–Phe– =

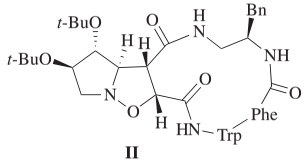


non-racemic

Alkene (0.8 eq), solvent



I



II

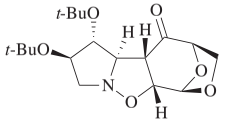
Solvent	Temp (°)	Time (h)	**I + II**	**I/II**
DMSO	84	5	(99)	4:1
toluene	87	11	(100)	5:1

637



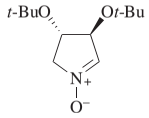
non-racemic

Alkene (1 eq), toluene, rt, 2 h



(89)

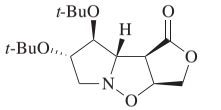
306, 311



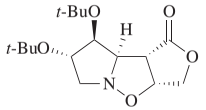
non-racemic



Alkene (0.7 eq), toluene



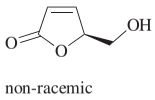
I



II

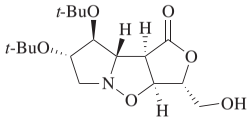
Temp 1	Time 1 (h)	Temp 2	Time 2 (h)	**I + II**	**I/II**
rt	46	reflux	1	(72)	91:9
rt	72	—	—	(89)	93:7

625, 638



non-racemic

Alkene (0.7 eq), toluene, rt, 48 h; then reflux, 1h

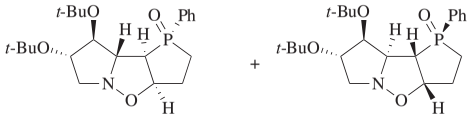


(81)

625



Alkene (*x* eq), benzene, 60°



I **II**

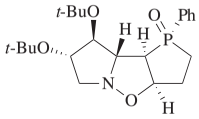
x	Time (h)	**I** + **II**	**I/II**
1.5	38	(91)[h]	2.9:1
1.8	8	(67)[i]	6.4:1

307



non-racemic

Benzene, 60°, 12 h



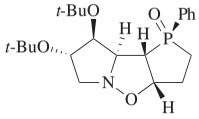
(100)

312



non-racemic

Benzene, 60°, 12 h

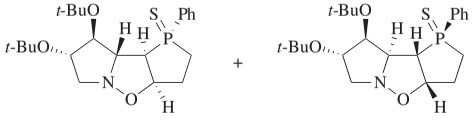


(90)

312

 [j]

Alkene (1.8 eq), benzene, 60°, 4 d



I (52) **I/II** = 8:1 **II**

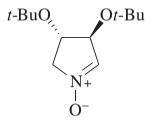
307

TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

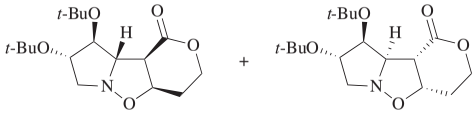
C_4



non-racemic

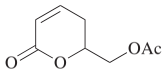


Alkene (1 eq), toluene, rt, 48 h

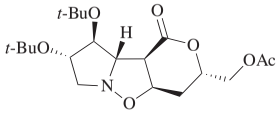


I **I + II** (91), **I/II** = 97:3 **II**

305

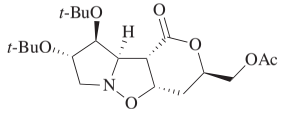


Alkene (*x* eq), toluene



I

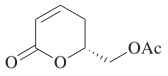
+



II

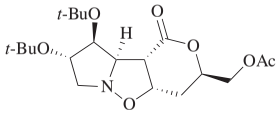
x	Temp 1	Time 1 (h)	Temp 2 (°)	Time 2 (h)	**I + II**	**I/II**
1	rt	24	110	0.5	(78)	65:35
2^k	rt	48	—	—	(86)	91:9

305, 635



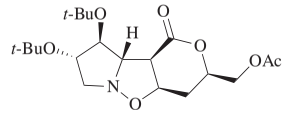
non-racemic (er 89:11)

Alkene (1 eq), toluene, 110°, 1 h



I

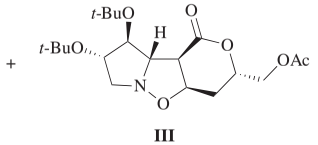
+



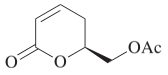
II

I + II + III (77)
I/II/III = 62:25:13

305, 635

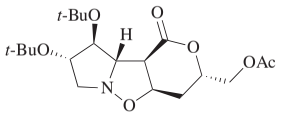


III

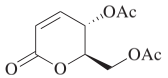


non-racemic

Alkene (1 eq), toluene, rt, 48 h

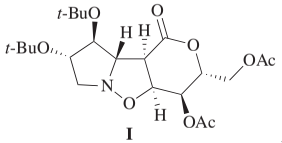


(88) 305, 635



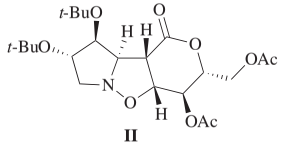
non-racemic

Alkene (0.8 eq), toluene, rt, 48 h

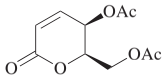


I + **II** (68), **I**/**II** = 92:8 635

I

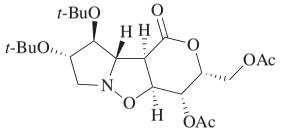


II



non-racemic

Alkene (1 eq), toluene, 110°, 1 h



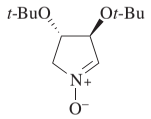
(76) 635

TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

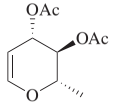
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

C_4

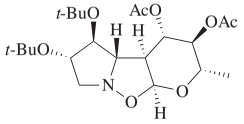


non-racemic



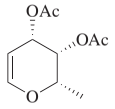
non-racemic

Alkene (*x* eq), toluene



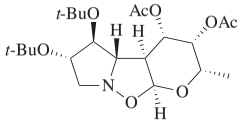
x	Pressure	Temp (°)	Time (d)	
2	10 kbar	60	3	(100)
3	1 atm	100	5	(68)

281, 470



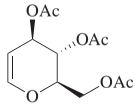
non-racemic

Alkene (*x* eq), toluene



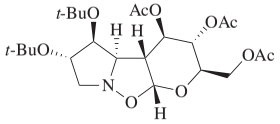
x	Pressure	Temp (°)	Time (d)	
2	10 kbar	60	3	(86)
3	1 atm	100	—	(29)

470



non-racemic

Alkene (*x* eq), toluene



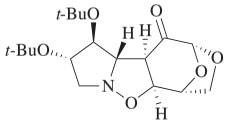
x	Pressure	Temp (°)	Time (d)	
2	10 kbar	60	3	(39)
3	1 atm	100	11	(33)

280, 281, 470, 636



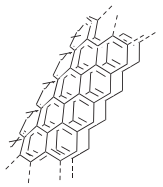
non-racemic

Alkene (1 eq), toluene, rt, 2 h



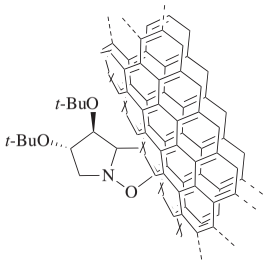
(88)

311



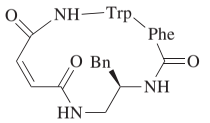
MWCNT

Nitrone (1.56 mmol), MWCNT (120 mg), dry degassed DMF, 160°, 3 d

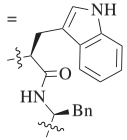


(—)[l]

56, 289

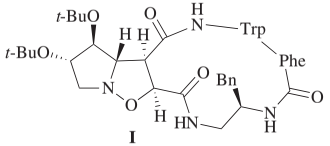


–Trp–Phe– =



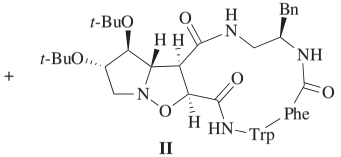
non-racemic

Alkene (0.8 eq), solvent



I

+



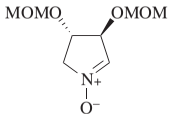
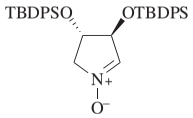
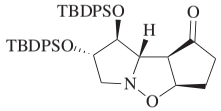
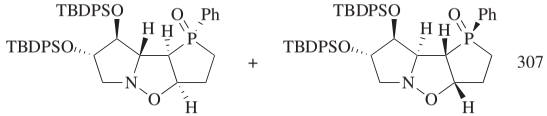
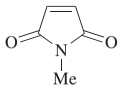
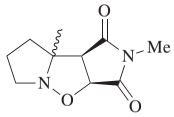
II

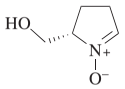
+ **III** + **IV**

637

Solvent	Temp (°)	Time (h)	**I** + **II** + **III** + **IV**	**I/II/III/IV**
DMSO	84	5	(95)	5:32:2:1
toluene	87	18	(100)	9:4:1:2

TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

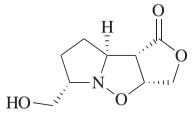
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_4				
 non-racemic	 *j*	Alkene (1.8 eq), benzene, 60°, 8 h	 **I** + **II** (65), **I/II** = 5:1	307
 non-racemic		Toluene, 80°	 (86)	639
	 *m*	Alkene (1.8 eq), benzene, 60°, 4 d	 **I** (60) **I/II** = 10:1 **II** (—)	307
C_5				
 *n*		MeCN, 80°, 1 h	 (80) dr 66:33	640



non-racemic

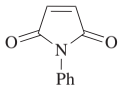


Alkene (2.1 eq), toluene, 110°, 18 h

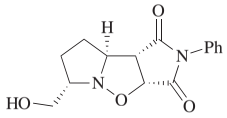


(45)

482

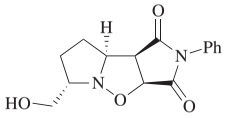


Alkene (*x* eq), solvent



I

+



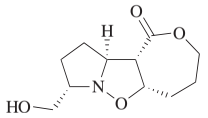
II

483

x	Solvent	Temp	Time (h)	**I**	**II**
1.2	AcOEt	rt	48	(35)	(32)
3	toluene	70°	4	(43)	(21)

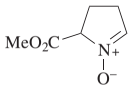


Alkene (2.1 eq), toluene, 110°, 26 h



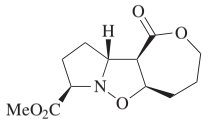
(45)

483





Alkene (0.92 eq), toluene, 110°, 5 h



(52)

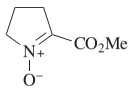
290

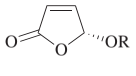
TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

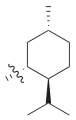
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_5



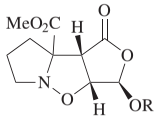


R =



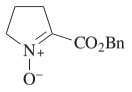
non-racemic

CH_2Cl_2 or benzene



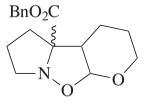
(58)

628



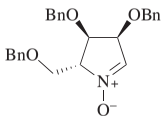


Alkene (xs), neat, 100°, 48 h



(14)

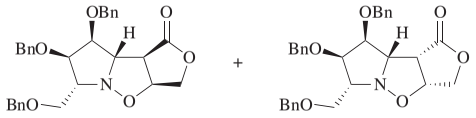
553



non-racemic

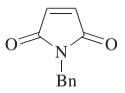


Alkene (2 eq), benzene, 60°, 3 h

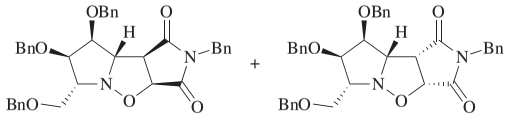


I **I** + **II** (92), **I**/**II** = 89:11 **II**

178



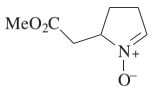
Alkene (2 eq), benzene, 60°, 3 h

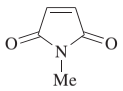


I **I** + **II** (95), **I**/**II** = 82.5:17.5 **II**

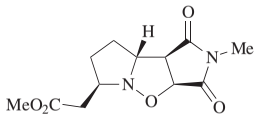
178

C_6



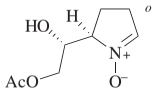


Alkene (1 eq), toluene, 110°, 15 h

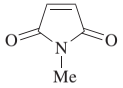


(50)

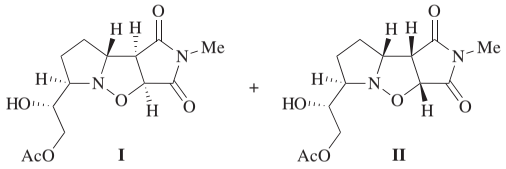
183



non-racemic

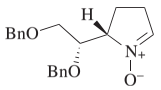


Alkene (1 eq), EtOH, 80°, 15 h



I + **II** (73), **I**/**II** = 1:1

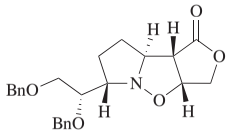
484



non-racemic

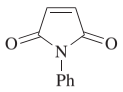


Alkene (1.1 eq), toluene, reflux, 2 h

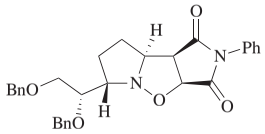


(89)

507, 567



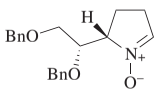
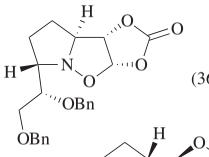
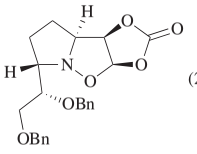
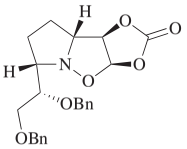
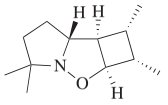
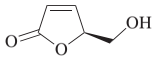
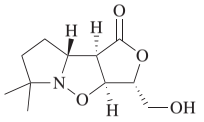
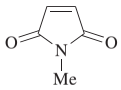
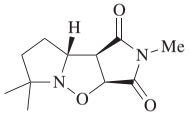
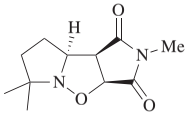
Alkene (1.1 eq), toluene, reflux, 2 h



(87)

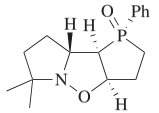
507, 567

TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*				
C_6				
 non-racemic		Alkene (5 eq), toluene, reflux, 2 h	 (36) +  (23) +  (11)	507, 567
		Alkene (0.5 eq), sealed vial, benzene, 80°, 8 d	 (81)	622
 non-racemic		Alkene (0.5 eq), $CHCl_3$, reflux, 2 d	 (66)	579
		Alkene (1.2 eq), benzene, rt, 1 h	 (82) +  (13)	581

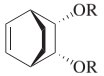


Alkene (0.9 eq), $CHCl_3$, 60°, 5 h

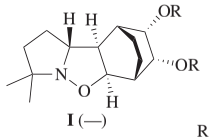


(65)

572, 574, 641

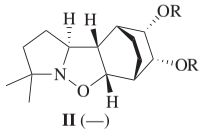


Toluene, 110°



I (—)

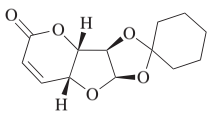
or



II (—)

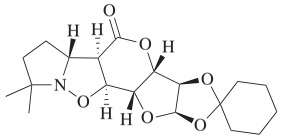
R	
H	**II** only
Ac	**I** only

642



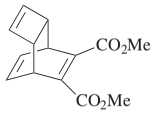
non-racemic

Alkene (1 eq), $CHCl_3$, reflux, 3 d

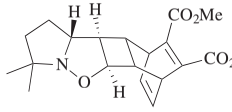


(78)

579

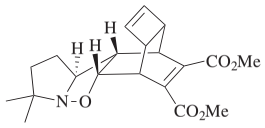


Alkene (3 eq), benzene, 80°, 16 h



(61)

+



(21)

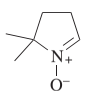
643

TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

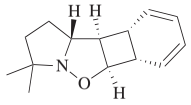
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_6

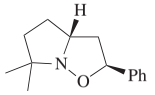




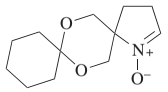
Alkene (xs), neat, 35°, 14 d

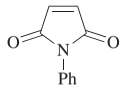


(6) +

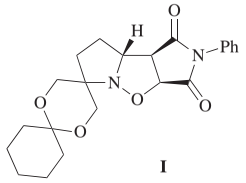


(8) 643



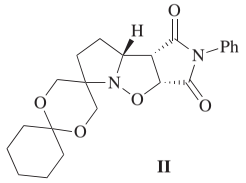


Alkene (1 eq), solvent



I

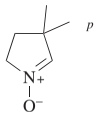
+



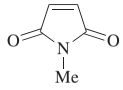
II

644, 645

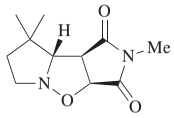
Solvent	Temp (°)	Time (h)	**I**	**II**	**I + II**	**I/II**
neat	70	5	(—)	(—)	(86)	87:13
neat	110	1	(89)	(—)	(95)	95:5
benzene	70	5	(70)	(10)	(—)	—
toluene	rt	120	(—)	(—)	(74)	84:16
toluene	85	18	(—)	(—)	(87)	86:14
toluene	110	1	(—)	(—)	(95)	95:5
toluene	110	5	(—)	(—)	(95)	95:5



p

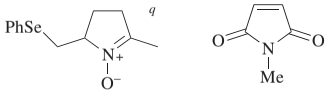


Alkene (1 eq), toluene, reflux, 4 h



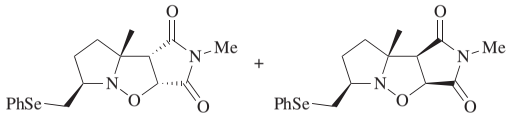
(34)

646



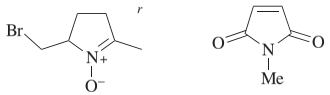
q

Alkene (1 eq), MeCN, 80°, 9 h



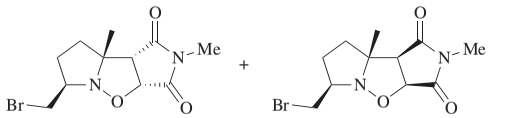
199, 201

I **I** + **II** (70), **I**/**II** = 3:2 **II**



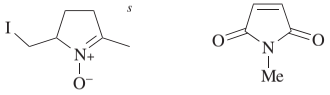
r

Alkene (1.5 eq), benzene, 80°, 13 h



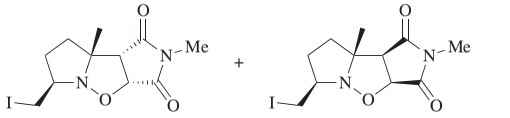
191, 647

I **I** + **II** (78), **I**/**II** = 2:1 **II**



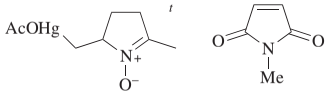
s

Alkene (1 eq), benzene, 40°, 6.5 h



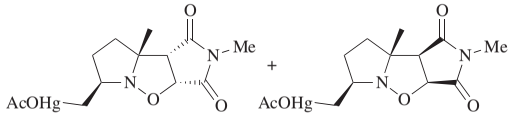
647

I **I** + **II** (59), **I**/**II** = 2:1 **II**



t

Alkene (1 eq), THF, 60°



197

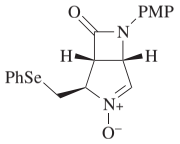
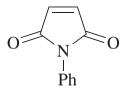
I **I** + **II** (40), **I**/**II** = 1.3:1 **II**

TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

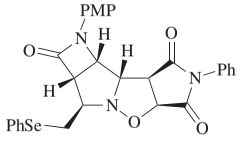
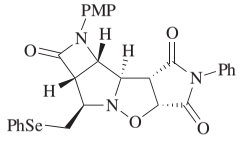
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_6

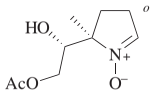
MeCN, 82°

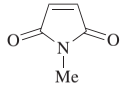
(40) (40)

206

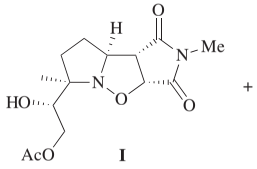
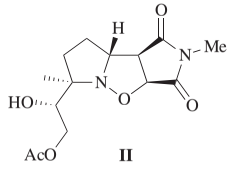
C_7



non-racemic



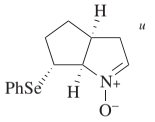
Alkene (1 eq), EtOH, 80°, 15 h

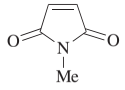



I **II**

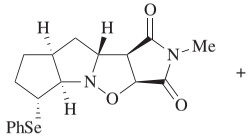
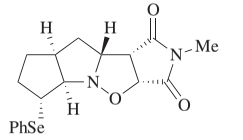
I + **II** (60), **I**/**II** = 2:1

485



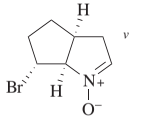


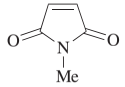
Alkene (1 eq), MeCN, rt, 10 h

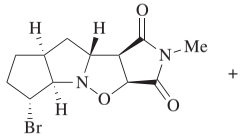
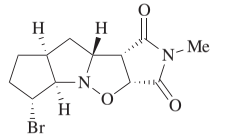
I **I** + **II** (70), **I**/**II** = 1:1 **II**

196



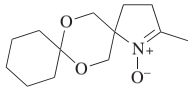


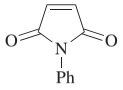
Alkene (1 eq), benzene, 60°, 13 h

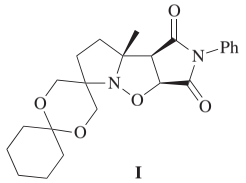
I **I** + **II** (61), **I**/**II** = 1:1 **II**

196



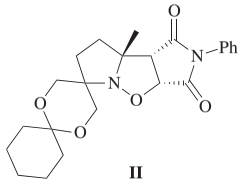


Alkene (1 eq), solvent



I

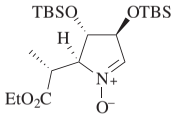
+



II

644

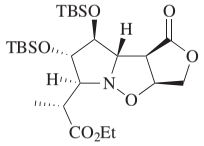
Solvent	Temp (°)	Time (h)	**I**	**II**	**I + II**	**I/II**
neat	70	5	(45)	(30)	(—)	—
neat	110	1	(90)	(—)	(—)	—
benzene	70	5	(—)	(—)	(70)	64:36
toluene	rt	288	(—)	(—)	(59)	57:43
toluene	110	1	(—)	(—)	(50)	61:39
toluene	110	5	(—)	(—)	(60)	63:37



non-racemic

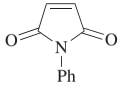


Alkene (3 eq), benzene, 70°, 12 h

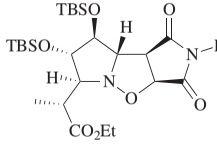


(84)

70



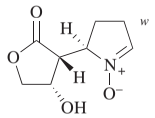
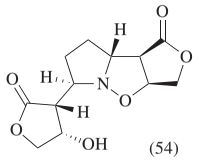
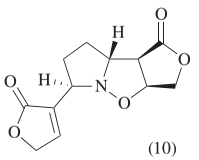
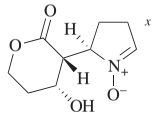
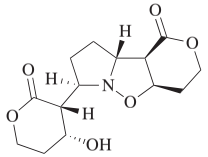
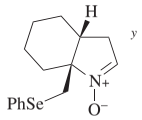
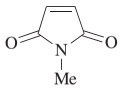
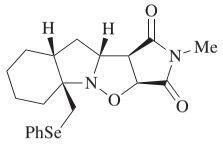
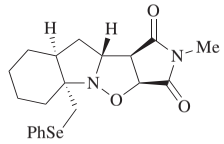
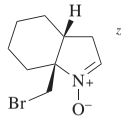
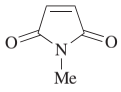
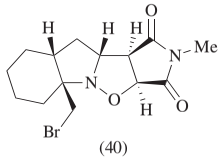
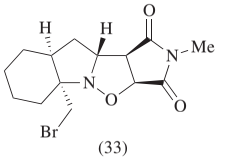
Alkene (3 eq), benzene, 70°, 4 h

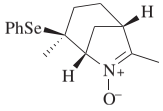


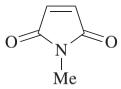
(89)

70

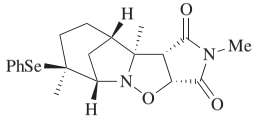
TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_8				
		Alkene (1 eq), toluene, 110°, 4 h	 (54) +  (10)	592
C_9				
		Alkene (1 eq), toluene, 110°, 4 h	 (47)	592
		Alkene (1 eq), MeCN, rt, 10 h	 +  **I** **I + II** (72), **I/II** = 1:1 **II**	196
		Alkene (1 eq), benzene, 60°, 13 h	 (40) +  (33)	196

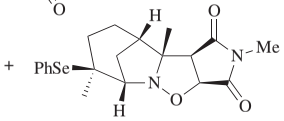




MeCN, 40°, 16 h



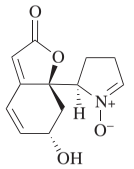
(28)



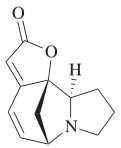
(24)

202

C_{12}

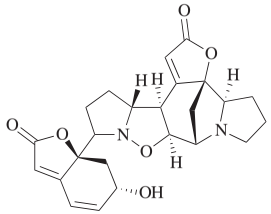


non-racemic



non-racemic

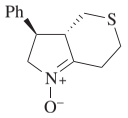
Alkene (2 eq), toluene, reflux, 12 h



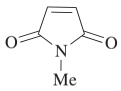
(77)

369

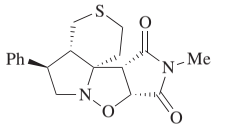
C_{13}



non-racemic

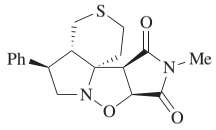


Alkene (10 eq), toluene, reflux, 4 h



(50)

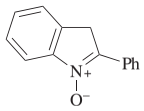
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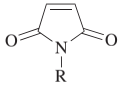


(33)

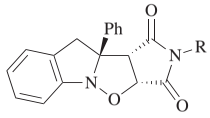
598

C_{14}





Alkene (4 eq), toluene, reflux, 72 h



R	
Me	(18)
Ph	(21)

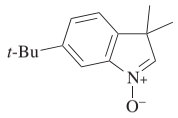
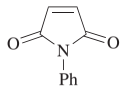
648

TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

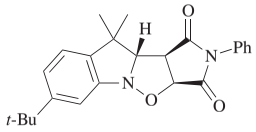
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

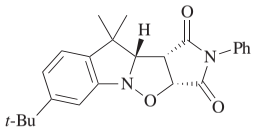
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_{14}

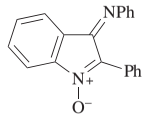
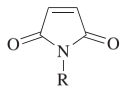



Alkene (1 eq), benzene, rt, 1 h

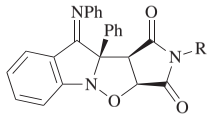
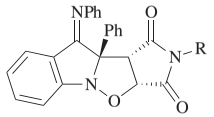

(70)


(21)

600

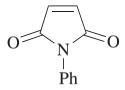



Alkene (4 eq), toluene, reflux, 6 h

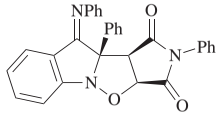



I	R	**I + II**	**I/II**	**II**
	H	(71)	91:9	
	Me	(86)	90:10	

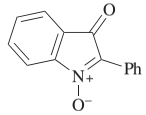
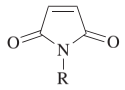
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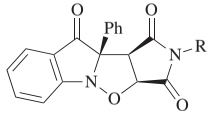
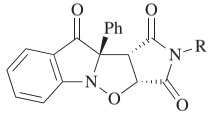
Alkene (4 eq), toluene, reflux, 6 h


(75)

648

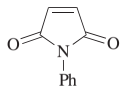



Alkene (4 eq), toluene, reflux, 20 h

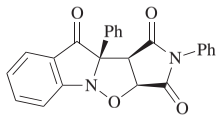



I	R	**I + II**	**I/II**	**II**
	H	(79)	52:48	
	Me	(92)	74:26	

648

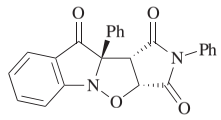


Alkene (*x* eq),
catalyst (1 eq),
solvent



I

+

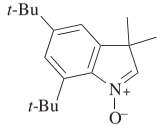


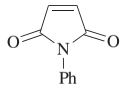
II

648

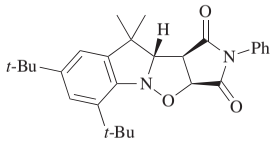
x	Catalyst	Solvent	Temp	Time (h)	**I + II**	**I/II**
1	$Co(OAc)_2 \cdot 4H_2O$	EtOH (95%)	rt	48	(30)	47:53
1	$Cu(NO_3)_2 \cdot 3H_2O$	EtOH (95%)	rt	48	(27)	51:49
1	$Cu(OAc)_2 \cdot H_2O$	EtOH (95%)	rt	48	(25)	52:48
1	$CaCl_2 \cdot 2H_2O$	EtOH (95%)	rt	48	(19)	49:51
1	$MnCl_2$	EtOH (95%)	rt	48	(29)	50:50
1	$Mn(OAc)_2 \cdot 4H_2O$	EtOH (95%)	rt	48	(22)	47:53
1	$ZnCl_2$	EtOH (95%)	rt	48	(12)	49:51
1	$Ni(OAc)_2 \cdot 4H_2O$	EtOH (95%)	rt	48	(23)	59:41
4	none	toluene	reflux	20	(85)	58:42
4	none	EtOH (95%)	reflux	70	(84)	56:44
4	none	EtOH (95%)	rt	48	(0)	(—)

C_{18}





Alkene (1 eq),
CH_2Cl_2, −15°, 14 h



(47)

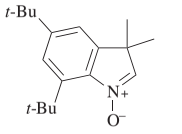
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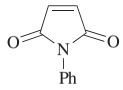
TABLE 2C. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

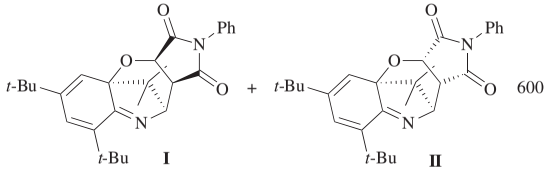
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_{18}

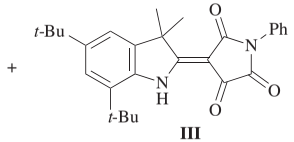




Alkene (1 eq), solvent, 2 h



I + **II**



III

Solvent	Temp	**I**	**II**	**III**
CH_2Cl_2	rt	(91)	(2)	(2)
benzene	reflux	(58)	(10)	(2)
THF	reflux	(82)	(10)	(2)
EtOH	reflux	(52)	(15)	(5)

600

[a] The alkene was prepared from 4-methoxyphenol and diacetoxyiodobenzene in MeOH and used without purification through evaporation and solvent exchange.

[b] The nitrone was generated in situ by retrocycloaddition of the kinetic cycloadduct **I**.

[c] Functionalized multi-walled nanotubes with ca. one cycloadduct every 110 carbon atoms.

[d] Unreacted enantioenriched (*S*)-alkene was recovered in 95% yield with er 90.5:9.5.

[e] Unreacted enantioenriched (3*R*,4*S*)-nitrone was recovered in 32% yield with er 71.5:28.5.

[f] Unreacted enantioenriched (3*S*,4*R*)-nitrone was recovered in 34% yield with er 68.5:31.5.

[g] Unreacted enantioenriched (*R*)-alkene was recovered in 45% yield with er 80.5:19.5.

[h] Unreacted enantioenriched (*R*)-alkene was recovered in 27% yield with er 98.0:2.0.

[i] Unreacted enantioenriched (*R*)-alkene was recovered in 39% yield with er 74.5:25.5.

[j] Unreacted enantioenriched (*R*)-alkene was recovered in 45-46% yield; the er was not determined.

[k] Unreacted enantioenriched (*R*)-alkene was recovered with er 88.5:11.5.

[l] Functionalized multi-walled nanotubes with ca. one cycloadduct every 161-184 carbon atoms.

[m] Unreacted enantioenriched (*R*)-alkene was recovered in 39% yield with er 79.5:20.5.

[n] The nitrone was generated in situ by cyclization of 5-chloropentan-2-one oxime.

[o] The nitrone was generated in situ by cyclization of (4*S*,5*S*)-6-acetoxy-4,5-epoxyhexanaldoxime.

[p] The nitrone was generated in situ from 4-chloro-2,2-dimethylbutyraldehyde and hydroxylamine hydrochloride.

[q] The nitrone was generated by addition of PhSeBr to the oxime of 5-hexen-2-one followed by treatment with K_2CO_3 and was used without purification.

[r] The nitrone was used as the crude product obtained by reaction of (2*E*)-hex-5-en-2-one oxime with *N*-bromosuccinimide.

[s] The nitrone was used as the crude product obtained by reaction of (2*E*)-hex-5-en-2-one oxime with I_2 followed by treatment with K_2CO_3; generation of the nitrone using ICl or *N*-iodosuccinimide afforded the same mixture of products in 60% and 42% yield, respectively.

[t] The nitrone was generated in situ by $Hg(OAc)_2$ addition to the oxime of 5-hexen-2-one.

[u] The nitrone was generated in situ by reaction of 2-(cyclopent-2-en)-1-acetaldoxime with PhSeBr followed by treatment with diisopropylethylamine.

[v] The nitrone was used as the crude product obtained by reaction of 2-(cyclopent-2-en)-1-acetaldoxime with *N*-bromosuccinimide.

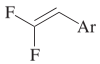
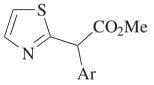
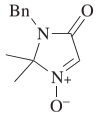
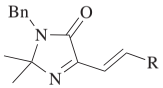
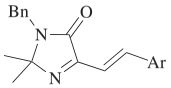
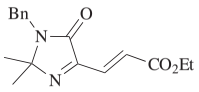
[w] The nitrone was generated in situ by oxidation of hexahydrofuro[3,4-*d*]pyrrolo[1,2-*b*]isoxazol-1-one with *m*-CPBA.

[x] The nitrone was generated in situ by oxidation of octahydro-5,8-dioxa-8a-azacyclopenta[*a*]inden-4-one with *m*-CPBA.

[y] The nitrone was generated in situ by reaction of 2-methylenecyclohexyl acetaldoxime with PhSeBr followed by treatment with diisopropylethylamine.

[z] The nitrone was used as the crude product obtained by reaction of (*E*)-2-methylenecyclohexyl acetaldoxime with *N*-bromosuccinimide.

TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_3 		Alkene (0.7 eq), MeOH, pressure tube, dry THF, 50°, 4 d	 Ar: 4-BrC_6H_4 (22)[a]; 3-$O_2NC_6H_4$ (43)[a]	320
C_5 		1. Alkene (10 eq), sealed vial, EtOH, 80°, 3 d 2. 1 N NaOH, rt, overnight 3. 1 N HCl, CH_2Cl_2, 0°, 0.5 h	 R: *t*-$BuCH_2$ (41)[a]; *c*-C_6H_{11} (68)[a]	649
		1. Alkene (5 eq), sealed vial, EtOH, 80°, 18 h 2. 1 N NaOH, rt, overnight 3. 1 N HCl, CH_2Cl_2, 0°, 0.5 h	 Ar: Ph (90)[a]; 4-BrC_6H_4 (71)[a]; 4-ClC_6H_4 (89)[a]; 4-$MeOC_6H_4$ (84)[a]; 3-$CF_3C_6H_4$ (72)[a]; 4-$EtO_2CC_6H_4$ (78)[a]; 4-*t*-BuC_6H_4 (83)[a]	649
		1. Alkene (5 eq), sealed vial, EtOH, 80°, 18 h 2. 1 N NaOH, rt, overnight 3. 1 N HCl, CH_2Cl_2, 0°, 0.5 h	 (60)[a]	649

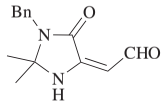
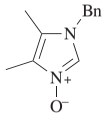
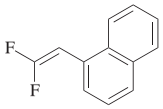
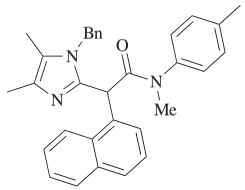
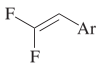
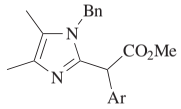
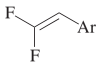
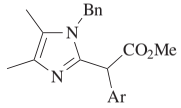
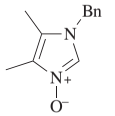
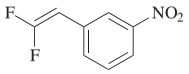
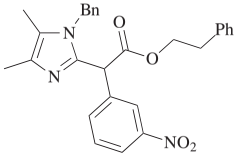
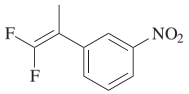
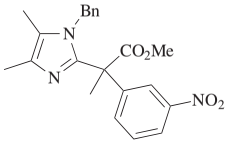
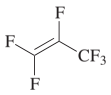
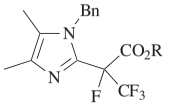
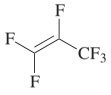
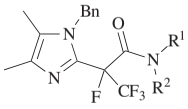
		1. Alkene (5 eq), sealed vial, EtOH, 80°, 18 h 2. 1 N NaOH, rt, overnight		(96)[a]	649
		Alkene (0.7 eq), 4-MeC_6H_4NHMe (3.3 eq), DMF, rt, 14 d		(55)[a]	320
		Alkene (0.7 eq), MeOH, pressure tube, dry THF, 70°, 48 h		Ar  (13)[a] 2-thienyl (45)[a] 4-BrC_6H_4 (72)[a] 2,3-$Cl_2C_6H_3$ (87)[a] 3-$O_2NC_6H_4$ (65)[a] 4-NCC_6H_4 (92)[a] 4-$MeO_2CC_6H_4$ (50)[a] 1-Np (70)[a]	320
		Alkene (0.7 eq), MeOH, dry DMF, rt		Ar — Time (d) 4-BrC_6H_4 7 (47)[a] 2,3-$Cl_2C_6H_3$ 7 (51)[a] 3-$O_2NC_6H_4$ 14 (74)[a] 1-Np 7 (44)[a]	320

TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_5				
		Alkene (0.7 eq), $PhCH_2CH_2OH$, pressure tube, dry THF, 40°, 48 h	 (72)[a]	320
		Alkene (0.7 eq), MeOH, pressure tube, dry THF, 70°, 48 h	 (26)[a]	320
		Alkene (4.2 eq), ROH (*x* eq), pressure vial, DMF, 80°		245

R	*x*	Time (h)	
Me	10	5	(34)[a]
4-$CF_3C_6H_4CH_2$	2	24	(63)[a]

	Alkene (4.2 eq), R^1R^2NH (2 eq), pressure vial, DMF, rt			245

R^1	R^2	Time (h)	
2-F-6-$CF_3C_6H_3CH_2$	H	38	(46)[a]
Ph(Me)CH	H	38	(48)[a]
dihydroindole		24	(83)[a]

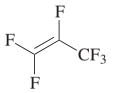
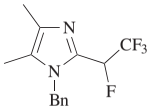
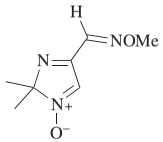
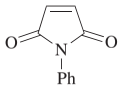
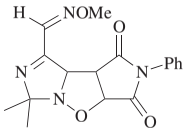
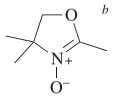
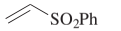
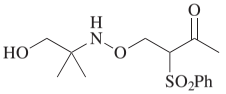
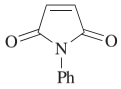
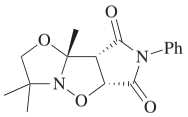
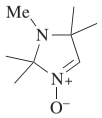
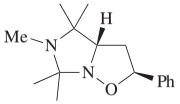
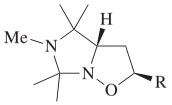
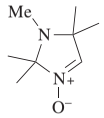
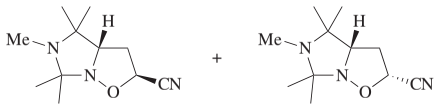
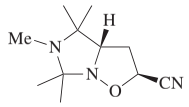
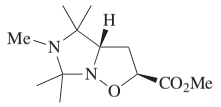
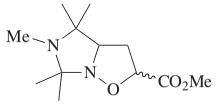
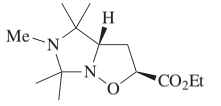
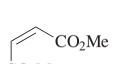
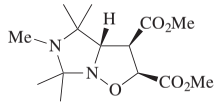
		Alkene (4 eq), DMF, rt, 1.5 d		(—)[a]	244
C_6					
		Alkene (1 eq), CH_2Cl_2, rt, 24 h		(80)	650
 [b]		1. Alkene (1.2 eq), CH_2Cl_2, reflux, 10 h 2. H_2O		(9)[a]	164
		Alkene (1 eq), CH_2Cl_2, reflux, 4 h		(21)	164
C_7					
		Alkene (5 eq), neat, 20°, 10 h		(98)	650a
		Alkene (1.5 eq), $CHCl_3$, 20°, 10–18 h		R Ph (—) 4-pyridyl (95) Ac (97)	651

TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_7 		Alkene (1.5 eq), $CHCl_3$, 20°, 10–18 h	 **I** (—) **I/II** = 4:1[c] **II** (—)	650a, 651
		Alkene (5 eq), neat, 20°, 10 h	 (97)	650a
		Alkene (3 eq), neat, 20°, 10 h	 (100)	650a
		Alkene (xs), 20°, 10 h	 (—)	650a, 652
		Alkene (1.5 eq), $CHCl_3$, 20°, 10–18 h	 (95)	651
		Alkene (3 eq), $CHCl_3$, 50°, 10 h	 (62)	650a

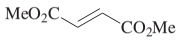
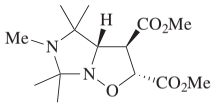
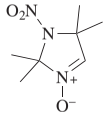
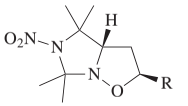
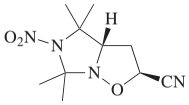
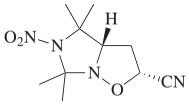
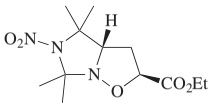
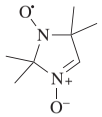
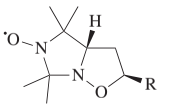
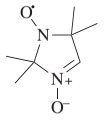
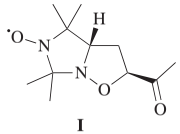
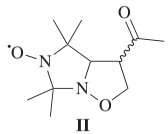
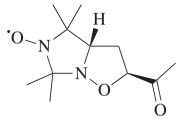
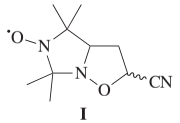
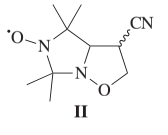
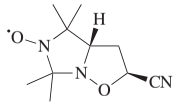
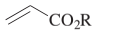
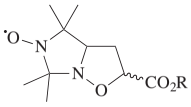
		Alkene (3 eq), $CHCl_3$, 50°, 16 h		(60)	650a
		Alkene (1.5 eq), $CHCl_3$, 20°, 10–18 h		R: 4-pyridyl (80); Ac (97)	651
		Alkene (1.5 eq), $CHCl_3$, 20°, 10–18 h	 + 	**I** (63); **I/II** = 3:1[c]; **II** (—)	651
		Alkene (1.5 eq), $CHCl_3$, 20°, 10–18 h		(95)	651
		Alkene (x eq), $CHCl_3$, 20°		R: Ph, x = 1.5, Time 10–18 h, (—); Ph, 7, 25, (82); 4-pyridyl, 1.5, 10–18, (—); 4-pyridyl, 1.5, 10, (58)	650a, 651; 652

TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_7				
		Alkene (*x* eq), solvent, rt, 10–18 h	 **I** +  **II**	650a, 651, 652
			x Solvent **I** **II** 1.5 $CHCl_3$ (97) (3) xs — (50) (—)	
		Alkene (5 eq), neat, 20°, 2 h	 (60)	650a
		Alkene (*x* eq), solvent, rt, 10–18 h	 **I** +  **II**	651, 652
			x Solvent **I** dr **I** **II** **I/II** 1.5 $CHCl_3$ (—) 1:1 (5) 10:1 xs — (91) (—) (—) (—)	
		Alkene (5 eq), neat, 20°, 10 h	 (91)	650a

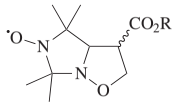


Alkene (*x* eq),
solvent, rt, 10–18 h



I

+



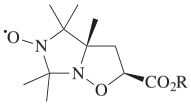
II

651, 652

R	*x*	Solvent	**I**	**II**
Me	xs	—	(quant)	(—)
Et	1.5	$CHCl_3$	(83)	(3)

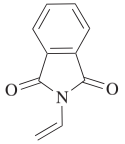


Alkene (*x* eq), solvent, 20°

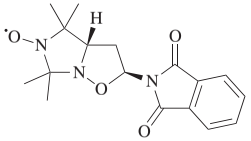


R	*x*	Solvent	Time (h)	
Me	5	neat	8	(100)
Me	1.5	$CHCl_3$	16	(87)
Et	2	$CHCl_3$	10	(76)

650a

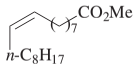


Alkene (2 eq),
$CHCl_3$, 50°, 15 h

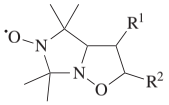


(37)

650a



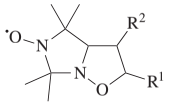
Alkene (10 eq),
$CHCl_3$, 50°, 60 h



I

I + **II** (12), **I**/**II** = —

+

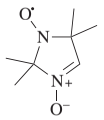
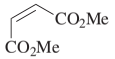
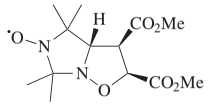
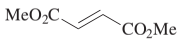
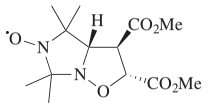
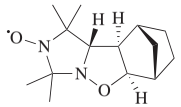
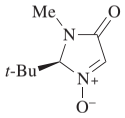
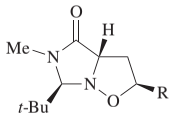
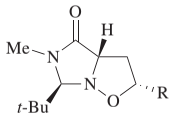


II

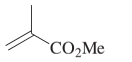
650a

$R^1 = n\text{-}C_8H_{17}$, $R^2 = n\text{-}C_7H_{14}CO_2Me$

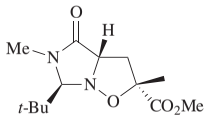
TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_7				
		Alkene (3 eq), $CHCl_3$, 50°, 4 h	 (70)	650a
		Alkene (3 eq), $CHCl_3$, 50°, 10 h	 (60)	650a
		Alkene (1.2 eq), $CHCl_3$, 50°, 2 h	 (72)	650a
 non-racemic		Alkene (10 eq), DCE, reflux	 **I** +  **II**	315

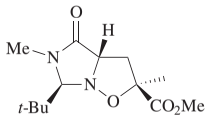
R	Time (h)	**I + II**	**I/II**
c-C_6H_{11}	52	(86)	10:1
Ph	6	(89)	10:1
4-*t*-BuC_6H_4	5	(95)	>20:1



Alkene (2 eq),
DCE, reflux, 5.5 h

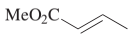


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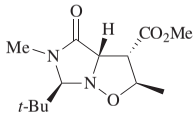


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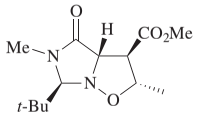
I **I + II** (98), **I/II** = >20:1 **II**



Alkene (2 eq),
DCE, reflux, 25 h

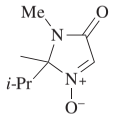


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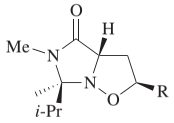
315

I **I + II** (98), **I/II** = >20:1 **II**



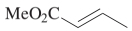


Alkene (10 eq),
sealed vial,
neat, 80°, 3.5 h

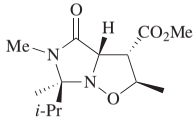


R	Time (h)		dr
$HOCH_2$	3.5	(94)	—
$AcOCH_2$	16	(96)	—
Ph	3	(90)	—
EtO_2C	4	(84)	—
n-BuO	16	(88)	95:5

316



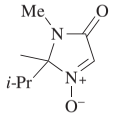
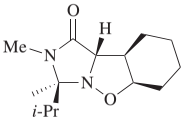
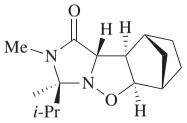
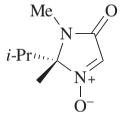
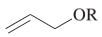
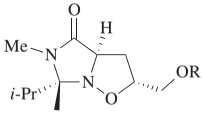
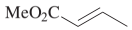
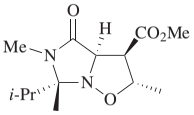
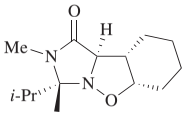
Alkene (10 eq),
sealed vial,
neat, 80°, 16 h



(80)

316

TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_7				
		Alkene (10 eq), sealed vial, toluene, 80°, 48 h	 (74) 90% conv	316
		Alkene (1.2 eq), sealed vial, toluene, 80°, 16 h	 (74) 90% conv	316
 non-racemic		Alkene (10 eq), sealed vial, neat, 80°, 3.5 h	 R Time (h) er H 3.5 (86) 95.5:4.5 Ac 16 (94) 98.5:1.5	316
		Alkene (10 eq), sealed vial, neat, 80°, 16 h	 (80) er 99.5:0.5	316
		Alkene (10 eq), sealed vial, toluene, 80°, 48 h	 (65), 90% conv, er 99.5:0.5	316

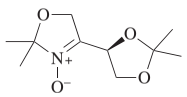
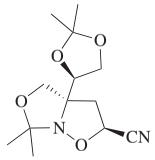
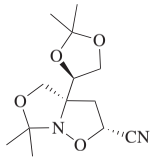
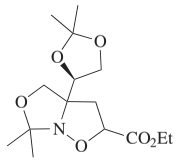
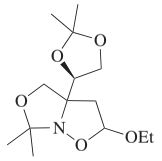
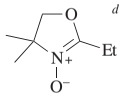
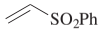
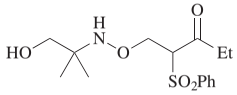
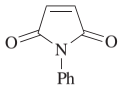
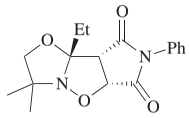
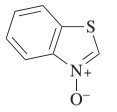
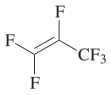
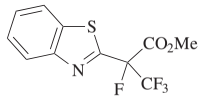
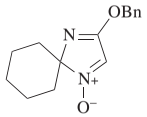
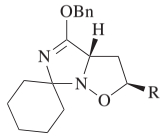
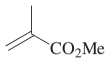
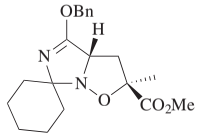
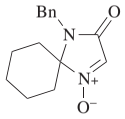
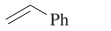
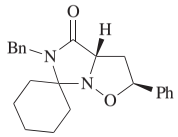
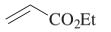
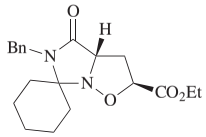
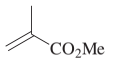
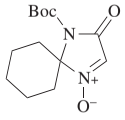
 non-racemic		Alkene (1.1 eq), toluene, reflux, 2 h	 **I** +  **II** **I + II + III + IV** (95), **I/II/III/IV** = 77:13:5:5	+ **III** + **IV**	653
		Alkene (1.1 eq), toluene, reflux, 2 h		(88) dr 41:34:17:8	653
		Alkene (xs), pressure vial, 150°, 2 h		(30) dr 75:25	653
 [d]		1. Alkene (1.2 eq), CH_2Cl_2, reflux, 10 h 2. H_2O		(14)[a]	164
		Alkene (1 eq), CH_2Cl_2, reflux, 4 h		(29)	164

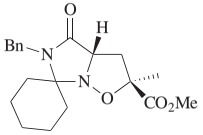
TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_7				
		Alkene (4.2 eq), MeOH (10 eq), pressure vial, DMF, rt, 24 h	 (80)[a]	245
C_8				
		Alkene (x eq), DCE, reflux, 8 h	 R = Ph, x = 2 (97); R = EtO_2C, x = 4 (87)	654
		Alkene (4 eq), DCE, reflux, 16 h	 (82)	654
		Alkene (2 eq), DCE, reflux, 6 h	 (97)	654
		Alkene (4 eq), solvent, reflux	 Solvent / Time (h): toluene 12 (15); xylene 24 (23); EtOH 7 (68); DCE 5 (96)	654



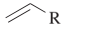


Alkene (4 eq),
DCE, reflux, 12 h

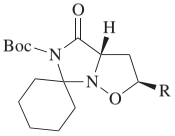


(82)

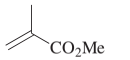
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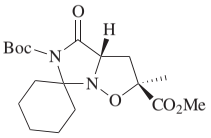
Alkene (*x* eq),
solvent, reflux



R	*x*	Solvent	Time (h)		
$HOCH_2$	3	DCE	16	(67)	654
Ph	2	DCE	5	(96)	
EtO_2C	4	EtOH	7	(68)	
EtO_2C	4	DCE	5	(96)	
n-BuO	3	DCE	12	(73)	

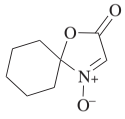


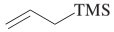
Alkene (4 eq),
DCE, reflux, 12 h



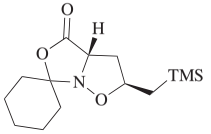
(83)

654





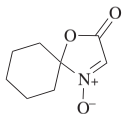
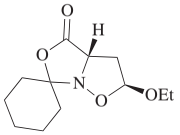
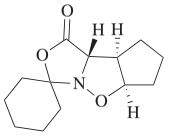
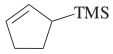
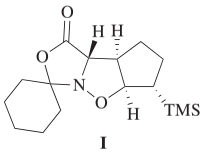
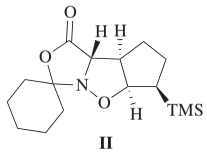
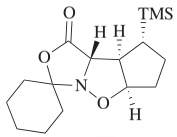
Alkene (11.3 eq),
sealed tube,
CH_2Cl_2, 8 kbar, rt



(100)

231, 314

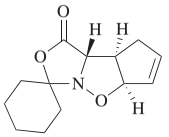
TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_8				
		Alkene (xs), sealed tube, neat, 8 kbar, rt, 19 h	 (99)	231, 314
		Alkene (xs), sealed tube, neat, 8 kbar, 30°, 48 h	 (100)	314
		Alkene (*x* eq), additive, solvent, rt, 24 h	 **I** +  **II** +  **III**	313, 314

x	Additive	Solvent	Pressure	**I**	**I + II + III**	**I/II/III**
1.2	BF_3•Et_2O	MeCN	1 atm	(96)	—	—
5	—	CH_2Cl_2	8 kbar	—	(96)	70:13:13



Alkene (25 eq), CH_2Cl_2, rt



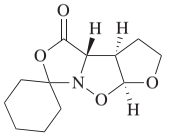
(100)

Pressure	Time (h)
8 kbar	19
1 atm	72

231



CH_2Cl_2, 800 MPa, rt

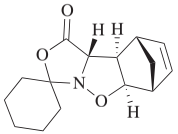


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655

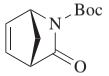


Alkene (4 eq), neat, rt, 9 h

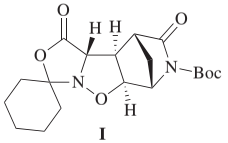


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314, 655

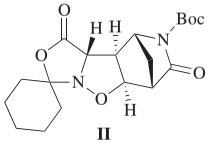


CH_2Cl_2, 800 MPa, rt



I

+

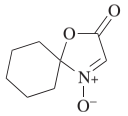
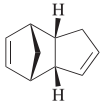
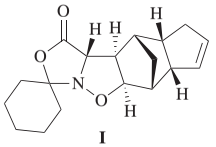
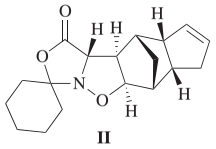
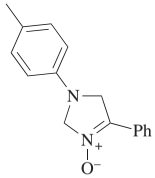
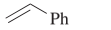
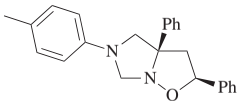
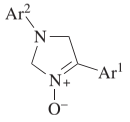
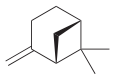
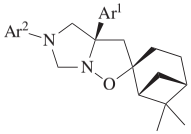


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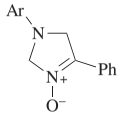
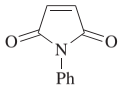
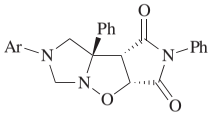
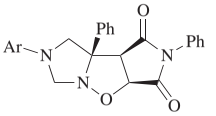
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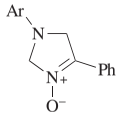
I + **II** (—), **I**/**II** = —

TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

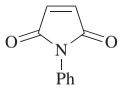
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_8				
		CH_2Cl_2 or neat, 800 MPa, rt	 +  **I** **II** **I** + **II** (—), **I**/**II** = —	655
C_9				
		Alkene (11 eq), toluene, reflux, 3 d	 (49)	656
	 non-racemic	Alkene (9 eq), xylene, reflux, 72 h		657

Ar^1	Ar^2	
Ph	4-$MeOC_6H_4$	(80)
Ph	4-MeC_6H_4	(85)
3-$MeOC_6H_4$	4-$MeOC_6H_4$	(47)
3-$MeOC_6H_4$	4-MeC_6H_4	(60)
4-$MeOC_6H_4$	4-$MeOC_6H_4$	(55)

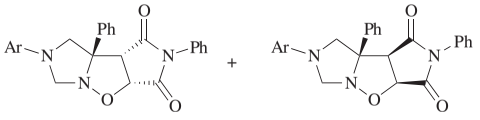
 Ar = 4-$MeOC_6H_4$		Alkene (4 eq), benzene, 51 h	 (62) +  (38)	658



Ar = 4-MeC_6H_4



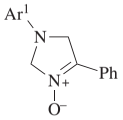
Alkene (4 eq), solvent, reflux



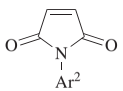
I **II**

658

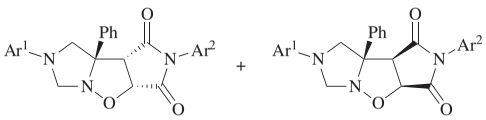
Solvent	Time (h)	**I**	**II**	**I + II**
benzene	10	(65)	(35)	(—)
toluene	10	(57)	(24)	(—)
THF	10	(33)	(23)	(—)
CH_2Cl_2	10	(—)	(—)	(12)
CH_2Cl_2	48	(20)	(19)	(—)
MeCN	10	(41)	(45)	(—)



Ar^1 = 4-MeC_6H_4



Alkene (4 eq), benzene, 10 h

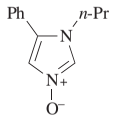
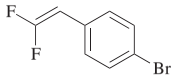
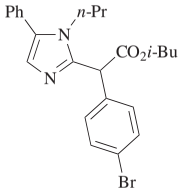
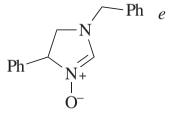
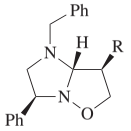
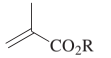
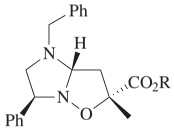
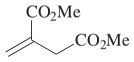
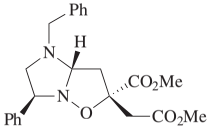


I **II**

658

Ar^2	**I**	**II**
4-$MeOC_6H_4$	(69)	(24)
4-$O_2NC_6H_4$	(50)	(35)
4-ClC_6H_4	(52)	(36)
4-MeC_6H_4	(60)	(28)

TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_9				
		Alkene (0.7 eq), *i*-BuOH, pressure tube, dry THF, 70°, 48 h	 (35)[a]	320
 *e*		Alkene (1.25 eq), toluene, 60°, 18 h	 R: NC– (23); MeO_2C (31); EtO_2C (44); MeO_2S (46); EtO_2S (32); PhO_2S (49)	169
		Alkene (1.25 eq), toluene, 60°	 R: Me (16); Et (13); allyl (8); *n*-Bu (10)	169
		Alkene (1.25 eq), toluene, 60°, 18 h	 (14)	169

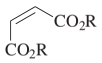
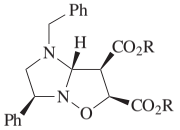
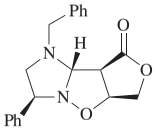
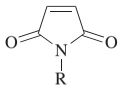
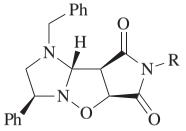
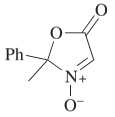
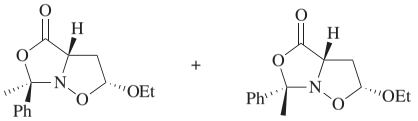
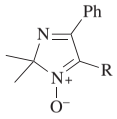
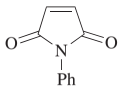
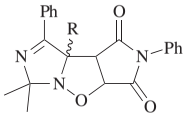
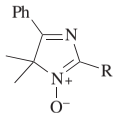
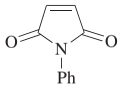
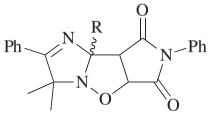
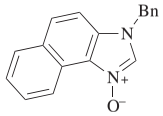
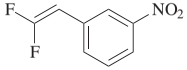
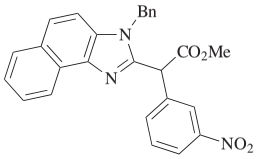
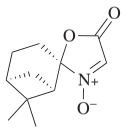
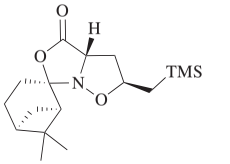
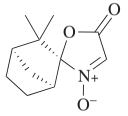
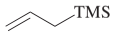
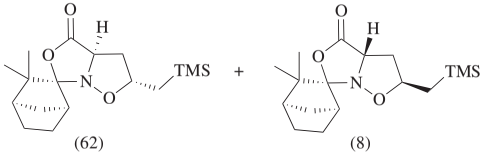
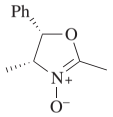
		Alkene (1.25 eq), toluene, 60°, 18 h		R: Me (64); Et (36); *i*-Pr (35); *n*-Bu (55)	169
		Alkene (1.25 eq), toluene, 60°, 18 h		(42)	169
		Alkene (1.25 eq), toluene, 60°, 18 h		R: Me (58); Ph (38)	169
C_{10}		 Alkene (xs), neat, 8 kbar, rt, 19 h	 **I** **I + II** (99), **I/II** = 3:1 **II**		231
C_{11}		 Alkene (1 eq), CH_2Cl_2, rt, 24 h		R: H (80); MeO (70)	650

TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

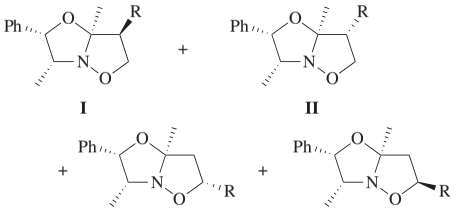
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{11} 		Alkene (1 eq), CH_2Cl_2, rt	 R: H, Time (d): 1, (70); R: MeO, Time (d): 10, (40)	650
		Alkene (0.7 eq), MeOH, pressure tube, dry THF, 70°, 48 h	 (91)[a]	320
 non-racemic		Alkene (11.3 eq), sealed tube, CH_2Cl_2, 8 kbar, 40°, 17 h	 (100)	314
 non-racemic		Alkene (11.3 eq), sealed tube, CH_2Cl_2, 8 kbar, 40°, 69 h	 (62) + (8)	314



non-racemic

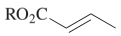


CH_2Cl_2, 18 h

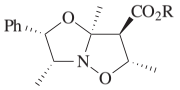


I + **II** + **III** + **IV** (75), **I/II/(III + IV)** = 86:12:2

318

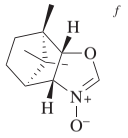


See table.

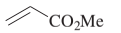


R	Solvent	Temp (°)	Time (h)	
Me	CH_2Cl_2	40	48	(76)
Bn	toluene	80	18	(48)

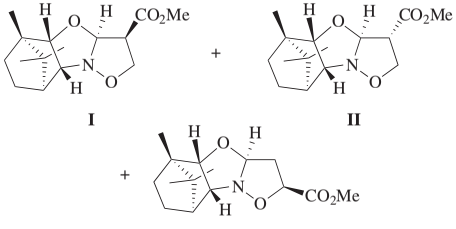
318



non-racemic



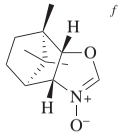
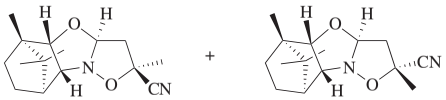
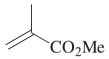
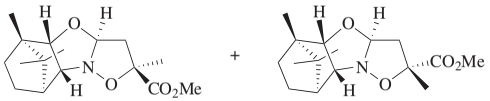
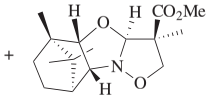
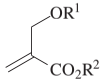
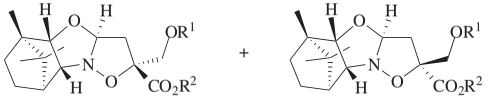
Alkene (4 eq), CH_2Cl_2, reflux, 3 h



I + **II** + **III** (53), **I/II/III** = 64:21:15

165

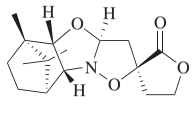
TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{11}  non-racemic		Alkene (5 eq), CH_2Cl_2, reflux, 16 h	 **I** **I** + **II** (60), **I/II** = 95:5 **II**	659
		Alkene (4 eq), toluene, 80°, 2 h	 **I** (65) **II** (—)  **III** (—) **I/II** > 95:5, **I/III** > 95:5	165
		Alkene (2 eq), toluene, 16 h	 **I** **II**	659

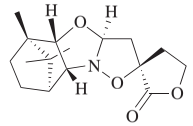
R^1	R^2	Temp (°)	**I** + **II**	**I/II**
TBDPS	Et	60	(50)	>95:5
Bn	*t*-Bu	70	(56)	>95:5



Alkene (2.5 eq), toluene, 60°, 16 h



+

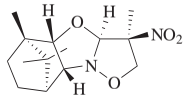


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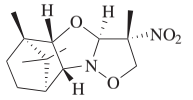
I **I + II** (63), **I/II** > 95:5 **II**



Alkene (4 eq), CH_2Cl_2, reflux

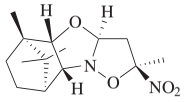


+



I **II**

+

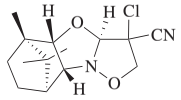


III

Time (h)	**I**	**II**	**III**	**I/II**	**I/III**	
7	(58)	(—)	(—)	>90:10	>95:5	165
18	(64)	(16)	(—)	—	—	660

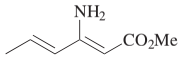


Alkene (10 eq), CH_2Cl_2, reflux, 16 h

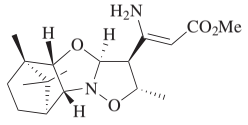


(56) dr 2:1

659



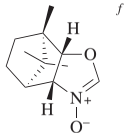
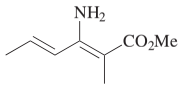
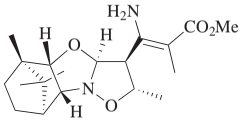
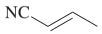
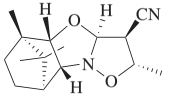
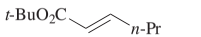
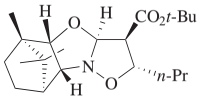
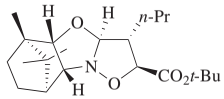
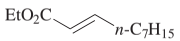
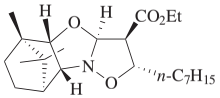
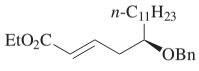
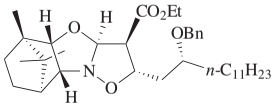
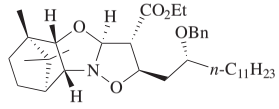
Alkene (4 eq), CH_2Cl_2, 40°, 2 h

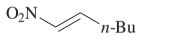


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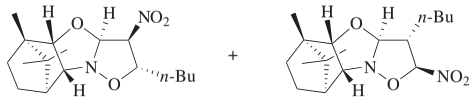
661

TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{11}  *f* non-racemic		Alkene (3 eq), CH_2Cl_2, 40°, 2 h	 (54)	661
		Alkene (8 eq), CH_2Cl_2, 45°, 16 h	 (71), *endo/exo* = 9:1	659, 661
		Alkene (4 eq), toluene, 80°, 18 h	 +  **I** **I + II** (80), **I/II** > 95:5 **II**	165
		Alkene (1.5 eq), toluene, 80°, 18 h	 (67)	166
	 non-racemic (er 95:5)	Alkene (0.49 eq), toluene, 80°, 16 h	 (61) +  (<5)	168



Alkene (4 eq), CH_2Cl_2, reflux, 2 h

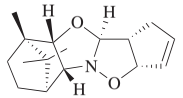


I **I + II** (70), **I/II** = >95:5 **II**

165

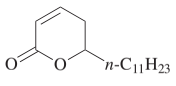


CH_2Cl_2, 40°, 24 h

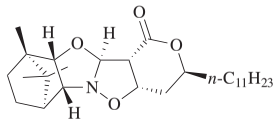


(75)

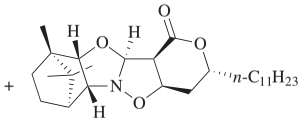
662



Alkene (*x* eq), toluene, 80°, 12 h



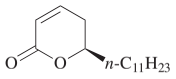
I



II

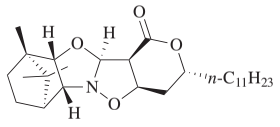
309

x	**I**	**II**	Recovered Enantioenriched (*S*)-Alkene	er
0.5	(83.4)	(4.6)	(58.7)	—
1	(63)	(2.8)	(63)	—
2	(38.3)	(1.2)	(78)	60.5:39.5



non-racemic (er 95:5)

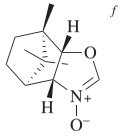
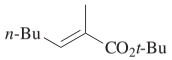
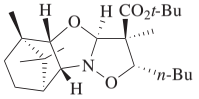
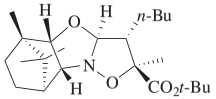
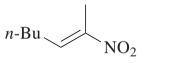
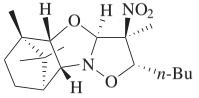
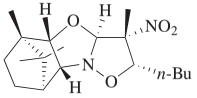
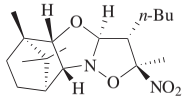
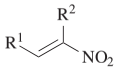
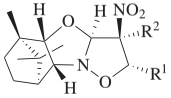
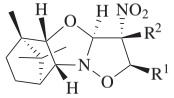
Alkene (1.15 eq), toluene, 80°, 12 h



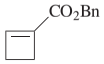
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309

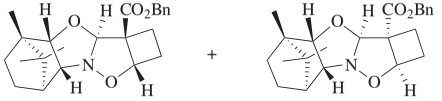
TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{11}  *f* non-racemic		Alkene (4 eq), toluene, 80°, 16 h	 +  **I** **I + II** (16), **I/II** = 50:50 **II**	165
		Alkene (4 eq), toluene, 80°, 16 h	 +  **I** (75) **II** (—)	165, 660
			+  **I/II** > 95:5, **I/III** > 95:5 **III** (—)	
		Alkene (4 eq), CH_2Cl_2, 45°	 +  **I** **II**	660

R^1	R^2	Time (h)	**I + II**	**I/II**
Ph	Me	18	(73)	>95:5
n-Bu	Ph	2	(43)	>95:5



Alkene (2 eq),
toluene, 80°, 18 h

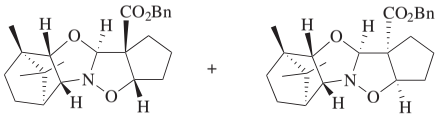


659

I **I** + **II** (40), **I**/**II** > 95:5 **II**

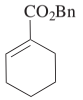


Alkene (3.8 eq),
toluene, 80°, 18 h

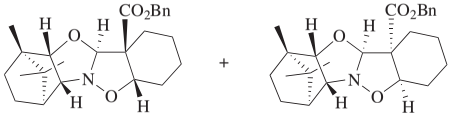


659

I **I** + **II** (50), **I**/**II** > 95:5 **II**

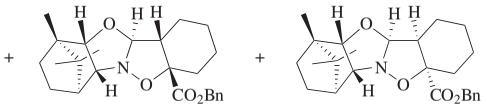


Alkene (4 eq),
toluene, 80°, 18 h



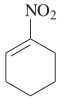
659

I **II**

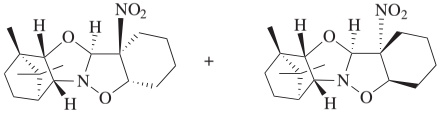


III **IV**

I + **II** + **III** + **IV** (12), (**I** + **II**)/(**III** + **IV**) = 1:1, **I**/**II** = 95:5



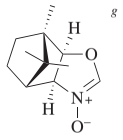
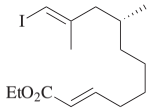
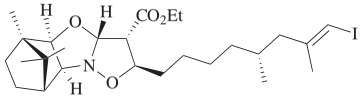
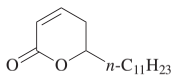
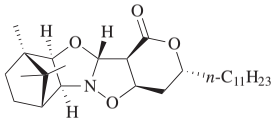
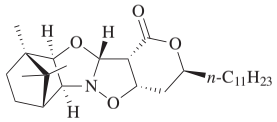
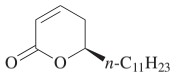
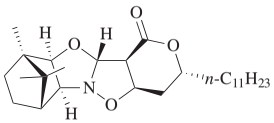
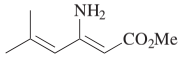
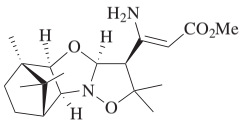
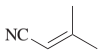
Alkene (4 eq),
CH_2Cl_2, 45°, 2 h

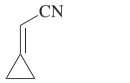


660

I **I** + **II** (67), **I**/**II** > 95:5 **II**

TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{11}  *g* non-racemic		Alkene (1.4 eq), toluene, 80°, 18 h	 (58)	166
		Alkene (0.5 eq), toluene, 80°, 12 h	 (84)[h] +  (5)[h]	309
	 non-racemic (er 95.0:5.0)	Alkene (1.15 eq), toluene, 80°, 12 h	 (84)	309
		Alkene (2.5 eq), CH_2Cl_2, reflux, 2 h	 (52)	396
		Alkene (10 eq), toluene, 80°, 21 h	 **I** **I** + **II** (16), **I**/**II** > 95:5 **II**	396

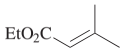


Alkene (2 eq),
toluene, 80°, 1.1 h



I **I + II** (84), **I/II**= 88:12 **II**

619



Alkene (10 eq),
toluene, 80°, 19 h

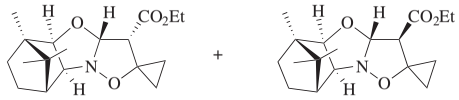


I **I + II** (11), **I/II** = 50:50 **II**

396



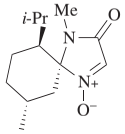
Alkene (2 eq),
toluene, 80°, 1.3 h



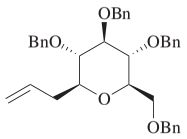
I **I + II** (54), **I/II**= 83:17 **II**

619

C_{12}

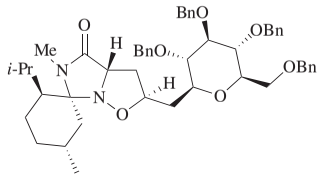


non-racemic



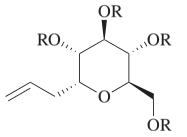
non-racemic

Alkene (0.83 eq),
toluene, reflux, 3 d



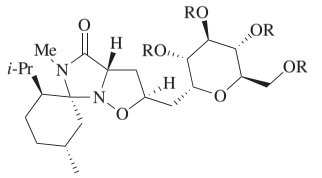
(92)

24



non-racemic

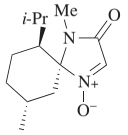
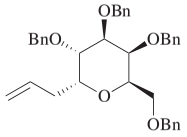
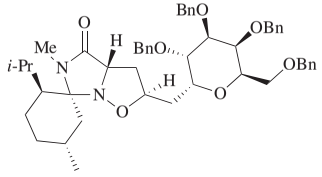
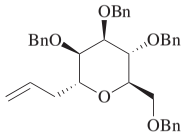
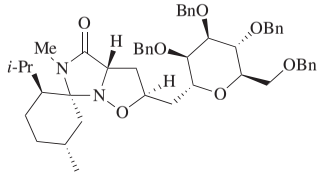
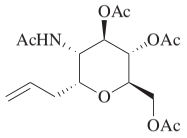
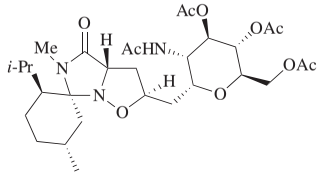
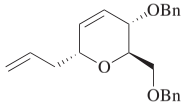
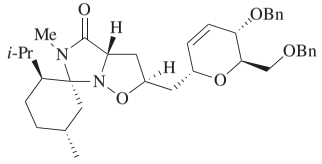
Alkene (0.83 eq),
toluene, reflux, 3 d



R	
Bn	(85)
Ac	(88)

24

TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{12}				
 non-racemic	 non-racemic	Alkene (0.83 eq), toluene, reflux, 3 d		(82)	24
	 non-racemic	Alkene (0.83 eq), toluene, reflux, 3 d		(90)	24
	 non-racemic	Alkene (0.83 eq), toluene, reflux, 3 d		(87)	24
	 non-racemic	Alkene (0.83 eq), toluene, reflux, 3 d		(—)	24

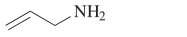
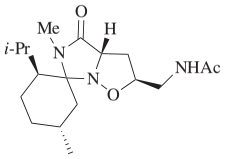
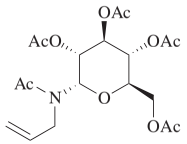
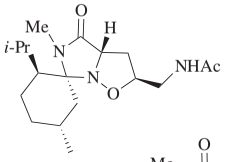
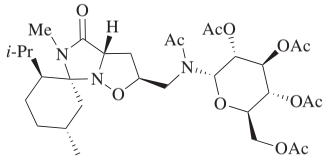
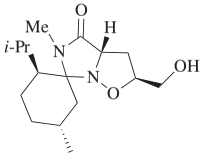
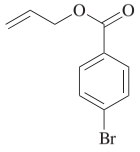
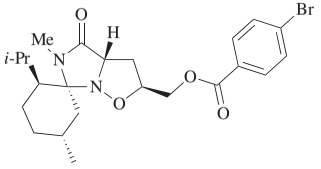
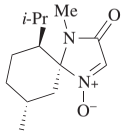
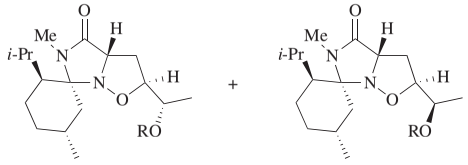
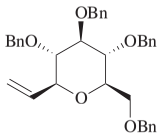
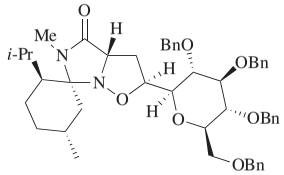
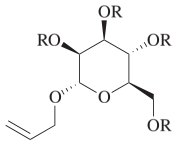
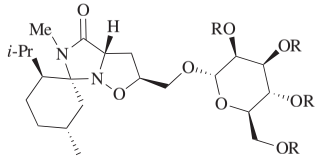
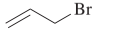
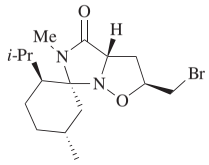
	1. Alkene (6 eq), MW (400 W), toluene, 130°, 2.5 h 2. Ac_2O (xs), pyridine, 75°, 6 h		(66)[a]	317
 non-racemic	Alkene (0.86 eq), toluene, 110°, 3 d	 + 	(60) (7)	317
	Alkene (xs)		(—)	317
	Alkene (0.83 eq), toluene, reflux, 3 d		(—)	24

TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{12}				
 non-racemic		Alkene (*x* eq), toluene, 110°	 **I** + **II**	
			R = H, *x* = 9, Time (h) = 24, **I** (60), **II** (38)	663, 664
			R = Bn, *x* = 5, Time (h) = 48, **I** (59), **II** (30)	663
			R = Bz, *x* = 2, Time (h) = 48, **I** (57), **II** (18)	663
			R = TBS, *x* = 3, Time (h) = 72, **I** (55), **II** (36)	663
	 non-racemic	Alkene (0.83 eq), toluene, reflux, 3 d	 (—)	24
	 non-racemic	Alkene (*x* eq), toluene, 110°		317
			R = H, *x* = 1.1, Time (d) = 5, (85)	
			R = Me, *x* = 0.86, Time (d) = 3, (86)	
			R = Ac, *x* = 0.7, Time (d) = 3, (71)	



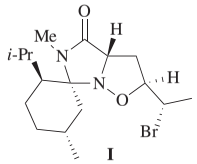
Toluene, MW, 110°, 2 h



(98) 664a

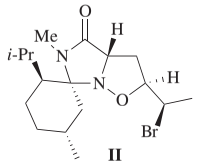


Alkene (*x* eq),
toluene, 110°



I

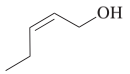
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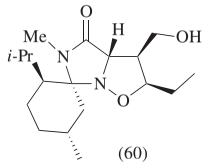
II

663

x	Time (h)	**I**	**II**
2.7	72	(71)	(20)
6	48	(60)	(17)
66	24	(74)	(18)
69	24	(70)	(18)

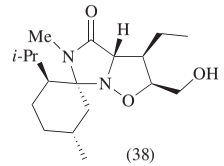


Alkene (2.9 eq),
toluene, 110°, 24 h



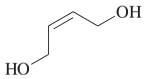
(60)

+

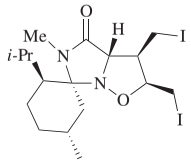


(38)

665

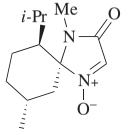
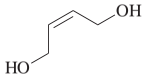
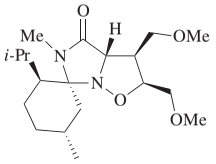
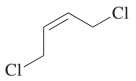
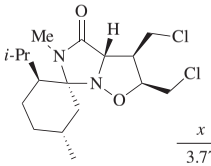


1. Alkene (3 eq),
toluene, 110°, 48 h
2. I_2 (4 eq), PPh_3 (6 eq),
imidazole (6 eq),
toluene, 110°

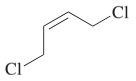
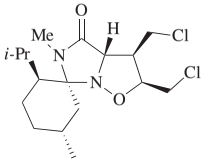
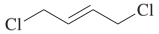
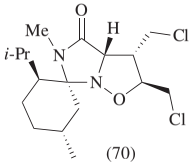
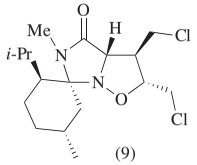


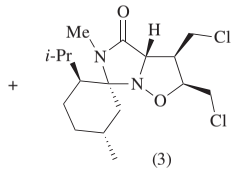
(70)[a] 666

TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{12}				
 non-racemic		1. Alkene (3 eq), toluene, 110°, 48 h 2. MeI, KOH, $Bu_4N^+Br^-$, acetone, 18 h	 (77)[a]	665
		Alkene (*x* eq), toluene		667

x		Temp (°)	Time (h)	
3.77	—	reflux	48	(88)
5	MW	130	2	(78)

		1. Alkene (4 eq), MW, toluene, 130°, 2 h 2. Alkene (2 eq), MW, toluene, 130°, 2 h	 (82)	667
	 (*E*)/(Z) = 98:2	Alkene (3 eq), toluene, 110°, 7 d	 (70) +  (9)	668



(3)

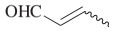
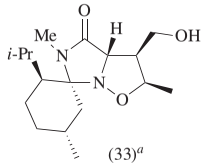
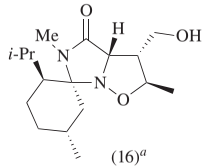
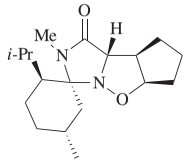
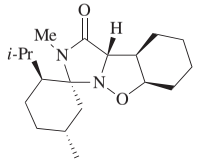
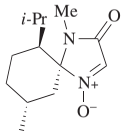
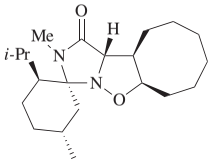
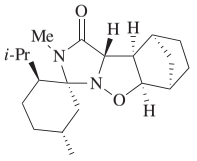
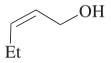
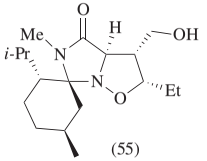
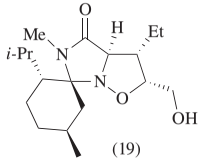
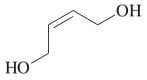
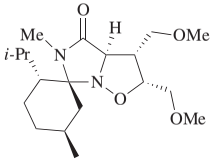
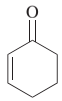
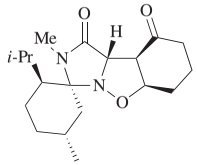
 (*E*)/(*Z*) = 93.5:6.5	1. Alkene (5.34 eq), toluene, reflux, 7 d 2. $NaBH_4$	 (33)[a] +  (16)[a]		666
	Alkene (4 eq), toluene, 110°, 3 d		(88)	669
	Alkene (6 eq), toluene, 110°, 2 d		(83)	669

TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

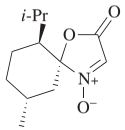
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{12}				
 non-racemic		Alkene (1 eq), toluene, 110°, 3 d	 (82)	669
		Alkene (4 eq), toluene, 110°, 3 d	 (88)	669
		Alkene (2.9 eq), toluene, 110°, 24 h	 (55) +  (19)	665
		1. Alkene (3 eq), toluene, 110°, 48 h 2. MeI, KOH, $Bu_4N^+Br^-$, acetone, 18 h	 (76)[a]	665



Alkene (5 eq), toluene, 110°, 3 d



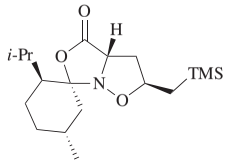
(80) 669



non-racemic

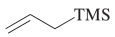


Alkene (*x* eq), additive, solvent

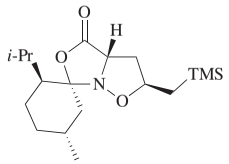


314

x	Additive	Solvent	Pressure	Temp	Time (d)	
1.2	BF_3•Et_2O	MeCN	8 kbar	rt	2	(90)
11.4	—	CH_2Cl_2	—	rt	5	(91)
11.4	—	CH_2Cl_2	—	40°	2	(91)

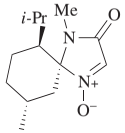


Additive, solvent



342

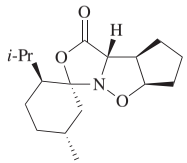
Additive	Solvent	Pressure	Temp	
—	CH_2Cl_2 or toluene	800 MPa	40°	(90)
BF_3•Et_2O	CH_2Cl_2 or MeCN	1 atm	rt	(100)



non-racemic

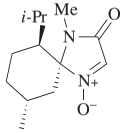
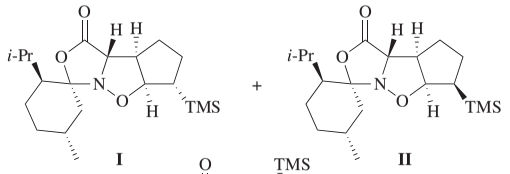
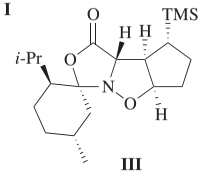


Alkene (xs), sealed tube, neat, 8 kbar, 30°, 72 h

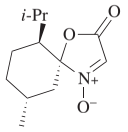
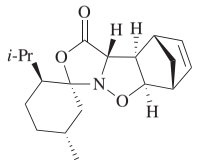
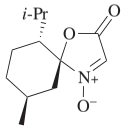
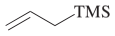
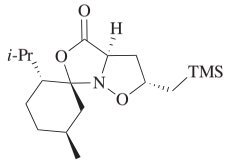


(69) 314

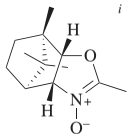
TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{12}				
 non-racemic		Alkene (*x* eq), additive, solvent	 **I** + **II** +  **III**	313, 314

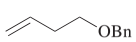
x	Additive	Solvent	Pressure	Temp	Time (h)	**I**	**II**	**III**	**I + II + III**	**I/II/III**
2	—	CH_2Cl_2	8 kbar	40°	48	(—)	(—)	(—)	(99)	55:20:24
2.4	BF_3•Et_2O	MeCN	—	rt	91	(69)	(—)	(—)	(—)	—

 non-racemic		Alkene (19.6 eq), neat, rt, 21 h	 (99)	314
 non-racemic		Alkene (11.3 eq), sealed tube, CH_2Cl_2, 800 MPa, 40°, 2 d, or rt, 5 d	 (92)	314

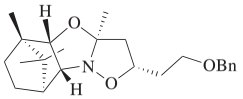
i



non-racemic



Alkene (2–10 eq), toluene, 100°, 4 h

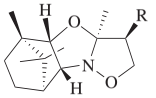


(50)

670

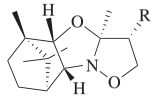


Alkene (2–10 eq), CH_2Cl_2, 40°



I

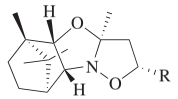
+



II

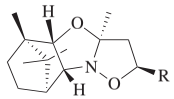
318, 670

+



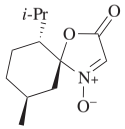
III

+

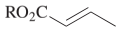


IV

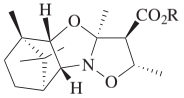
R	Time (h)	**I + II + III + IV**	**I/II/(III + IV)**
NC–	3	(49)	70:25:5
MeO_2C	18	(50)	60:25:15



non-racemic

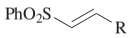


Toluene, 80°

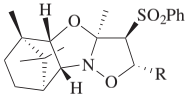


R	Time (h)	
Me	5	(53)
Bn	2	(52)

318, 670



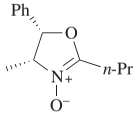
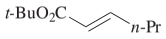
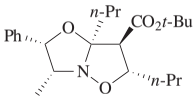
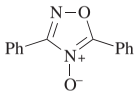
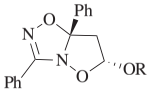
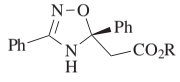
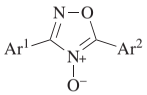
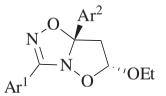
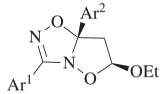
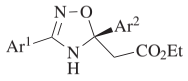
CH_2Cl_2, 40°



R	Time (h)	
Me	60	(42)
$BnO(CH_2)_2$	24	(30)

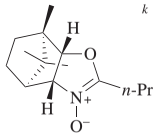
670

TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

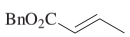
	Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{13}	 non-racemic		Toluene, 80°, 18 h	 (52)	318
C_{14}			Alkene (10 eq), closed vessel, benzene, 80°, 18 h	 +  **I** **II**	319
			Alkene (10 eq), closed vessel, benzene, 80°, 18 h	 +  **I** **II** +  **III**[j]	319

R	I	II
Et	(38)	(33)[j]
n-Bu	(38)	(38)[j]

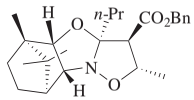
Ar^1	Ar^2	I	II	III[j]
Ph	4-$MeOC_6H_4$	(12)	(—)	(10)
Ph	4-$O_2NC_6H_4$	(29)	(2)	(7)
4-$MeOC_6H_4$	Ph	(28)	(—)	(14)
4-$MeOC_6H_4$	4-$MeOC_6H_4$	(6)	(—)	(10)
4-$O_2NC_6H_4$	Ph	(36)	(—)	(24)
4-$O_2NC_6H_4$	4-$O_2NC_6H_4$	(39)	(10)	(24)



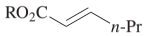
non-racemic



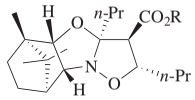
See table.



Solvent	Temp (°)	Time (h)		
CH_2Cl_2	40	24	(52)	318, 670
toluene	80	1.5	(50)	



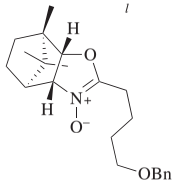
See table.



318, 670

R	Solvent	Temp (°)	Time (h)	
Me	toluene	80	18	(63)
t-Bu	CH_2Cl_2	40	48	(53)

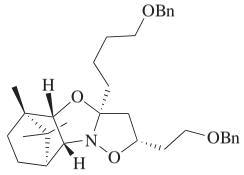
C_{15}



non-racemic

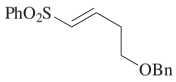


Toluene, 80°, 60 h

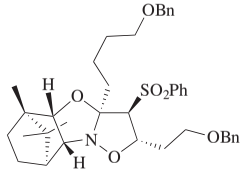


(23)

670

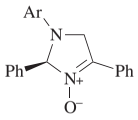


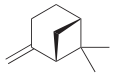
CH_2Cl_2, 40°, 40 h



(25)

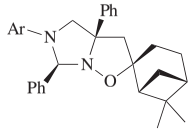
670





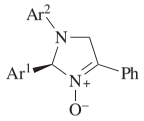
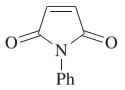
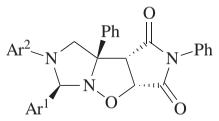
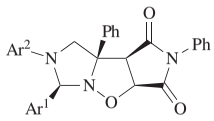
non-racemic

Alkene (9 eq),
toluene, reflux, 18 d



Ar		
4-$MeOC_6H_4$	(24)	657
4-MeC_6H_4	(25)	

TABLE 3. INTERMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{15} 		Alkene (4 eq), benzene, 51 h	 + 	658

I **II**

Ar^1	Ar^2	**I**	**II**
3-$O_2NC_6H_4$	4-$MeOC_6H_4$	(41)	(33)
4-$MeOC_6H_4$	4-$MeOC_6H_4$	(60)	(32)
4-$MeOC_6H_4$	4-MeC_6H_4	(57)	(33)

[a] The primary cycloadduct was not isolated.

[b] The nitrone was generated by reaction of triethyl orthoacetate and hydroxylamine hydrochloride in the presence of triethylamine.

[c] A minor product (<10%) was assigned as the regioisomeric 4-substituted isoxazolidine.

[d] The starting nitrone was generated by reaction of triethyl orthopropionate and hydroxylamine hydrochloride in the presence of triethylamine.

[e] The nitrone was used as the HCl salt and treated in situ with Et_3N (2 eq).

[f] The nitrone was generated in situ by reaction of (1*R*,2*S*,3*R*,4*S*)-3-(hydroxyamino)-1,7,7-trimethylbicyclo[2.2.1]heptan-2-ol with trimethyl orthoformate in toluene at 45° for 4 h in the presence of $CaCO_3$ and 4 Å MS.

[g] The nitrone was generated in situ by reaction of (1*S*,2*R*,3*S*,4*R*)-3-(hydroxyamino)-1,7,7-trimethylbicyclo[2.2.1]heptan-2-ol with trimethyl orthoformate in toluene at 45° for 4 h in the presence of $CaCO_3$ and 4 Å MS.

[h] The yield is based on the enantiomeric alkene partner. Unreacted enantioenriched (*R*)-alkene was recovered in 58% yield with er 84.5:15.5.

[i] The nitrone was generated in situ by reaction of (1*R*,2*S*,3*R*,4*S*)-3-(hydroxyamino)-1,7,7-trimethylbicyclo[2.2.1]heptan-2-ol with 1,1,1-trimethoxyethane in toluene at 45° for 4 h in the presence of $CaCO_3$ and 4 Å MS.

[j] The rearranged ring-opened product was derived from the *exo* cycloadduct.

[k] The nitrone was generated in situ by reaction of (1*R*,2*S*,3*R*,4*S*)-3-(hydroxyamino)-1,7,7-trimethylbicyclo[2.2.1]heptan-2-ol with 1,1,1-trimethoxybutane in toluene at 45° for 4 h in the presence of $CaCO_3$ and 4 Å MS.

[l] The nitrone was generated in situ by reaction of (1*R*,2*S*,3*R*,4*S*)-3-(hydroxyamino)-1,7,7-trimethylbicyclo[2.2.1]heptan-2-ol with 5-(benzyloxy)-1,1,1-trimethoxypentane in toluene at 45° for 4 h in the presence of $CaCO_3$ and 4 Å MS.

TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES

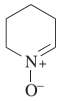
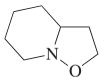
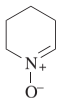
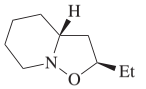
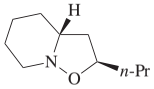
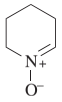
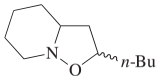
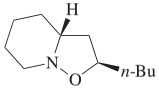
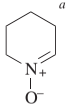
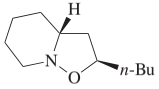
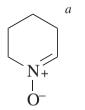
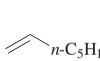
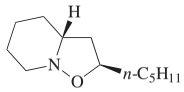
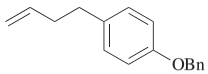
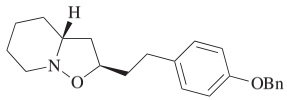
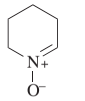
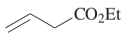
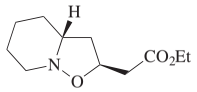
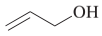
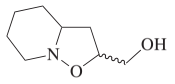
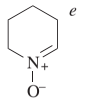
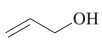
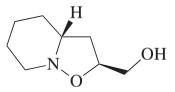
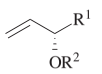
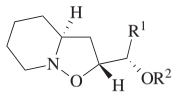
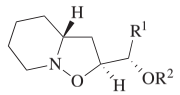
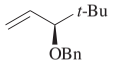
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_5				
	$H_2C{=}CH_2$	Alkene (xs), pressure bottle, EtOH, 3 atm, 125°, 10 h	 (88)	487
 [a]	 Et	Alkene (12 eq), sealed tube, toluene/EtOH (9:1), 110°, 12 h	 (87)	671
	 *n*-Pr	Alkene (6.9 eq), sealed tube, EtOH/$CHCl_3$ (1:1), 50°, 90 h	 (87)	265
	 *n*-Bu	Alkene (8 eq), CH_2Cl_2/EtOH (1:1), 40°, 12 h	 (63)	672
	 *n*-Bu	CH_2Cl_2 40°, 18 h	 (65)	266
 [a]	 *n*-Bu	Alkene (6.9 eq), sealed tube, EtOH/$CHCl_3$ (1:1), 60°, 70 h	 (93)	265

TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_5				
 *a*		Alkene (xs), $CHCl_3$, reflux, overnight	 (94)	673, 673a
		$CHCl_3$, reflux, 24 h	 (81)	674
		Toluene, N_2, reflux, 15 h	 (87)	675
		Alkene (7 eq), $CDCl_3$, 36°	 (—) dr —	675a
 *e*		Alkene (xs), MeOH, reflux, 12 h	 (17)	675b
	 non-racemic	Alkene (0.2–0.5 eq), toluene, reflux, 12–24 h	 **I** +  **II**	676, 677

R^1	R^2	**I + II**	**I/II**
Me	Bn	(68)	67:33
Me	TBDPS	(86)	60:40
i-Pr	Bn	(79)	91:9
i-Pr	TBDPS	(85)	93:7
n-Bu	Bn	(66)	79:21
n-Bu	TBS	(67)	71:29
n-Bu	TBDPS	(80)	75:25
		(74)	80:20



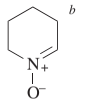
non-racemic

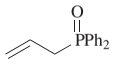
Toluene, reflux



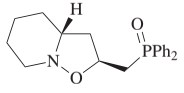
I **I + II** (75), **I/II** = 95:5 **II**

676

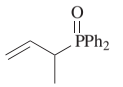




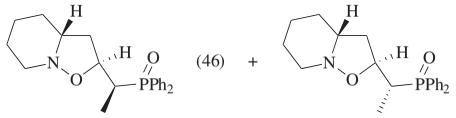
Alkene (0.25 eq), toluene, 85°, 24 h



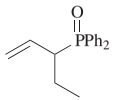
(88) 58



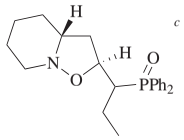
Alkene (0.2 eq), toluene, 85°, 24 h



(46) + (18) 58



Alkene (0.2 eq), toluene, reflux, 24 h



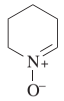
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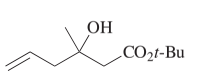
TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

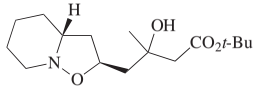
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_5



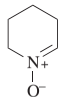


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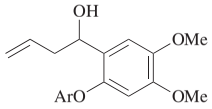


(72) dr 1:1

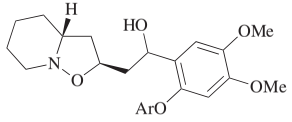
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[a]



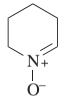
Alkene (0.5 eq), toluene, reflux, 1.5 h

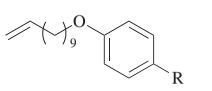


(99)[d]

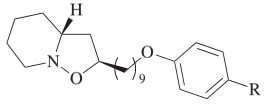
679

Ar = 4-$MeO_2C(CH_2)_2C_6H_4$



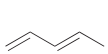


Alkene (*x* eq), toluene, reflux, 6 h

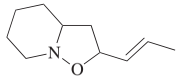


R	*x*	
H	0.4	(79)
MeO	0.5	(80)

495

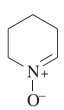


—



(—)

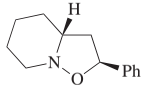
288



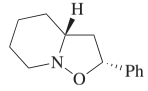
[a]



Alkene (xs), $CHCl_3$, reflux, 3 h

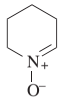


(85) +



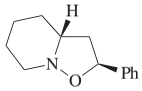
(3)

266, 680

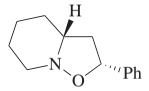




Alkene (4 eq), $CDCl_3$, 20°

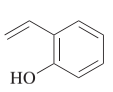


+

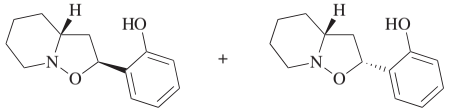


675a

I **I + II** (—), **I/II** = 78:22 **II**

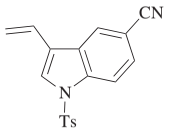


Alkene (3 eq), toluene, 120°, 5 d

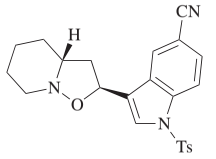


I (73) **I/II** = 85:15 **II** (—)

681

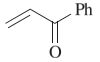


Alkene (0.25 eq), DCE, rt, 48 h

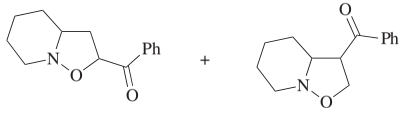


(84)

497



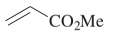
Alkene (1 eq), CH_2Cl_2, rt, 24 h



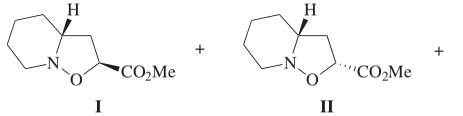
I dr 2.5:1 **II**[d]

I + **II** (33), **I/II** = 5:1

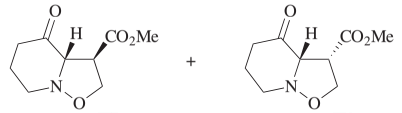
499, 500



Alkene (xs), $CDCl_3$, 20°



I **II**

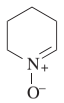
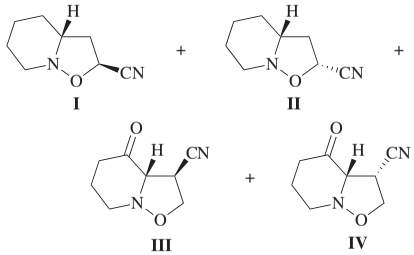
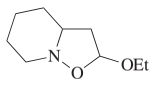
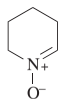
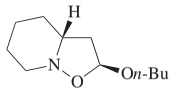
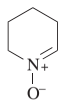
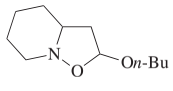


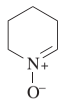
III **IV**

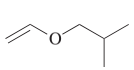
I + **II** + **III** + **IV** (—), **I/II/III/IV** = 69:15:10:6

675a

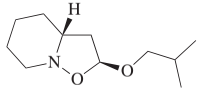
TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_5				
		Alkene (xs), $CDCl_3$, 20°	 **I** + **II** + **III** + **IV** (—), **I/II/III/IV** = 61:20:13:6	675a
		Alkene (xs), CH_2Cl_2/EtOH (1:1), 40°, 12 h	 (67)	672
		Alkene (xs), $CDCl_3$, 20°	 **I** **I** + **II** (—), **I/II** = 93:7 **II**	675a
 [b]		90°, 1.5 h	 (69)	90
 [e]		Alkene (2.1 eq), H_2O, 90°, 1 h	 (54)	91

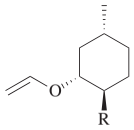




Alkene (xs), MeOH, rt, 24 h

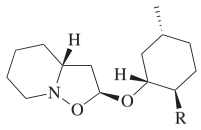


(30) 675b



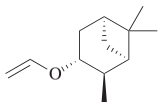
non-racemic

$CHCl_3$, reflux



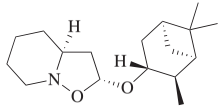
R		dr
i-Pr	(52)	57.5:42.5
$PhMe_2C$	(36)	1:1

257

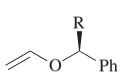


non-racemic

$CHCl_3$, reflux

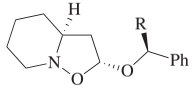


(59) dr 52.5:47.5 257



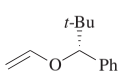
non-racemic

$CHCl_3$, reflux



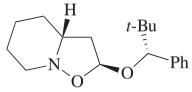
R		dr
Me	(50)	75:25
i-Pr	(62)	87:13

257



non-racemic

$CHCl_3$, reflux



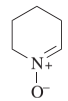
(89) dr > 97.5:2.5 257

TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

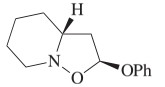
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_5

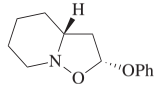




Alkene (2 eq)
TCE, 50°, 16 h



+

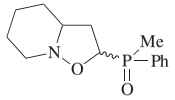


502

I **I + II** (58), **I/II** = 50:50 **II**



Alkene (0.5 eq),
$CHCl_3$, 60°, 48 h

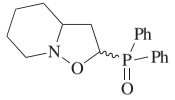


(91) dr 41:29:15:15

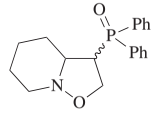
576



Alkene (0.9 eq),
$CHCl_3$, rt, 2 d



+

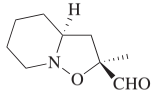


574

I[d] **I + II** (93), **I/II** = 76:24 **II**[d]



Alkene (1.2 eq),
11 (0.05 eq),
2,6-lutidine (0.05 eq),
CH_2Cl_2, –20°

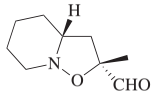


(71) er >98.0:2.0

82

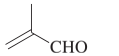


Alkene (7 eq),
catalyst (0.05 eq),
CH_2Cl_2[f], 4 Å MS

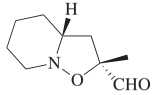


259

Catalyst	Temp (°)	Time (h)		er
9a	–25	15	(99)	95.5:4.5
9a	–45	45	(100)	97.5:2.5
9b	–25	15	(100)	96.0:4.0

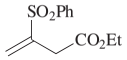


Alkene (1.4 eq), **14** (0.05 eq), CH_2Cl_2, 4 Å MS, –25°, 16 h

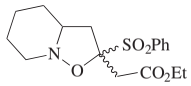


(100) er 53.5:46.5

348

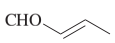


Alkene (0.5 eq), benzene, 50°, 18 h

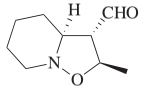


(96)

682

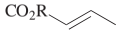


Alkene (1.2 eq), **11** (0.05 eq), 2,6-lutidine (0.05 eq), CH_2Cl_2, –20°

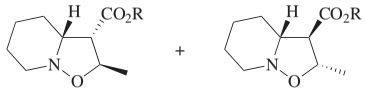


(75) er 88:12

82



Alkene (3 eq), solvent



I **II**

275, 504, 505, 506, 675a

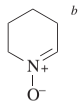
R	Solvent	Temp (°)	Time (h)	**I + II**	**I/II**
Me	CH_2Cl_2	40	1	(94)	90:10
Me	C_6D_6	128 (sealed tube)	8	(—)	25:75
i-Pr	CH_2Cl_2	50	48	(86)	84:16
t-Bu	CH_2Cl_2	40	48	(80)	78:22
t-Bu	C_6D_6	128 (sealed tube)	8	(—)	32:68

TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

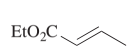
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

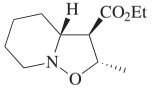
C_5



b

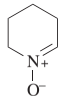


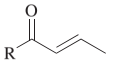
90°, 1.5 h



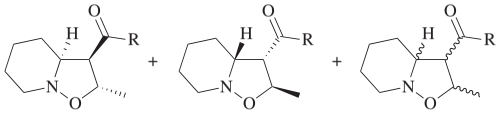
(56)

90





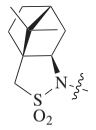
Additive (1.5 eq), CH_2Cl_2, 35°



I **II** **III**

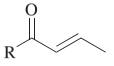
255

R =

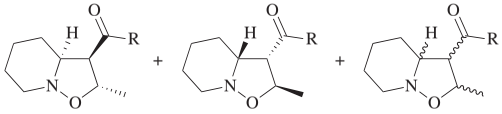


non-racemic

Additive	Pressure	Time (h)	**I + II + III**	**I/II/III**
—	—	24	(99)	54:27:19
ZnI_2	—	96	(30)	78:4:18
ZnI_2, 4 Å MS	10 Kbar	24	(74)	71:18:11



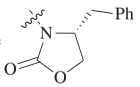
Additive (1.5 eq), CH_2Cl_2, 35°



I **II** **III**

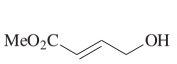
255

R =



non-racemic

Additive	Time (h)	**I + II + III**	**I/II/III**
—	24	(99)	34:48:18
ZnI_2	48	(82)	86:3:11



Alkene (0.6 eq), CH_2Cl_2, rt, 24 h



I **I + II** (88), **I/II** = 77:23 **II**

506

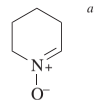
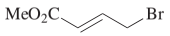
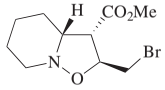
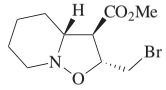
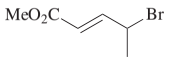
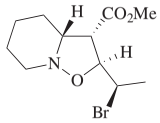
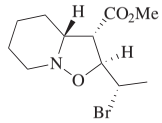
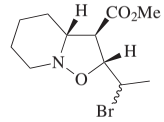
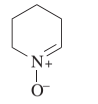
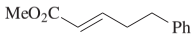
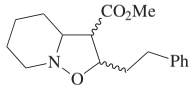
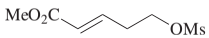
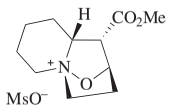
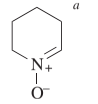
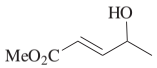
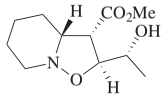
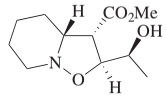
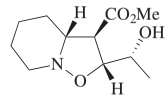
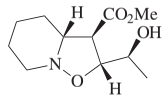
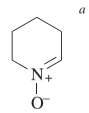
 [a]		Alkene (0.45 eq), $CHCl_3$, 60°, 13 h	 (51) +  (8)	509
		Alkene (0.51 eq), $CHCl_3$, 60°, 19 h	 (57) +  (16) +  (9)	509
		—	 (—)	291
		Alkene (0.5 eq), toluene, 0°, 3 h; then rt, 12 h	 (77)[g]	297
 [a]		Alkene (0.66 eq), CH_2Cl_2, rt, 20 h	 (33) +  (37) +  (19) +  (5)	508

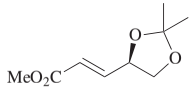
TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

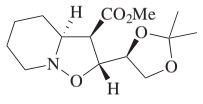
C_5





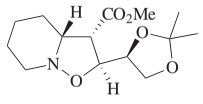
non-racemic

Alkene (0.5 eq), CH_2Cl_2, rt, 20 h



(50)

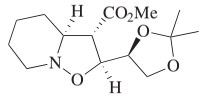
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(26)

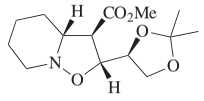
508

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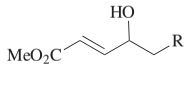


(12)

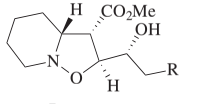
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(5)

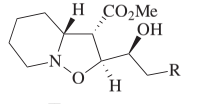


Alkene (*x* eq), CH_2Cl_2, rt



I

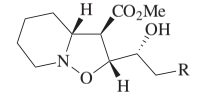
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II

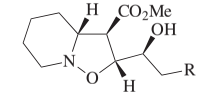
508

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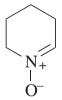
III

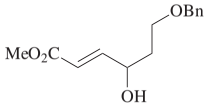
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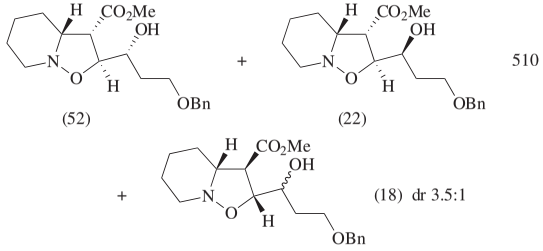
IV

R	*x*	Time (d)	**I**	**II**	**III**	**IV**
HO	0.77	3	(35)	(42)	(13)	(4)
$MeOCH_2$	0.7	2	(44)	(23)	(10)	(tr)



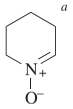


Alkene (1 eq),
CH_2Cl_2, rt, 48 h

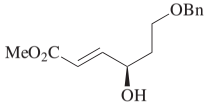


(52) (22) (18) dr 3.5:1

510

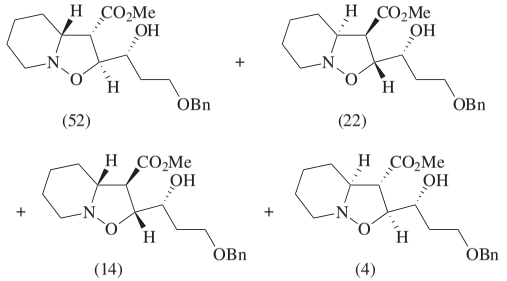


[a]



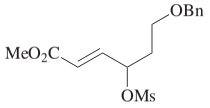
Alkene (1 eq),
CH_2Cl_2, rt, 48 h

non-racemic

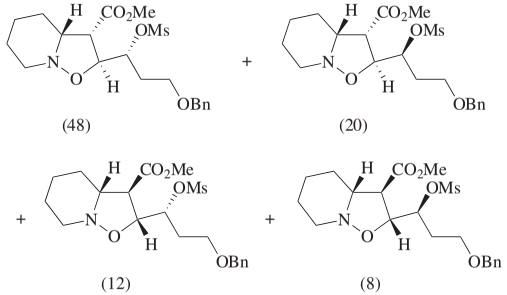


(52) (22) (14) (4)

508



Alkene (1 eq),
CH_2Cl_2, rt, 4 d



(48) (20) (12) (8)

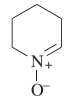
508

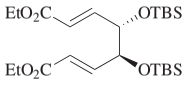
TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

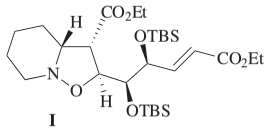
C_5



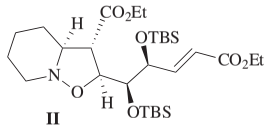


non-racemic

Alkene (0.10–0.33 eq), benzene, 80°



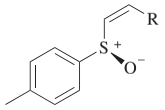
I



II

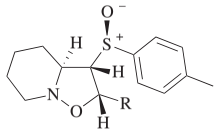
I + II (77), **I/II** = 16:1

685



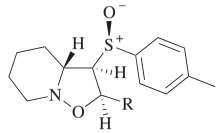
non-racemic

Alkene (0.2–0.3 eq), solvent



I

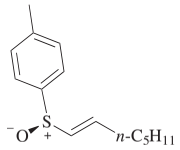
+



II

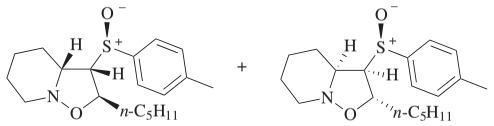
683, 684

R	Solvent	Temp	Time	**I + II**	**I/II**
Me	Et_2O	rt	7–10 d	(95)	94:6
n-Pr	Et_2O	rt	7–10 d	(90)	95:5
n-Pr	benzene/EtOH (9:1)	reflux	70 h	(49)	—
n-C_5H_{11}	Et_2O	rt	7–10 d	(85)	95:5
n-C_5H_{11}	benzene/EtOH (9:1)	reflux	70 h	(58)	—
Ph	Et_2O	rt	7–10 d	(97)	99:1

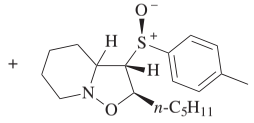


non-racemic

Alkene (0.27 eq), benzene/EtOH (9:1), reflux, 45 h



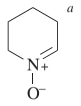
I + **II**



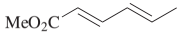
III

683

I + **II** + **III** (78), **I/II/III** = 43:20:15



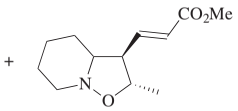
[a]



Alkene (1 eq), solvent, reflux



I + **II**



+ **III** + **IV**[h]

686

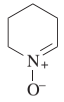
Solvent	Time (h)	**I**	**II**	**III**	**IV**	**I** + **II** + **III** + **IV**
$CHCl_3$	16	(4)	(14)	(—)	(—)	(32)
toluene	19	(5)	(—)	(10)	(46)	(61)

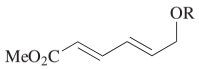
TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

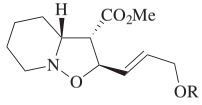
Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

C_5

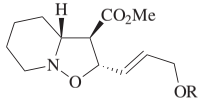




Alkene (1.2 eq), solvent



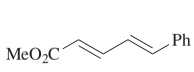
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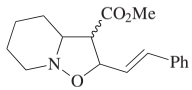
+ **III**[h] 290

I **II**

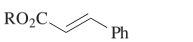
R	Solvent	Temp (°)	Time (d)	**I**	**II**	**I + II**	**III**
H	CH_2Cl_2	4	195	(—)	(—)	(11)	(18)
H	$CHCl_3$	60	7	(—)	(—)	(9)	(20)
Bz	CH_2Cl_2	4	60	(14)	(8)	(—)	(18)
Bz	$CHCl_3$	60	1	(18)	(11)	(—)	(19)



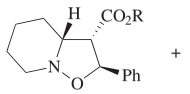
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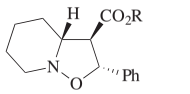
(—) 291



Alkene (2 eq), solvent



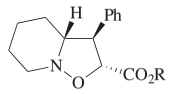
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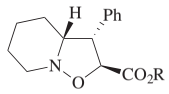
275, 504, 505, 506

I **II**

+

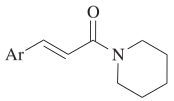


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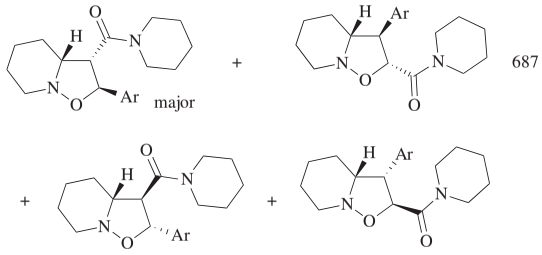
III **IV**

R	Solvent	Temp (°)	Time (h)	**I + II + III + IV**	**I/II/III/IV**
Me	toluene	55	2	(79)	83:12:5:0
i-Pr	CH_2Cl_2	50	48	(83)	78:16:5:1
t-Bu	CH_2Cl_2	40	48	(73)	72:18:8:2
t-Bu	C_6D_6	128	8	(—)	20:80:0:0



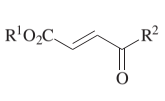
Ar = Ph, 4-ClC_6H_4,
4-$MeOC_6H_4$,
4-$O_2NC_6H_4$

Alkene (1 eq),
toluene, 110°, 16 h

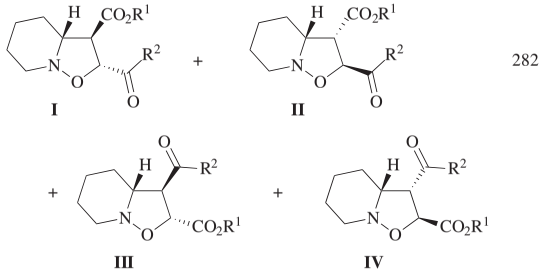


major

687



Alkene (0.66 eq),
solvent



I **II** **III** **IV**

282

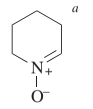
R^1	R^2	Solvent	Temp	Time (h)	**I**	**II**	**III**	**IV**
Me	Me	CH_2Cl_2	rt	18	(40)	(36)	(11)	(3)
Me	Me	toluene	110°	6	(78)	(6)	(4)	(—)
Me	*i*-Pr	CH_2Cl_2	rt	18	(42)	(35)	(8)	(tr)
Me	$BnO(CH_2)_2$	CH_2Cl_2	rt	18	(38)	(34)	(12)	(3)
Me	$BnO(CH_2)_2$	toluene	110°	12	(70)	(6)	(7)	(—)
Et	Ph	CH_2Cl_2	rt	16	(39)	(31)	(8)	(3)

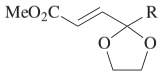
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Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

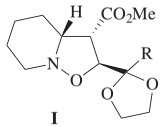
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

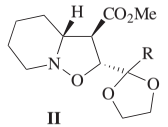
C_5





Alkene (0.67 eq), CH_2Cl_2, rt

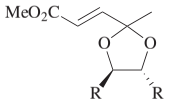


I + 

II

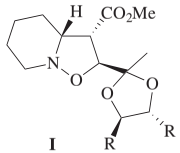
688

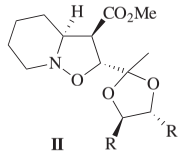
R	Time (d)	**I**	**II**
Me	2	(75)	(9)
$BnO(CH_2)_2$	3	(77)	(8)



non-racemic

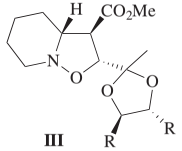
Alkene (0.67 eq), CH_2Cl_2, rt

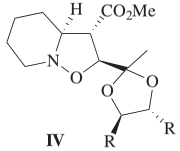


I + 

II

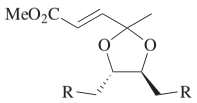
688

+ 

III + 

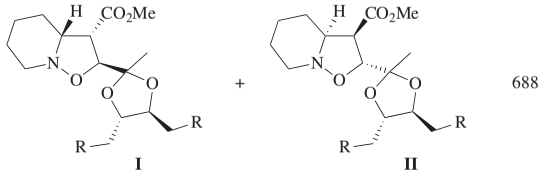
IV

R	Time (d)	**I + II**	dr **I/II**	**III + IV**	dr **III/IV**
c-C_6H_{11}	15	(63)	1:1	(12)	1:1
Ph	2	(77)	3:2 or 2:3	(8)	3:2 or 2:3

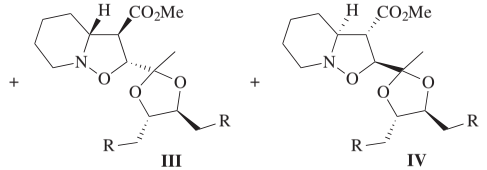


non-racemic

Alkene (0.67 eq), CH_2Cl_2, rt



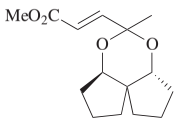
I + **II**



III + **IV**

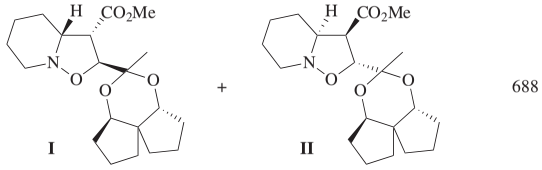
688

R	Time (d)	**I** + **II**	dr **I**/**II**	**III** + **IV**	dr **III**/**IV**
2-$MeOC_6H_4$	15	(82)	1:1	(11)	2:1 or 1:2
BnO	15[i]	(82)	1:1	(10)	2:1 or 1:2

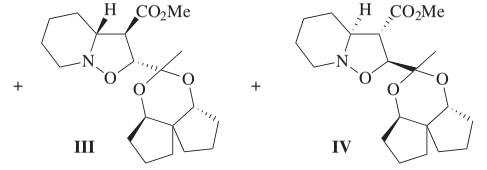


non-racemic

Alkene (0.67 eq), CH_2Cl_2, rt, 10 d



I + **II**



III + **IV**

688

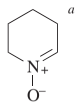
I + **II** (68) dr 4:1 or 1:4, **III** + **IV** (9) dr 10:1 or 1:10

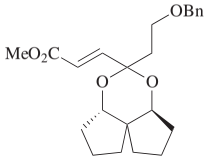
TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

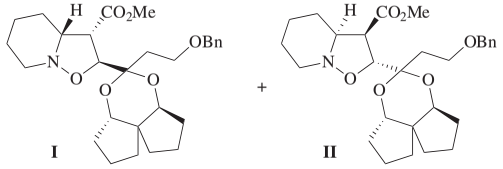
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_5



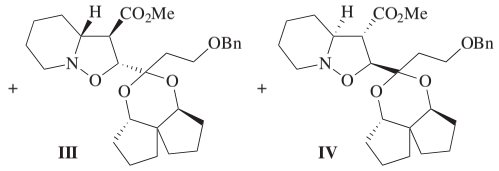


Alkene (0.67 eq), CH_2Cl_2, rt, 20 d

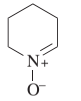


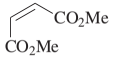
688

non-racemic



I + **II** (57) dr 7:1 or 1:7, **III** + **IV** (11) dr 10:1 or 1:10



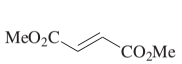


CH_2Cl_2, rt, 2 h

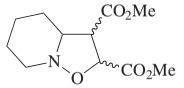


506, 675a

I **I** + **II** (93), **I**/**II** = 84:16 **II**

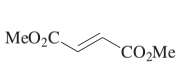


Alkene (1 eq), $CHCl_3$, reflux, 1 h



(75)

107



CH_2Cl_2, rt, 2 h



506, 675a

I **I** + **II** (89), **I**/**II** = 60:40 **II**

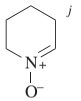
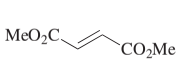
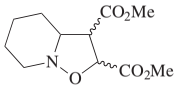
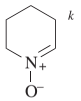
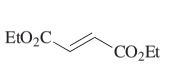
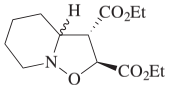
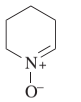
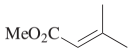
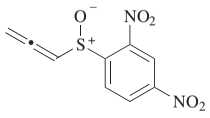
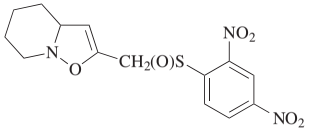
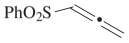
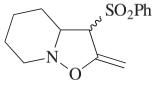
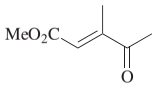
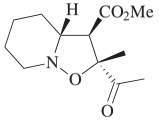
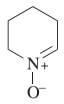
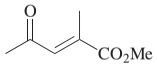
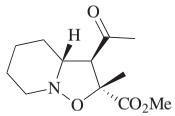
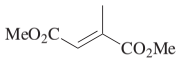
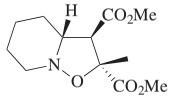
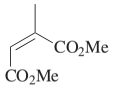
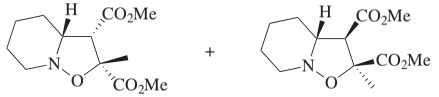
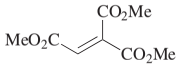
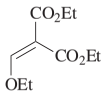
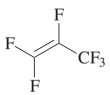
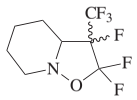
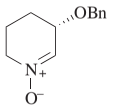
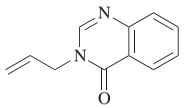
 *j*		Alkene (1 eq), Ar, MeCN/H_2O, reflux, 2 h		(75)	247
 *k*		Alkene (1.5 eq), MeCN, rt, 3.5 h		(68) dr 1.3:1	118
		Alkene (2 eq), toluene, 80°, 5 h	 **I** **I** + **II** (81), **I**/**II** = 57:43 **II**		515
		—		(95)[g]	583
		—		(—)	689
		Alkene (0.66 eq), CH_2Cl_2, rt, 18 h		(90)	282

TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

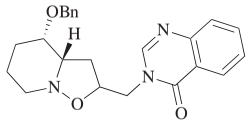
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_5				
		Alkene (0.66 eq), CH_2Cl_2, rt, 18 h	 (91)	282
		Alkene (0.9 eq), CH_2Cl_2, 20°, 24 h	 (93)	515
		Alkene (1.4 eq), toluene, 65°, 2 h	 **I** **I** + **II** (86), **I/II** = 75:25 **II**	515
		Alkene (0.75 eq), CH_2Cl_2, –15°, 0.5 h	 **I** **I** + **II** (—), **I/II** = 64:36 **II**	275
		Alkene (1.15 eq), CH_2Cl_2, 20°, 24 h	 **I** **I** + **II** (81), **I/II** = 57:43 **II**	515
		Alkene (4.2 eq), pressure vial, MeCN, rt, 24 h	 (86) dr 3.4:1	283



non-racemic

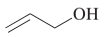


Alkene (1 eq), toluene, reflux, 24 h

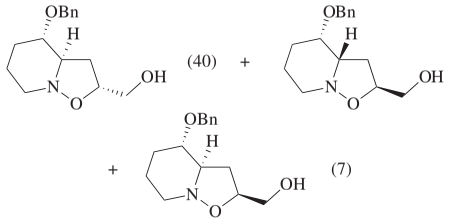


(48)[l]

321



Alkene (15 eq), toluene, 110°, 24 h

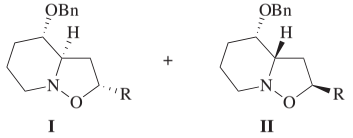


(40) + (10) + (7)

690



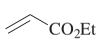
Alkene (3 eq), $CHCl_3$, 60°, 20 h



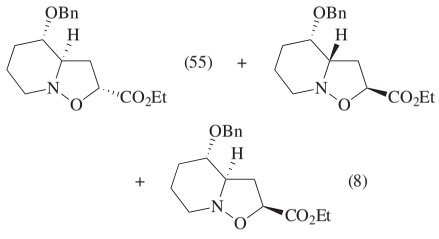
I **II**

690

R	**I**	**II**
$TBSO(CH_2)_2$	(52)	(20)
Ph	(64)	(34)



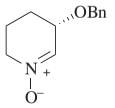
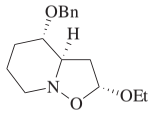
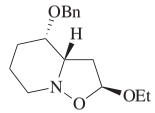
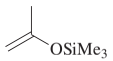
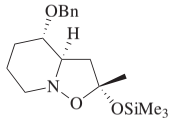
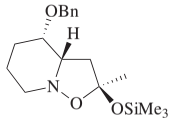
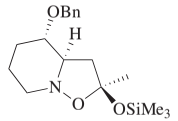
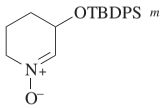
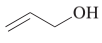
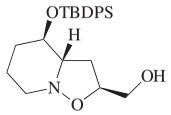
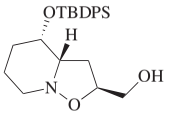
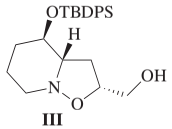
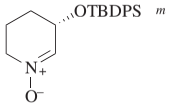
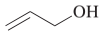
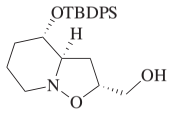
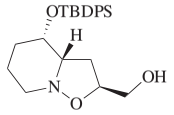
Alkene (3 eq), CH_2Cl_2, rt, 3 h

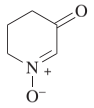


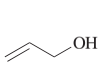
(55) + (24) + (8)

690

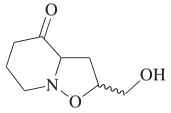
TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_5				
 non-racemic		Alkene (10 eq), toluene, 45°, 3 h	 (53) +  (27)	690
		Alkene (2 eq), toluene, 110°, 48 h	 (27) +  (16) +  (12)	690
		Alkene (xs), rt, 11 h	 **I** +  **II** +  **III** **I + II + III** (74) **I/II/III** = 64:26:10	691
 non-racemic		Alkene (xs), neat, rt, 11 h	 **I** +  **II**	69



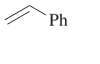


Alkene (xs), neat, rt

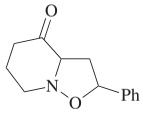


(—) dr —

675a

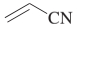


Alkene (xs), neat, rt

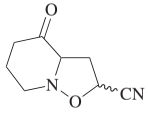


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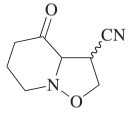
675a



Alkene (xs), neat, rt



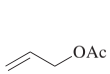
+



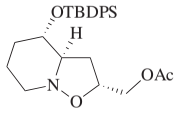
675a

I dr 3:1 **II** dr 2:1

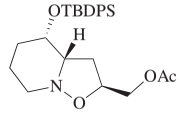
I + **II** (—), **I**/**II** = 79:21



—

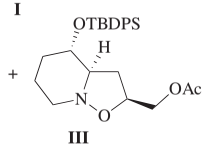


+



69

I **II**



III

I + **II** + **III** (74)

I/**II**/**III** = 64:26:10

III

I + **II** + **III** (quant)

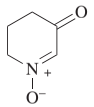
I/**II**/**III** = 64:26:10

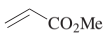
TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

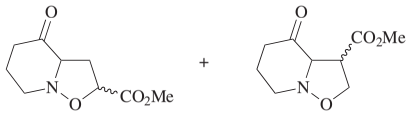
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_5





Alkene (xs), neat, rt



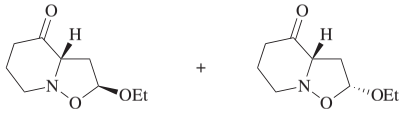
I dr 2:1 + **II** dr 1:1

675a

I + **II** (—), **I/II** = 87:13

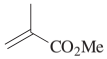


Alkene (xs), neat, rt

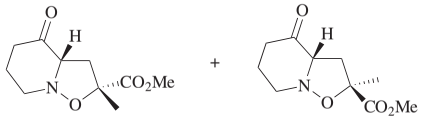


I **I** + **II** (—), **I/II** = 92:8 **II**

675a

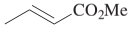


Alkene (xs), neat, rt

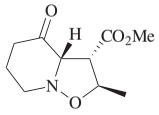


I **I** + **II** (—), **I/II** = 96:4 **II**

675a

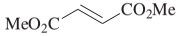


Alkene (xs), neat, rt

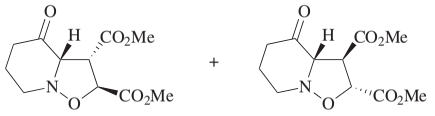


(—)

675a

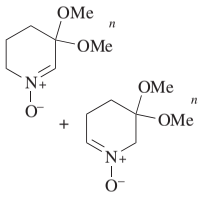


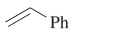
Alkene (1.5 eq), CH_2Cl_2, rt



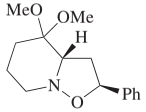
I **I** + **II** (—), **I/II** = 63:37 **II**

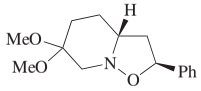
675a

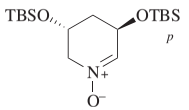




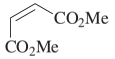
CHCl$_3$, reflux, 3 h



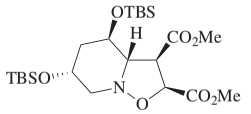
(44) +  (46)^{o} 692

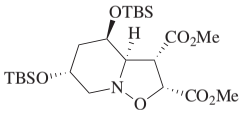


non-racemic

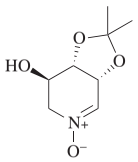


rt, 12 h

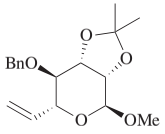


+  322

I **I** + **II** (50), **I**/**II** = 8:1 **II**

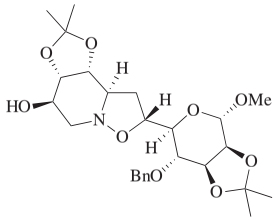


non-racemic



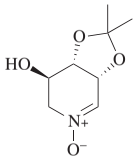
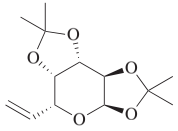
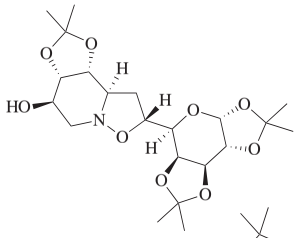
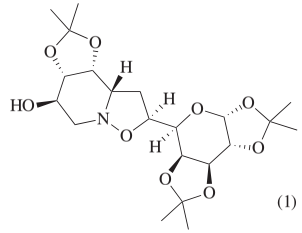
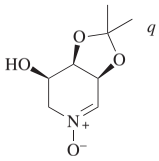
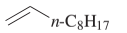
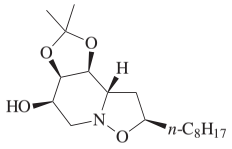
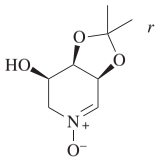
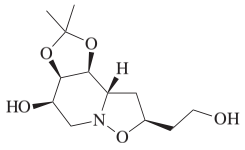
non-racemic

Toluene, reflux



(84) 177

TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*				
C_5				
 non-racemic	 non-racemic	Toluene, reflux	 (88) +  (1)	177
 *q* non-racemic	 *n*-C_8H_{17}	Alkene (10 eq), toluene, 80°, 11 h	 (66)	182
 *r* non-racemic	 OH	Alkene (10 eq), neat, 100°, 4 h	 (73)	182

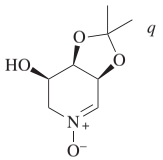
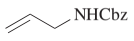
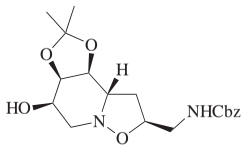
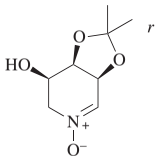
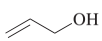
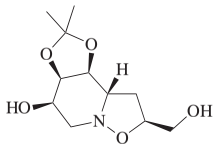
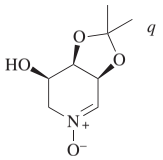
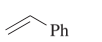
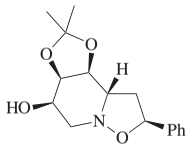
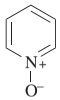
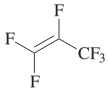
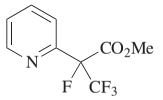
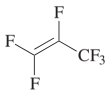
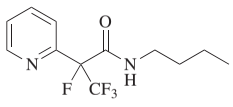
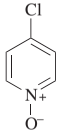
 *q* non-racemic		Alkene (10 eq), EtOH, 70°, 10 h		(67)	182
 *r* non-racemic		Alkene (10 eq), neat, 100°, 4 h		(68)	182
 *q* non-racemic		Alkene (10 eq), EtOH, 70°, 8 h		(69)	182
		Alkene (2.9 eq), MeOH (10 eq), pressure vial, DMF/MeOH (6.2:1), 80–85°, 5 h		(76)[g]	245
		1. Alkene (4.2 eq), pressure vial, DMF, 80°, 5 h 2. n-$BuNH_2$ (2 eq), Et_3N (2 eq), 0° to rt, overnight		(45)[g]	245

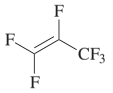
TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

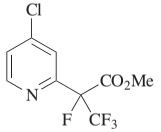
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_5

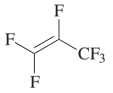




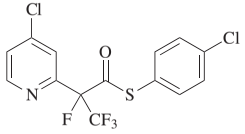
Alkene (4.2 eq), MeOH (10 eq), pressure vial, DMF, 80°, 5 h



(85)[g] — 245

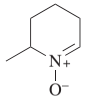


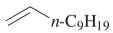
1. Alkene (4.2 eq), pressure vial, DMF, 80°, 5 h
2. 4-ClC_6H_4SH (2 eq), rt, overnight



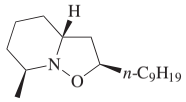
(52)[g] — 245

C_6

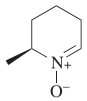




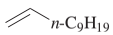
Alkene (*x* eq), solvent



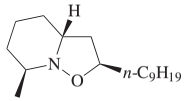
x	Solvent	Temp (°)	Time (min)		
—	$CHCl_3$	50	—	(47)	693
4.7	neat	150	25	(87)	694



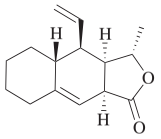
non-racemic



Alkene (xs), neat, 145°, 0.75 h

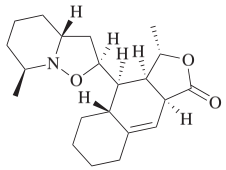


(81) — 149



non-racemic

Alkene (0.81 eq), 2-xylene, 158°, 2.5 h



(49) — 695

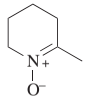
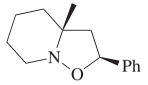
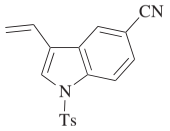
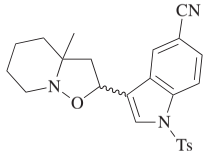
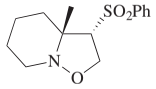
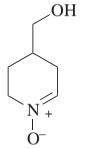
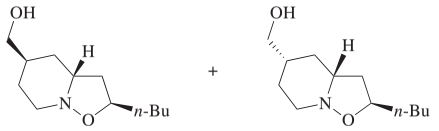
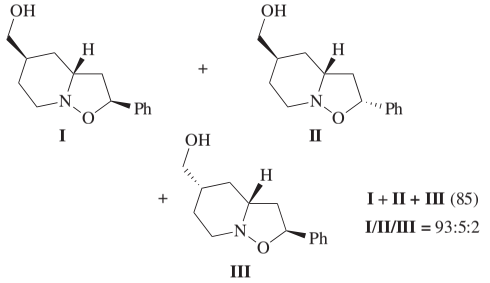
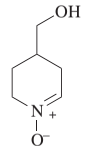
		Alkene (2 eq), toluene, reflux		(30)	266, 696
		—		(32)	497
		Alkene (1 eq), toluene, 80°, 4 h		(45)	164
		Alkene (5 eq), EtOH, 90°, 24 h	 **I** **I + II** (78), **I/II** = 93:7 **II**		32
		Alkene (5 eq), EtOH, 90°, 4 h	 **I** **II** **III** **I + II + III** (85) **I/II/III** = 93:5:2		32

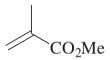
TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

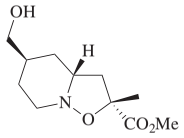
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_6



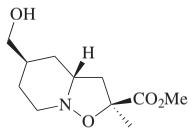


Alkene (6 eq),
EtOH, 90°, 10 h



I

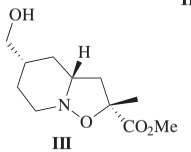
+



II

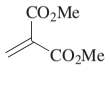
32

+

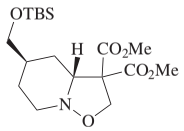


III

I + **II** + **III** (92)
I/II/III = 92:5:3



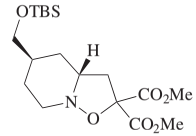
1. Alkene (1.2 eq),
MeOH, 90°, 10 h
2. TBSCl, ImH



I[g]

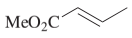
I + **II** (82), **I/II** = 75:25

+

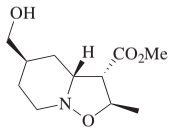


II[g]

32

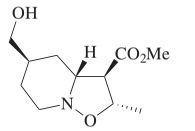


Alkene (6 eq),
EtOH, 90°, 10 h



I

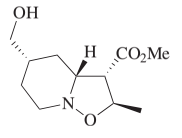
+



II

32

+



III

I + **II** + **III** (85)
I/II/III = 81:16:3

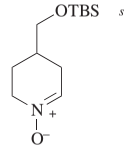
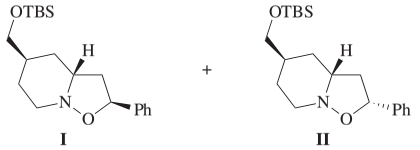
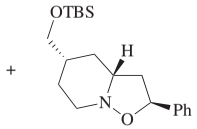
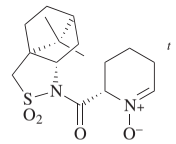
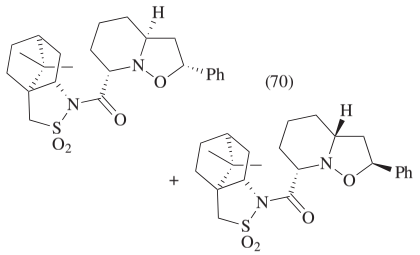
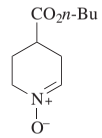
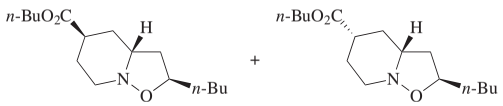
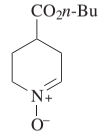
 *s*		Alkene (10 eq), toluene, 100°, 12 h	 **I** + **II** +  **III**	32 **I** + **II** + **III** (83) **I/II/III** = 94:3:3
 *t* non-racemic		Alkene (10 eq), CH_2Cl_2, reflux, 2 h	 (70) + (1.5)	258
		Alkene (6.4 eq), toluene, 90°, 12 h	 **I** **I** + **II** (80), **I/II** = 90:10 **II**	31, 697

TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

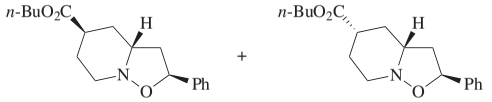
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_6

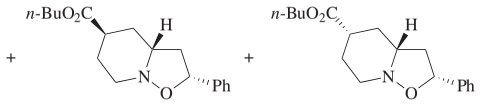




Alkene (7 eq), toluene, 90, 12 h[u]



I + **II** (31, 697)

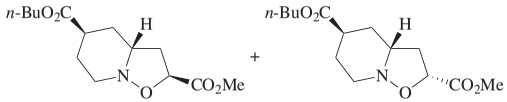


III + **IV**

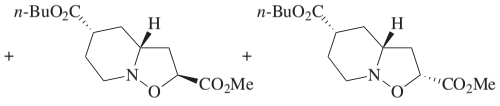
I + **II** + **III** + **IV** (84), **I/II/III/IV** = 88:9:2.5:0.5



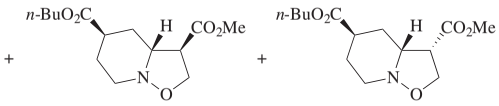
Alkene (3.3 eq), CH_2Cl_2, 20°, 2 h[v]



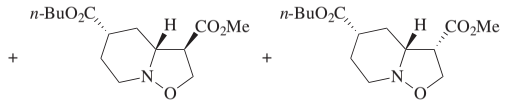
I + **II** (31)



III + **IV**



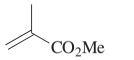
V + **VI**



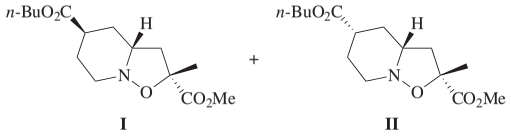
VII **VIII**

I + **II** + **III** + **IV** + **V** + **VI** + **VII** + **VIII** (87)

I/**II**/(**III** + **IV**)/(**V** + **VI** + **VII** + **VIII**) = 62:16:7:15

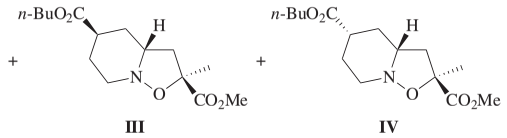


Alkene (3.8 eq),
CH_2Cl_2, 45°, 12 h



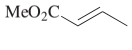
I **II**

31, 697

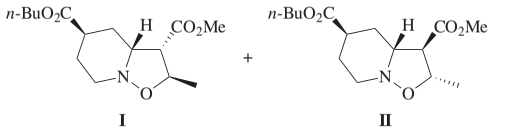


III **IV**

I + **II** + **III** + **IV** (92), **I**/**II**/**III**/**IV** = 88:9:3:tr

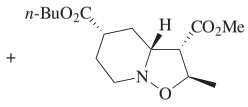


Alkene (7.5 eq),
toluene, 90°, 12 h



I **II**

31, 697

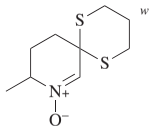
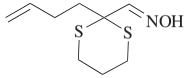
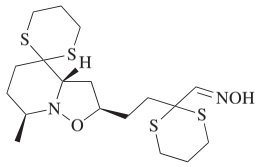
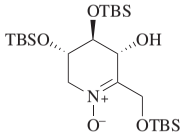
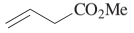
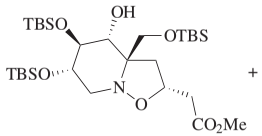
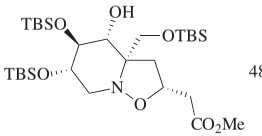
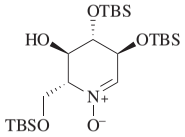
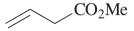
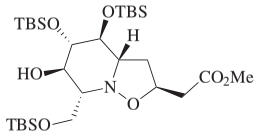
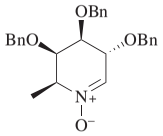
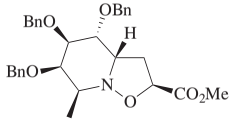
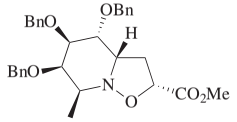


III

I + **II** + **III** (77)

I/**II**/**III** = 87:8:5

TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_6				
		Xylene, reflux, 16 h	 (23)	698, 699
 non-racemic		Alkene (3 eq), $CHCl_3$, radical scavenger (cat.), 15 kbar, overnight	 (39) +  (11)	483
 non-racemic		Alkene (3.3 eq), $CHCl_3$, 15 kbar, 16 h	 (23)	483
 non-racemic		Alkene (10 eq), toluene, 22°, 15 h	 (55) +  (34)	176

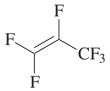
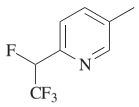
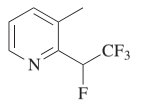
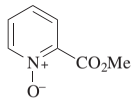
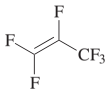
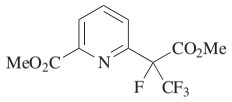
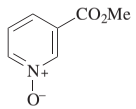
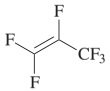
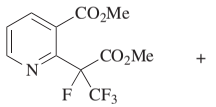
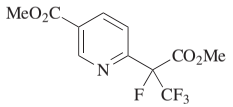
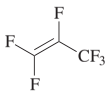
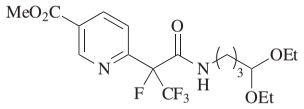
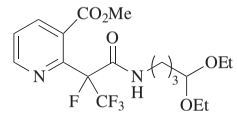
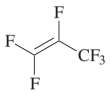
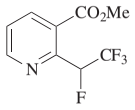
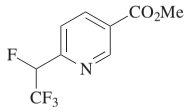
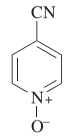
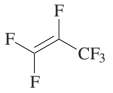
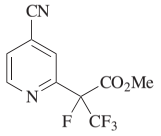
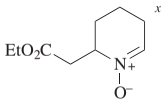
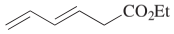
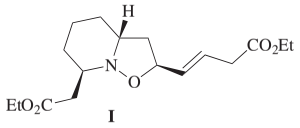
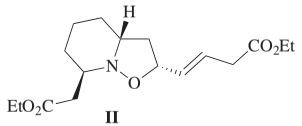
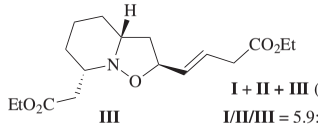
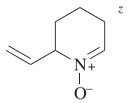
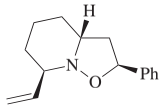
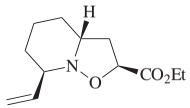
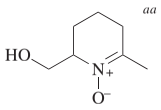
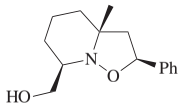
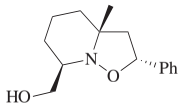
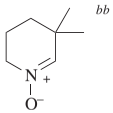
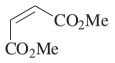
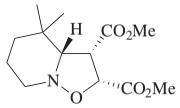
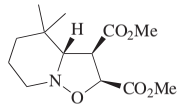
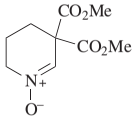
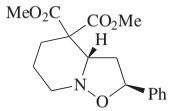
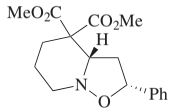
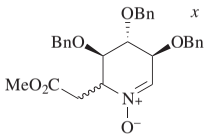
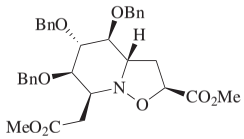
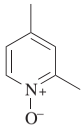
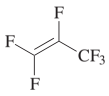
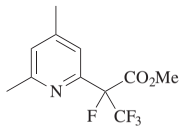
		Alkene (4 eq), pressure vial, DMF, rt, 2.5 h	 (48)[g] +  (8)[g]	244
		Alkene (4.2 eq), MeOH (10 eq), pressure vial, DMF, 80°	 Time (h): 5 (30)[g]; 24 (29)[g]	245
		Alkene (4.2 eq), MeOH (10 eq), pressure vial, DMF, 80°, 5 h	 (53)[g] +  (34)[g]	245
		1. Alkene (4.2 eq), pressure vial, DMF, 80°, 5 h 2. $NH_2(CH_2)_3CH(OEt)_2$ (2 eq), Et_3N (2 eq), 0° to rt, overnight	 **I**[g] +  **II**[g]	**I** + **II** (36), **I**/**II** = 2:1 245
		Alkene (4 eq), pressure vial, DMF, rt, 48 h	 (45)[g] +  (25)[g]	244

TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_6 		Alkene (4.2 eq), MeOH (10 eq), pressure vial, DMF, 80°, 5 h	 (43)[g]	245
C_7 		Neat, 120°	 **I** +  **II** +  **III** **I + II + III** (67)[y] **I/II/III** = 5.9:1.2:1	700
	 Ph	DCE or CH_2Cl_2	 Time (h): 15 (83); 48–72 (42); 96 (27)	207, 568
	CO_2Et	Alkene (2–5 eq), CH_2Cl_2 or DCE, rt, 48–72 h	 (25)	207, 568

 *aa*		Alkene (1 eq), xylene, 140°, 8 h	 (30) +  (20)	701, 702
 *bb*		Alkene (1.5 eq), toluene, 110°, 24 h	 +  **I** **I** + **II** (77), **I**/**II** = 61:39 **II**	646, 703
		Alkene (1.5 eq),[cc] toluene, reflux, 3 h	 +  **I** **I** + **II** (71), **I**/**II** = 5:1 **II**	381
 *x* non-racemic		—	 (36)	704
		Alkene (4.2 eq), MeOH (10 eq), pressure vial, DMF		245

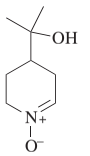
Temp	Time (h)	
rt	24	(44)[g]
80°	5	(34)[g]

TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

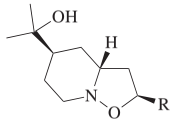
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_8

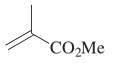


Alkene (xs), N_2, closed vessel, EtOH, 90°

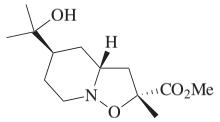


R	Time (h)	
n-Bu	20	(75)
Ph	4	(80)

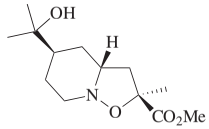
705



Alkene (xs), N_2, closed vessel, EtOH, 50°, 3 h

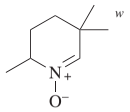


+



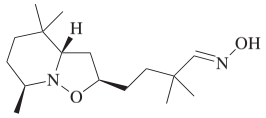
I **I** + **II** (83), **I**/**II** = 95:5 **II**

705





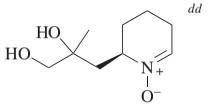
Xylene, 140°, 16 h

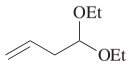


(72)

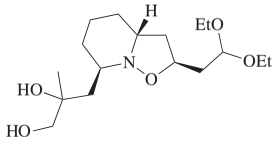
183, 699

C_9



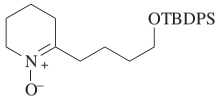


Alkene (xs), sealed vessel, CH_2Cl_2, 50°, 48 h



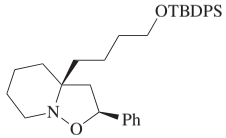
(66)

140

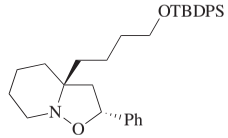




Alkene (xs), neat, 80°, 16 h



+



(73) (7)

431

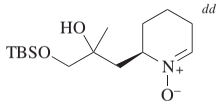
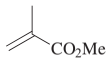
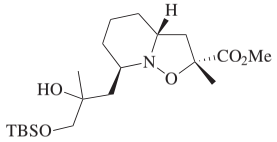
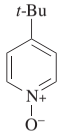
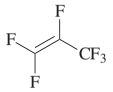
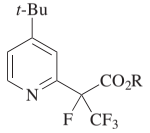
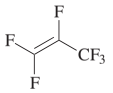
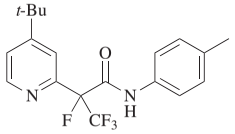
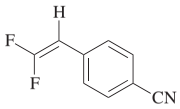
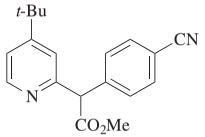
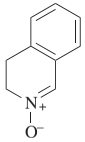
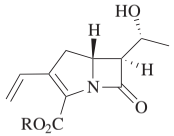
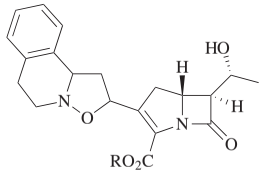
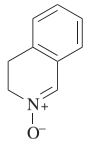
 *dd*		Alkene (xs), CH_2Cl_2, 20°, 24 h		(83)	140, 706
		Alkene (4.2 eq), ROH (10 eq), pressure vial, DMF, 80°, 5 h		R Me (70)[g] allyl (65)[g] PMB (61)[g]	245
		1. Alkene (4.2 eq), pressure vial, DMF, 80°, 5 h 2. 4-toluidine (2 eq), DMF, rt, overnight		(59)[g]	245
		1. Alkene (1 eq), sealed tube, DMF/MeOH (5:1), 50°, 48 h 2. H_2O		(18)[g]	320
	 R = 4-$O_2NC_6H_4CH_2$ non-racemic	Alkene (1 eq), dioxane, 50°, 7 h		(50)	707

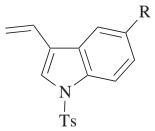
TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

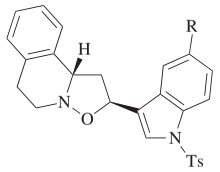
C_9





R = CN, F, OMe

Alkene (0.33 eq), toluene, reflux, 24 h

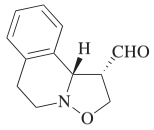


(61–74)

497



Alkene (7 eq), catalyst (0.10 eq), CH_2Cl_2, 4 Å MS, –25°, 25 h

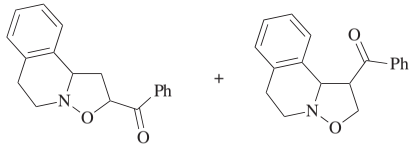


Catalyst		er
10a	(49)[ee]	88.0:12.0
10b	(69)[ee]	83.0:17.0

347



Alkene (1 eq), CH_2Cl_2, rt, 24 h



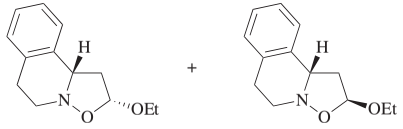
I dr 2.7:1 + **II**[d]

I + **II** (63), **I/II** = 1:1.5

500



Alkene (10 eq), **19** (0.1 eq), $CHCl_3$, rt, 24 h



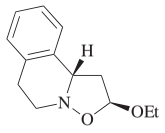
I er 50.0:50.0 + **II** er 50.0:50.0

I + **II** (82), **I/II** = 61:39

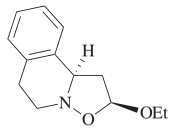
346



Alkene (*x* eq),
catalyst (*y* eq),
CH_2Cl_2, rt



+



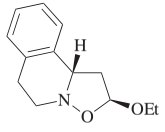
260

I **II**

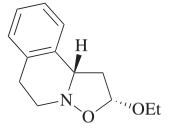
x	Catalyst	*y*	Time (h)	**I** + **II**	**I/II**	er **I**	er **II**
2	$AlCl_3$	10	20	(88)	20:80	50.0:50.0	—
4	—	0.2	24	(5)	>95:<5	50.0:50.0	—
4	**17a**	0.2	42	(11)	85:15	62.0:38.0	—
4	**17b**	0.2	20	(76)	92:8	83.0:17.0	—
4	**17c**	0.2	20	(98)	98:2	84.0:16.0[gg]	—
4	**17d**	0.2	20	(74)	98:2	91.0:9.0	—
4	**17d**	0.2	46	(30)	78:22	75.0:25.0	—
4	**17e**	0.2	46	(96)	89:11	79.0:21.0	—
4	**17f**	0.2	20	(78)	87:13	83.5:16.5	—
4	**18a**	0.2	25	(98)	87:13	74.0:26.0	50.0:50.0
4	**18b**	0.2	19	(100)	27:73	83.0:17.0	53.0:47.0
4	**18c**[ff]	0.2	20	(100)	42:58	56.5:43.5	51.5:48.5
10	$AlMe_3$	10	20	(28)	>95:<5	50.0:50.0	—



Alkene (3 eq),
4a (0.2 eq), CH_2Cl_2,
2 kbar, rt, 16 h



+



278

I **II**

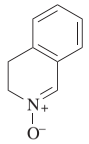
I + **II** (65), **I/II** = 67:33[hh]

TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

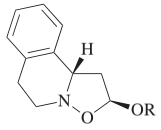
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_9



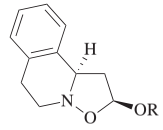


Alkene (4 eq),
catalyst (0.2 eq),
CH_2Cl_2, rt



I

\+



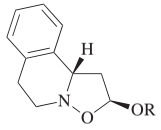
II

260

R	Catalyst	I	I/II	er I	er II
Et	**17d**	(85)	96:4	92.5:7.5	56.0:44.0
t-Bu	**17b**[ff]	(86)	95:5	85.0:15.0	63.0:37.0
Ph	**17b**	(24)	>95:5	55.0:45.0	—

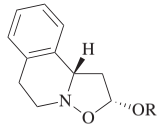


Alkene (1.3 eq),
catalyst (*x* eq),
proton sponge **2** (*y* eq),
CD_2Cl_2, rt



I

\+



II

344

R	Catalyst	*x*	*y*	Time (h)	Conv. (%)	I	II	I/II
Et	—	—	0.17	213	37	(—)	(—)	94:6
Et	**5**	0.07	—	25	>95	(—)	(—)	45:55
Et	**7**	0.07	—	18	>95	(—)	(—)	45:55
Et	TfOH	0.07	—	1.5	>95	(—)	(—)	45:55
Et	**6**	0.07	0.17	60	>95	(70)	(17)	75:25
Et	TfOH	0.07	0.17	64	15	(—)	(—)	95:5
t-Bu	—	—	0.18	150	17	(—)	(—)	>98:2
t-Bu	**6**	0.07	0.18	20	>95	(29)	(45)	39:61

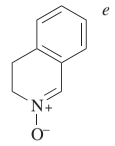
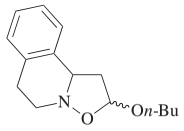
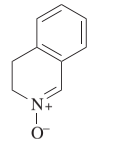
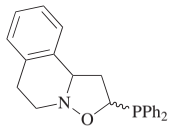
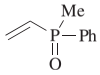
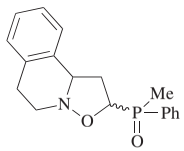
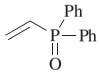
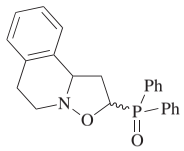
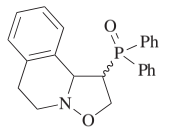
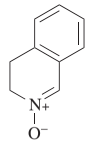
 *e*		Alkene (2.1 eq), H_2O, 90°, 1 h		(77)	91
		Alkene (1 eq), dry benzene, 80°, 24 h		(45) dr 2:1	571, 572, 573
		Alkene (0.8 eq), $CHCl_3$, rt, 7 d		(97) dr 48:24:24:4	576
		Alkene (0.9 eq), $CHCl_3$, rt, 18 d	 + 	**I**[d] **I + II** (83), **I/II** = 76:24 **II**[d]	574

TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

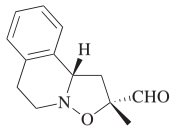
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_9





Alkene (7 eq),
catalyst (0.05 eq),
CH_2Cl_2, 4 Å MS[f]

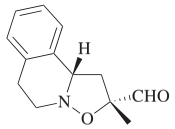


Catalyst	Temp (°)	Time (h)		er
9a	–25	24	(57)	90.5:9.5
9b	–35	24	(53)	97.5:2.5
9b	–25	15	(100)	96.5:3.5

259



Alkene (1.4 eq),
catalyst (5 mol %),
CH_2Cl_2, 4 Å MS, –25°

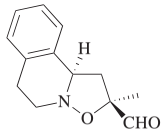


Catalyst	Time (h)		er
13	48	(86)	53.0:47.0
14	48	(98)	58.0:42.0
15	48	(100)	56.0:44.0
16	24	(51)	19.5:80.5

348



Alkene (1.2 eq),
11 (0.05 eq),
2,6-lutidine (0.05 eq),
CH_2Cl_2, –20°

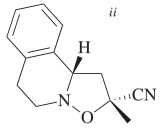


(71) er 97.0:3.0

82



Alkene (*x* eq),
10a (*y* eq),
solvent



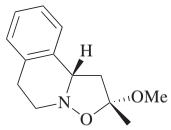
ii

261

x	*y*	Solvent	Temp	Time (h)		dr	er
0.2	0.2	CH_2Cl_2	–25°	24	(quant)*ii*	100:0	97.0:3.0
0.2	0.2	CH_2Cl_2	rt	3	(quant)*ii*	100:0	88.0:12.0
0.2	0.2	THF	–25°	24	(quant)*ii*	100:0	97.0:3.0
0.2	0.2	THF	rt	3	(quant)*ii*	100:0	92.0:8.0
7	0.1	CH_2Cl_2	–25°	72	(26)	99:1	68.0:32.0
7	0.1	CH_2Cl_2	rt	16	(82)	98:2	76.0:24.0
7	0.1	THF	rt	16	(90)	98:2	86.0:14.0

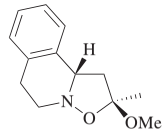


Alkene (1.92 eq),
catalyst (*x* eq),
CH_2Cl_2, rt, 24 h



I

+



II

344

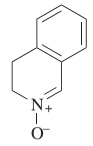
Catalyst	*x*	**I**	**II**	**I/II**
5	0.08	(—)	(—)	62:38
6	—	(28)	(48)	36:64

TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

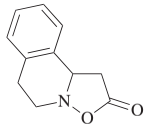
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_9





Alkene (1.5 eq), *i*-Pr_2EtN, (0.2 eq), toluene, 40°, 18 h

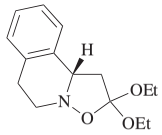


(58)

708



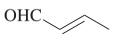
Alkene (2–3 eq), catalyst (0.2 eq), solvent, –78°, 5–24 h



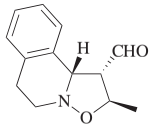
(80–99)

Catalyst	Solvent	er
4f	THF	56.0:44.0
4g	CH_2Cl_2	44.0:56.0
4h	CH_2Cl_2	47.0:53.0

262

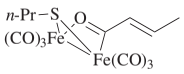


Alkene (7 eq), catalyst (0.1 eq), CH_2Cl_2, 4 Å MS, –25°, 25 h

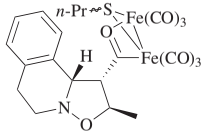


Catalyst		er
10a	(100)	87.0:13.0
10b	(100)	85.0:15.0

347

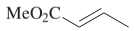


Alkene (0.83 eq), EtOAc, rt, 3 h

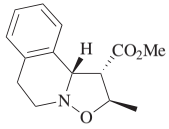


(95)[d]

308

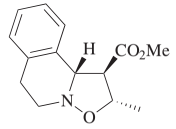


Alkene (0.83 eq), toluene



I

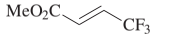
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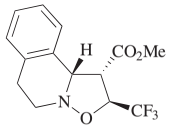
II

709

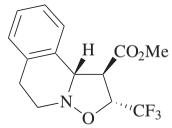
Temp (°)	Time (h)	**I**	**II**	**I + II**	**I/II**
20	43	(57)	(—)	(—)	—
80	24	(—)	(—)	(63)	71/29



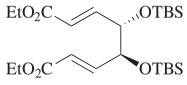
Alkene (0.83 eq), toluene, 20°, 20 h



(53) +

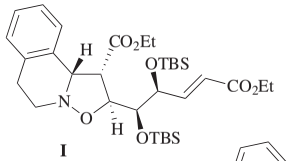


(18) 709



non-racemic

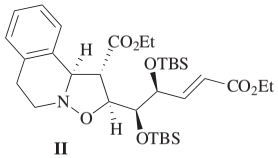
Alkene (0.10–0.33 eq), benzene, 80°



I

I + II (55), **I/II** = 4:1 685

+



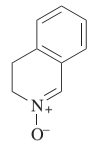
II

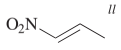
TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

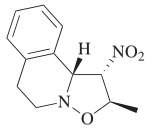
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_9



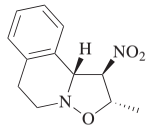


Alkene (xs), C_6D_6



I

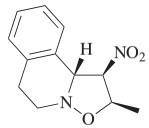
+



II

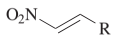
581

+

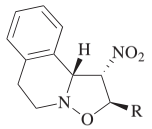


III^{mm}

Temp (°)	Time (h)	**II**	**I/II**
8	24	(90)	—
21	2	(—)	4:1

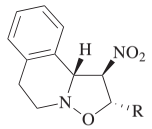


Alkene (1 eq), toluene, rt, 12 h



I

+



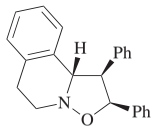
II

541

R	**I + II**	**I/II**
CHF_2	(45)	66:33
CF_2Cl	(61)	50:50
CF_3	(52)	66:33
CF_3CF_2	(48)	75:25

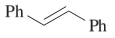


Alkene (1.9 eq), benzene, rt, 105 d

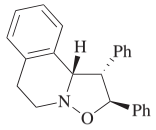


(30)

710

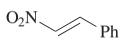


Alkene (0.8 eq), benzene, rt, 60 d

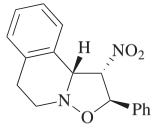


(8)

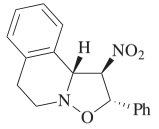
710



Alkene (1.3 eq), C_6D_6, dark



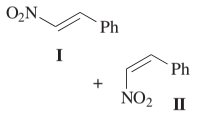
+



581

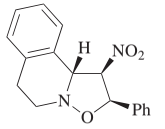
I **II**

Temp	Time	**I/II**
rt	4 h	85:15
rt	30 d	13:87[nn]
53°	64 h	16:84

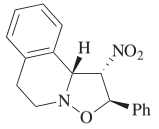


I + **II**

Alkenes (xs), benzene, dark



+

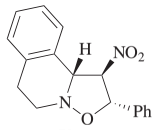


581

III **IV**

I/II	Temp (°)	Time (h)	**III**	**IV + V**
1:1	21	2	(77)	(5)
1:3	—	—	(>75)	(0)

+



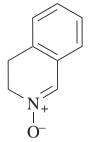
V

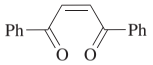
TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

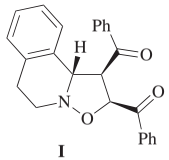
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_9



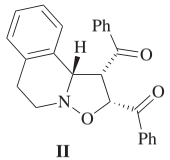


Alkene (0.76 eq), C_6D_6



I

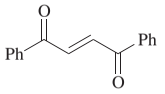
+



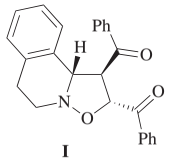
II

Time	**I/II**
5 min	50:50
4 h	**I** only

710

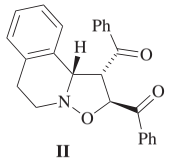


Alkene (0.76 eq), C_6D_6



I

+



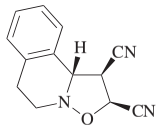
II

Time	**I/II**
5 min	75:25
4 h	>98:2

710

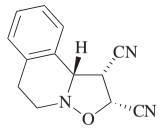


Alkene (2.7 eq), $CDCl_3$, 35°



I (—)

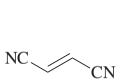
+



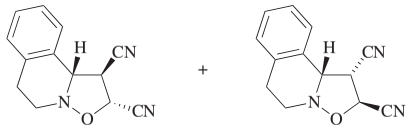
II (—)

Time (h)	**I/II**
0.33	50:50
48	80:20

710

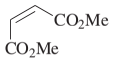


Alkene (2.7 eq), $CDCl_3$, 35°

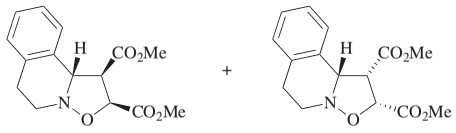


I (—)	Time (h)	II	I/II	II
	0.33	(60)	40:60	
	48	(—)	85:15	

710



Alkene (1.22 eq), benzene

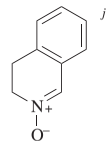


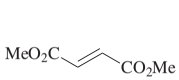
I	II

Temp	Time (h)	I + II	I/II
rt	12	(86)	48:52
reflux	96	(80)	>95:5

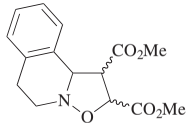
710

j



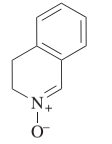


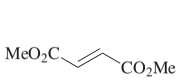
Alkene (1 eq), Ar, $MeCN/H_2O$, reflux, 2 h



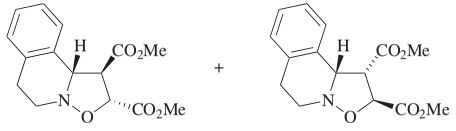
(70)

247





Alkene (*x* eq), solvent



I	II (—)

x	Solvent	Temp	Time	I	I/II
0.52	C_6D_6	35°	10 min	(—)	23:77
1.04	benzene	reflux	48 h	(77)	93:7

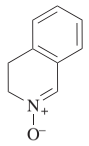
710

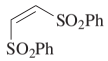
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Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

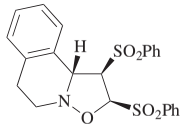
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_9



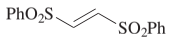


Alkene (0.5 eq), CH_2Cl_2, rt, 10 d

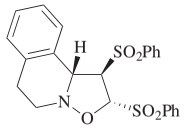


(—)

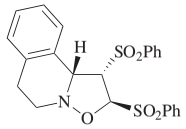
710



Alkene (0.5 eq), CH_2Cl_2, rt



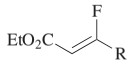
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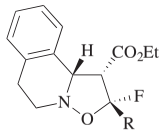
710

I (—) **II** (—)

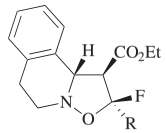
Time	**I/II**
5 min	83:17
10 d	**I** only



Alkene (1 eq), CH_2Cl_2, rt, 0.5 h

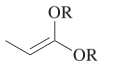


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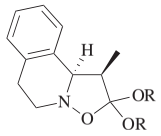


516, 517

I R	**I**	**II**	**II**
$BrCF_2$	(59)	(40)	
$Cl(CF_2)_3$	(40)	(60)	
$F(CF_2)_5$	(33)	(56)	
$Cl(CF_2)_5$	(45)	(45)	



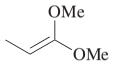
Alkene (2–3 eq),
catalyst (0.2 eq),
solvent, –78°, 5–24 h



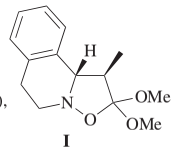
(80–99)[ii]

R	Catalyst	Solvent	er
Me	**4b**	EtCN	56.0:44.0
Me	**4g**	CH_2Cl_2	62.0:38.0
Me	**4h**	CH_2Cl_2	72.0:28.0
Me	**4i**	CH_2Cl_2	68.0:32.0
Et	**4e**	EtCN	56.0:44.0
Et	**4g**	CH_2Cl_2	60.0:40.0
Et	**4h**	CH_2Cl_2	61.0:39.0

262

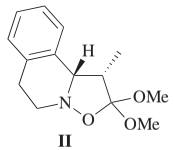


Alkene (*x* eq),
catalyst (0.04 eq),
proton sponge **2** (0.1 eq),
CD_2Cl_2, rt



I

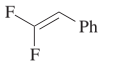
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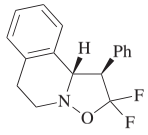
II

x	Catalyst	Time (h)	Conv (%)	**I**	**II**	**I/II**
1.2	none	95	<1	(—)	(—)	(—)
1.31	**7**	0.3	>95	(56)	(32)	65:35
2	**8**	72	25	(16)[oo]	(—)	92:8

344

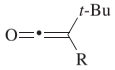


Alkene (0.5 eq),
THF, reflux, 3 h

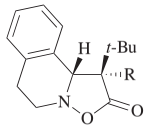


(64)

711



Alkene (*x* eq)
dry benzene,
reflux



R	*x*	Time (h)	
NC–[pp]	—	0.5	(51)
EtO_2C	1.2	6	(32)

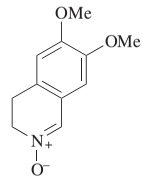
294

TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

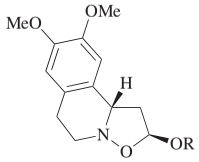
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_9



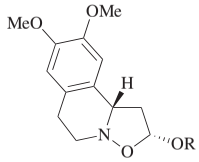


Alkene (4 eq),
17b (0.2 eq),
CH_2Cl_2, rt



I

\+



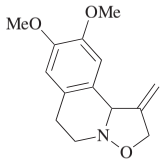
II (—)

R	**I**	**I/II**	er **I**	er **II**
Et	(76)	97:3	85.0:15.0	50.0:50.0
t-Bu	(92)	**I** only	82.5:17.5	—

260

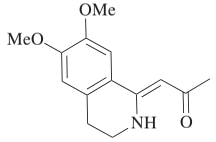


Alkene (xs),
sealed vessel,
dry benzene/THF (5:3),
85°, 5 h



(19)

\+

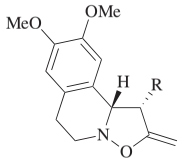


(27)[g]

712

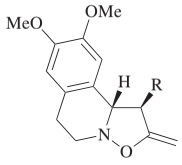


Alkene (2 eq),
CH_2Cl_2, rt, 1–6 h



I

\+



II

R	**I**	**II**
NC–	(48)	(30)
EtO_2C	(40)	(40)

292

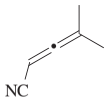
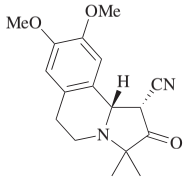
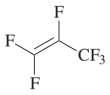
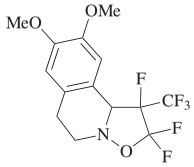
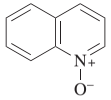
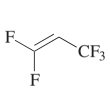
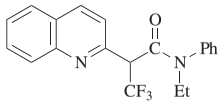
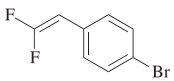
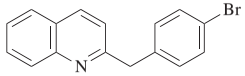
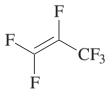
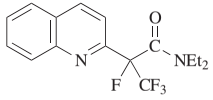
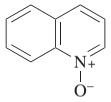
		Alkene (2 eq), CH_2Cl_2, rt, 6 h		(40)[g]	292
		Alkene (4.2 eq), pressure vial, MeCN, 80°, 24 h		(75) dr 3.7:1	283
		Alkene (4.2 eq), PhNHEt (5 eq), pressure vial, DMF, rt, 24 h		(75)[g]	245
		1. Alkene (1 eq), pressure tube, toluene, 80°, 24 h 2. H_2O		(46)[g]	320
		1. Alkene (4.2 eq), pressure vial, DMF, rt, 3 h 2. Et_2NH (5 eq), rt, 6 h		(40)[g]	245

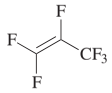
TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

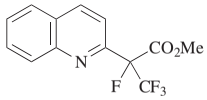
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_9



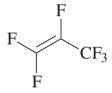


Alkene (4.2 eq), pressure vial, solvent

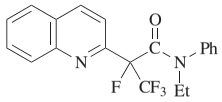


Solvent	Temp	Time (h)	
DMF/MeOH (6.2:1)	80°	5	(75)[g]
MeOH	rt	48	(48)[g]

245

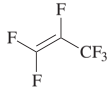


Alkene (4.2 eq), PhNHEt (2 eq), pressure vial, DMF, rt, 24 h

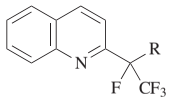


(76)[g]

245

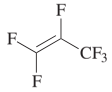


Alkene (4.2 eq), pressure vial, solvent, rt, 14 h

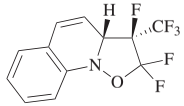


Solvent	R	D/H	CO_2Me/H	
DMF/D_2O	H(D)	38:1	—	(17)[g]
DMF then D_2O	H(D)	7.2:1	—	(75)[g]
DMF then MeOH	CO_2Me(H)	—	4.2:1	(68)[g]

245

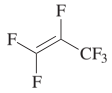


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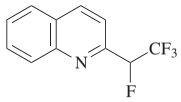


(5)

244



Alkene (4 eq), pressure vial, DMF, rt, 1.5 h



(73)[g]

244

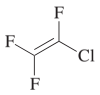
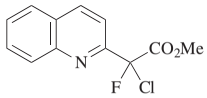
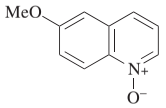
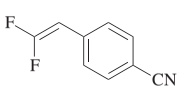
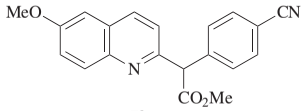
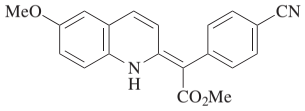
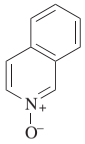
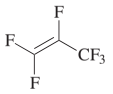
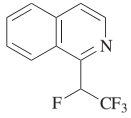
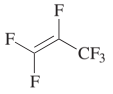
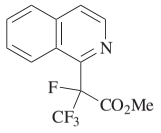
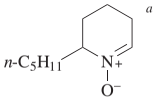
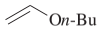
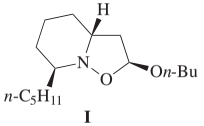
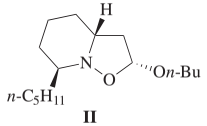
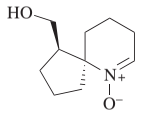
		Alkene (4.2 eq), MeOH (10 eq), pressure vial, DMF, 110°, 7 d		(66)[g]	245
		Alkene (1 eq), sealed tube, DMF/MeOH (5:1), 50°, 48 h	 **I**[g] +  **II**[g]	**I** + **II** (73), **I/II** 1:1.5	320
		Alkene (4 eq), pressure vial, DMF, rt, 24 h		(49)[g]	244
		Alkene (4.2 eq), MeOH (10 eq), pressure vial, DMF, 80°, 5 h		(28)[g]	245
C_{10}  [a]		Alkene (xs), closed vessel, CH_2Cl_2, 55°, overnight	 **I** +  **II**	**I** + **II** (92), **I/II** = 85:15	713

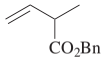
TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

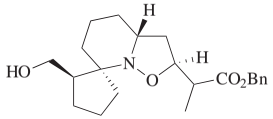
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_{10}



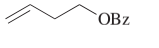


Alkene (3 eq), MW, toluene, 165°, 1 h

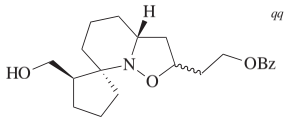


(60) dr 1:1

714

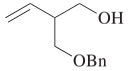


Alkene (3 eq), toluene, 110°

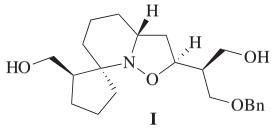


qq

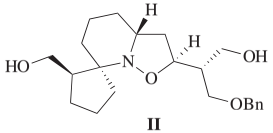
Time (h)		
8	(70)	715
14	(60)	714



Alkene (1.5 eq), MW, toluene, 210°, 2 h



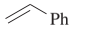
I



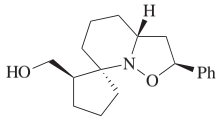
II

I + II (78), **I/II** = 50:50

715



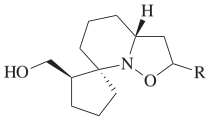
Alkene (3 eq), toluene, 110°, 13 h



(64)

714, 715

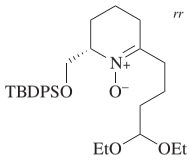




Alkene (17 eq), solvent

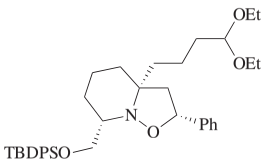
R	Solvent	Temp	Time (h)	
EtO_2C	CH_2Cl_2	rt	48	(90)[qq]
EtO	EtOH	40°	55	(80)[qq]

714, 715



rr

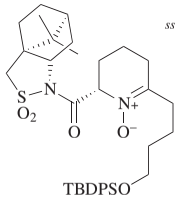
non-racemic



EtOH, 70°

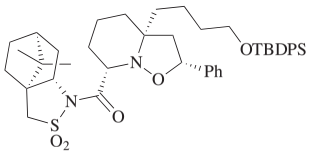
(62)

430



ss

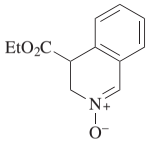
non-racemic

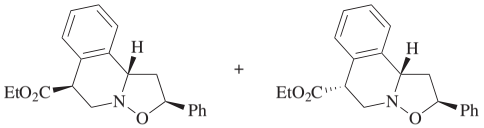


Alkene (xs), **1** (cat.), neat, 80°, 6 h

(85)

174, 218





Alkene (1.5 eq), CH_2Cl_2, rt, 10 h

(68) + (32)

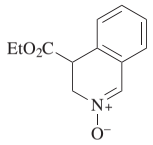
716

TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

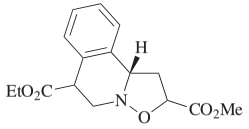
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_{10}



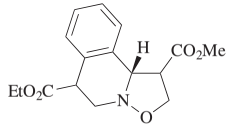


Alkene (1.5 eq), CH_2Cl_2, rt, 10 h



I

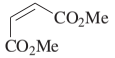
+



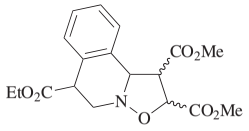
II

I + **II** (100)

716

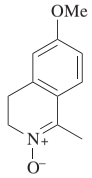


Alkene (1.5 eq), CH_2Cl_2, rt, 10 h



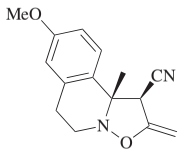
(92)

716



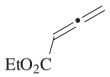


Alkene (2 eq), CH_2Cl_2, rt, 1–6 h

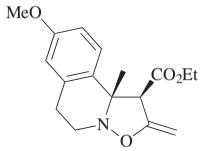


(52)

292

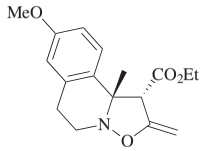


Alkene (2 eq), CH_2Cl_2, rt, 1–6 h



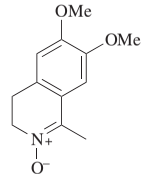
(51)

+



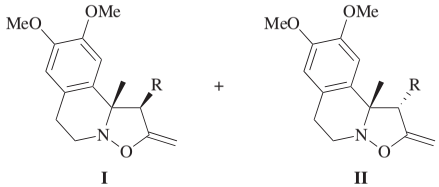
(32)

292





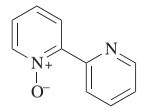
Alkene (2 eq), CH_2Cl_2, rt, 1–6 h

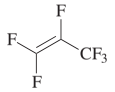


I **II**

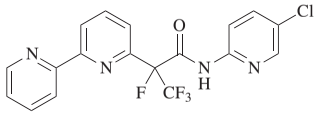
R	**I**	**II**
NC–	(50)	(18)
EtO_2C	(60)	(30)

292





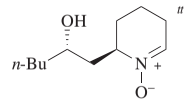
1. Alkene (4.2 eq), pressure vial, DMF, 80°, 24 h
2. 2-NH_2-5-Cl-pyridine (2 eq), Et_3N (2 eq), 0° to rt, overnight



(55)[g]

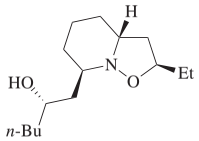
245

C_{11}





Alkene (xs), sealed vial, $CHCl_3$, 110°, 18 h

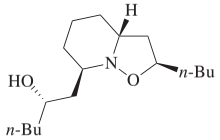


(18)

266



Alkene (xs), $CHCl_3$, reflux, 18 h



(21)

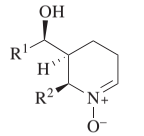
266

TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

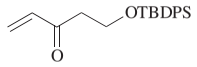
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_{11}

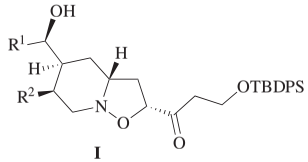


$R^1 = BnO(CH_2)_2$

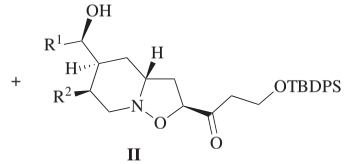
$R^2 = PhSO_2(CH_2)_3$



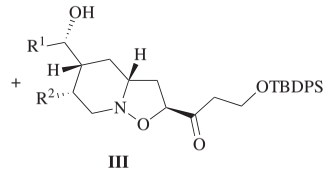
Benzene, reflux



I



II



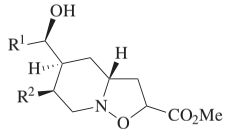
III

I + **II** + **III** (80), **I/II/III** = 1:1:1

717

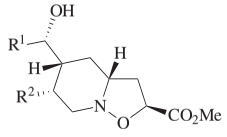


Alkene (43 eq), benzene, reflux, 24 h



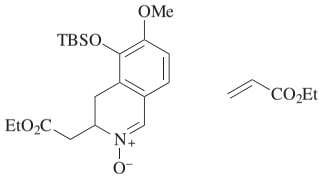
(49) dr 1:1

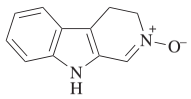
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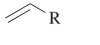


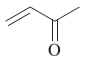
(42)

717

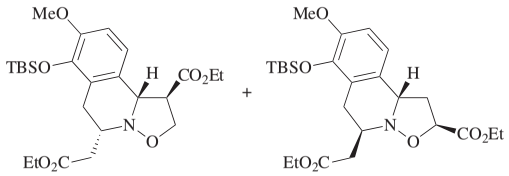








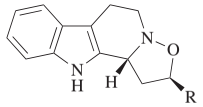
Alkene (5 eq), EtOH, reflux, 3.5 h



(50) (20)

718

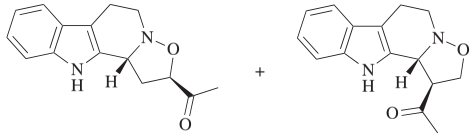
Alkene (3 eq), 1,4-dioxane



R	Temp (°)	Time (h)	
n-Bu	60	24	(73)
Ph	80	3	(75)

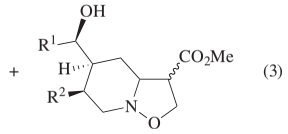
59

Alkene (3 eq), 1,4-dioxane, 80°, 2 h



I **I + II** (84), **I/II** = 79:21 **II**

59



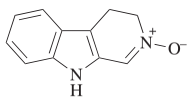
(3)

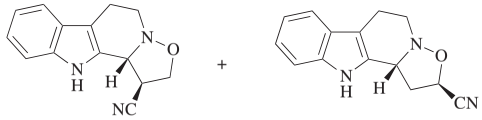
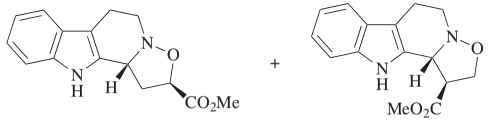
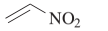
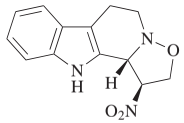
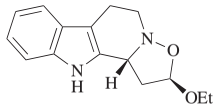
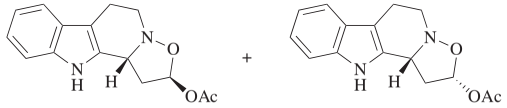
TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_{11}

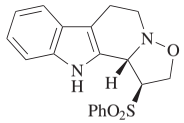


Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
	Alkene (3 eq), 1,4-dioxane, 80°, 3 h	 **I** **I + II** (81), **I/II** = 77:23 **II**	59
	Alkene (3 eq), 1,4-dioxane, 80°, 3 h	 **I** **I + II** (78), **I/II** = 95:5 **II**	59
	Alkene (3 eq), 1,4-dioxane, 80°, 1 h	 (89)	59
	Alkene (3 eq), 1,4-dioxane, rt, 3 d	 (79)	59
	Alkene (3 eq), 1,4-dioxane	 **I** **II**	59

Temp (°)	Time (h)	**I + II**	**I/II**
60	6	(66)	97:3
80	2	(86)	**I** only

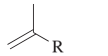


Alkene (3 eq),
1,4-dioxane, 80°, 2 h

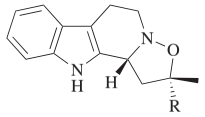


(74)

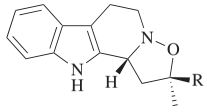
59



Alkene (3 eq),
1,4-dioxane, 100°



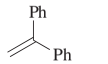
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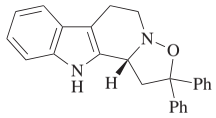
59

I **II**

R	Time (h)	**I + II**	**I/II**
Ph	5	(65)	60:40
MeO_2C	2	(85)	88:12

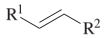


Alkene (3 eq),
1,4-dioxane, 100°, 5 h

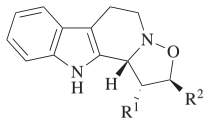


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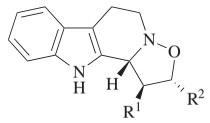
59



Alkene (3 eq),
1,4-dioxane



+

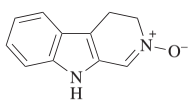
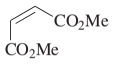
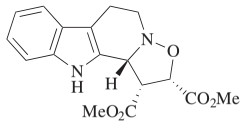
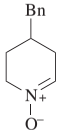
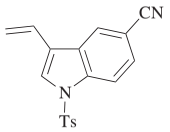
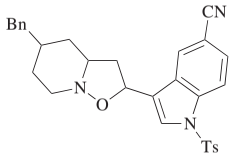
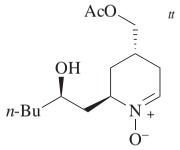
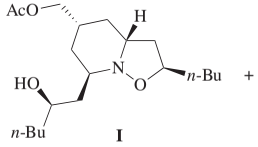
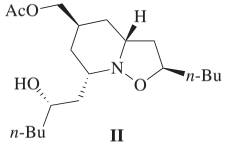
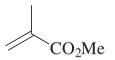
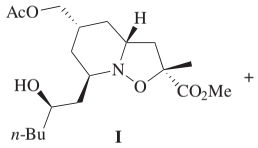
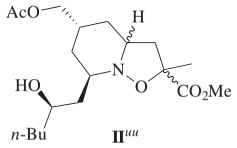


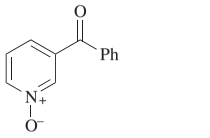
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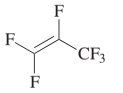
I **II**

R^1	R^2	Temp (°)	Time (h)	**I + II**	**I/II**
MeO_2C	Me	100	2	(85)	85:15
MeO_2C	Ph	100	24	(32)	45:55
O_2N	Ph	80	3	(64)	7:93
MeO_2C	MeO_2C	100	2	(85)	95:5

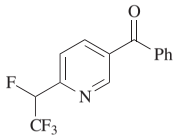
TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

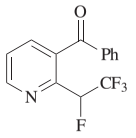
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_{11} 		Alkene (3 eq), 1,4-dioxane, 100°, 1 h	 (78)	59
C_{12} 		—	 (77)	497
		Alkene (15 eq), toluene, 75°, 48 h	 +  (61), **I**/**II** = 2:1	32
		Alkene (10 eq), toluene, rt, 12 h	 +  (72), **I**/**II** = 88:12	32

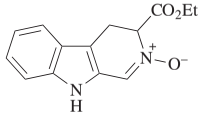


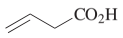


Alkene (4 eq), pressure vial, DMF, rt, 48 h

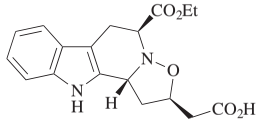


(26)[g] +  (38)[g] 244





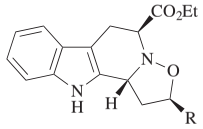
Alkene (11 eq), toluene, 80°, 24 h

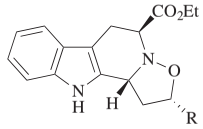


(80) 719

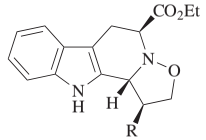
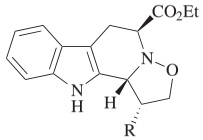


Alkene (10 eq), solvent



+  719

I **II**

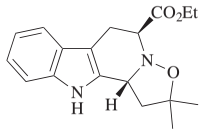
+  + 

III **IV**

R	Solvent	Temp	Time (h)	**I + II + III + IV**	**I/II/III/IV**
Ph	toluene	110°	1.5	(85)	85:2:2:10
MeO_2C	toluene/MeOH (9:1)	rt	5	(93)	31:5:12:52



Alkene (xs), closed vessel, toluene, 9 bar, 120°, 4 h



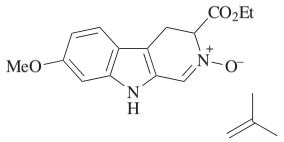
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TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

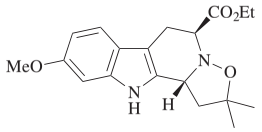
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_{12}



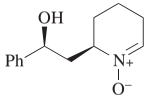
Alkene (xs), solvent, pressure vessel



Solvent	Pressure	Temp (°)	Time (h)	
toluene	9 bar	120	4	(82)
DMF	12 kbar	rt	20	(86)

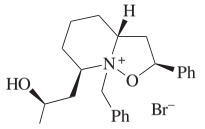
719a

C_{13}



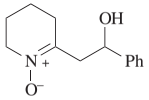


1. $CHCl_3$, reflux
2. $PhCH_2Br$, CH_2Cl_2



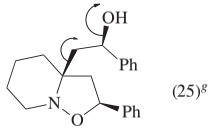
(80)[g]

263, 696





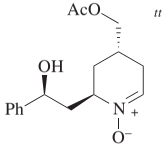
Alkene (10 eq), toluene, reflux, 3 h



(25)[g]

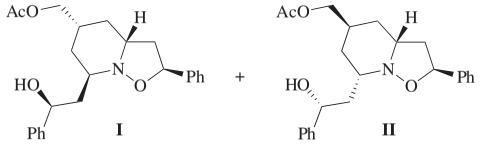
266, 696

C_{14}



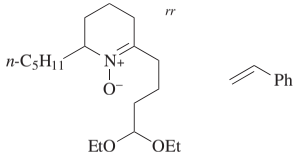


Alkene (15 eq), toluene, 60°, 48 h

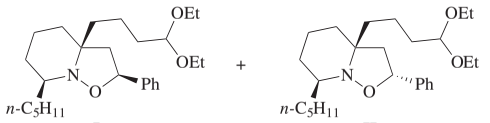


I + **II** (70), **I**/**II** = 40:60

32



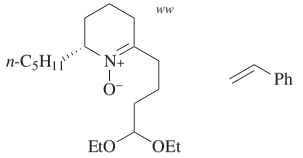
Alkene (xs), neat, MW, 105°, 6 h



I **II**

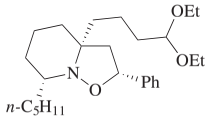
I + II (40), **I/II** = 85:15

221



non-racemic

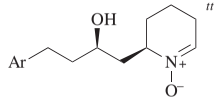
Alkene (xs), neat, 70°, 72 h



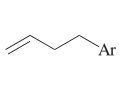
(44)

221

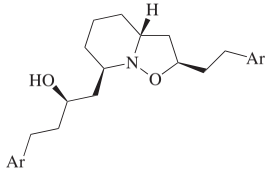
C_{15}



Ar = 4-BnOC_6H_4

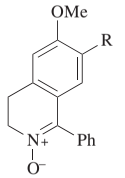


$CHCl_3$, reflux, 40 h



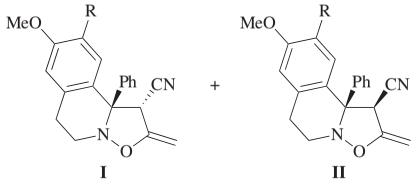
(31)

674

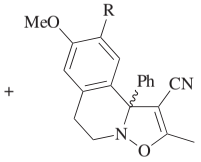




Alkene (2 eq), CH_2Cl_2, rt, 1–6 h



I **II**



III

R	**I**	**II + III**	**II/III**
H	(18)	(37)	1:1
MeO	(31)	(33)	1:4

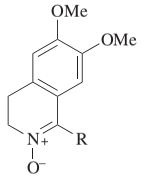
292

TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

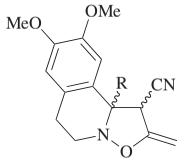
C_{15}



R = 4-$MeOC_6H_4$

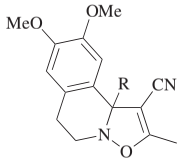


Alkene (2 eq), CH_2Cl_2, rt, 1–6 h



I + II

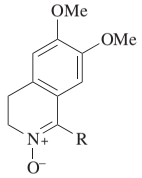
+



III

292

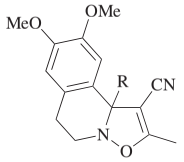
I + II + III (55), **I/II/III** = 20:45:35



R =4-$O_2NC_6H_4$



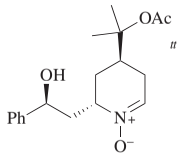
Alkene (2 eq), CH_2Cl_2, rt, 1–6 h



(60)[g]

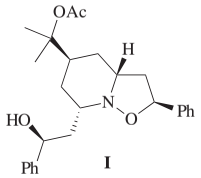
292

C_{16}



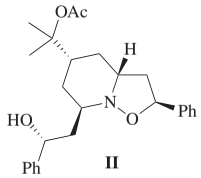


Alkene (xs), CH_2Cl_2, 45°, overnight



I

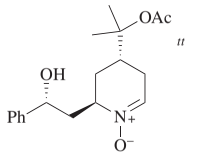
+



II

705

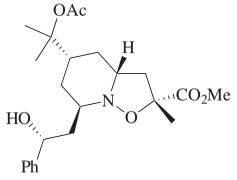
I + II (82), **I/II** = 3:1



tt



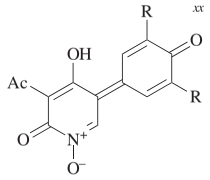
Alkene (xs), CH_2Cl_2, 45°, overnight



(91)[vv]

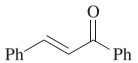
705

C_{21}

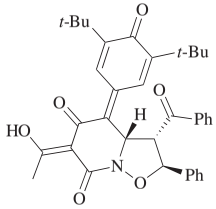


xx

R = *t*-Bu

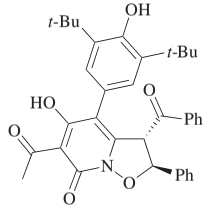


1. Alkene (1 eq), CH_2Cl_2, rt, 2 h
2. Reflux, 24 h



(53)

+



(21)

329

[a] The nitrone was generated in situ by oxidation of the corresponding hydroxylamine with HgO.

[b] The nitrone was generated in situ by oxidation of the corresponding amine with H_2O_2 and catalytic SeO_2.

[c] Two diastereoisomers were isolated in 12% and 6% yield, respectively, with relative configuration at the exocyclic stereogenic center not assigned.

[d] A mixture of two diastereoisomers was formed.

[e] The nitrone was generated in situ by oxidation of the corresponding amine with H_2O_2 and catalytic Na_2WO_4.

[f] The nitrone was added over a 10–15 h period.

[g] The primary adduct was not isolated.

[h] An adduct of undetermined structure in agreement with double cycloaddition was isolated.

[i] The mixture left stirred for two more days after addition of one more equivalent of nitrone.

[j] The nitrone was generated in situ by photolysis of the appropriate hydroxylamine and then directly trapped with the alkene.

[k] The nitrone was generated in situ by oxidation of 1-hydroxypiperidine with *N*-methylmorpholine *N*-oxide (1.5 eq) and catalytic tetra-*n*-propylammonium perruthenate (0.05 eq).

[l] Only one isomer was formed. The configuration at the isoxazolidine C-5 position was not assigned.

TABLE 4A. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ACYCLIC ALKENES (*Continued*)

[m] The nitrone was generated in situ by ozonolysis of the appropriate alkenyl methanesulfonate followed by treatment of the crude aldehyde with NH_2OH to give the oxime which spontaneously underwent cyclization.

[n] The nitrones (1:1 mixture) were generated in situ from 3,3-dimethoxypiperidin-1-ol and HgO in $CHCl_3$ and directly used after filtration through celite.

[o] A constitutional isomer was also isolated in trace amounts (<0.2%).

[p] The unstable nitrone was generated in situ by oxidation of (3*R*,5*R*)-3,5-bis(*tert*-butyldimethylsilyloxy)piperidine with 3-phenyl-2-(phenylsulfonyl)oxaziridine) and used without purification.

[q] The nitrone was generated in situ by reaction of 2,3-*O*-isopropylidene-5-*O*-tosyl-α-D-ribofuranose with hydroxylamine hydrochloride (4 eq) and triethylamine (5 eq) in EtOH at rt for 45 min.

[r] The nitrone was generated in situ by reaction of 2,3-*O*-isopropylidene-5-*O*-tosyl-α-D-ribofuranose with hydroxylamine hydrochloride (4 eq) and triethylamine (5 eq) at rt for 30 min.

[s] The nitrone was generated in situ by pyrolysis of its adducts with dimethyl methylenemalonate.

[t] The nitrone was generated in situ from the reaction of (2*S*)-*N*-[5-(1,3-dioxan-2-yl)pentanoyl]bornane-10,2-sultam with 1-chloro-1-nitrosocyclohexane and sodium hexamethyldisilamide.

[u] The reaction carried out in water (40°, 36 h) in the presence of the surfactants CTAB or SDS gave the cycloadducts in similar yield and composition.

[v] The reaction carried out in water (alkene (2 eq), 20°, 12 h) in the presence of the surfactants CTAB at different concentrations (0.1, 0.3, 0.5, 1 eq), or SDS and sucrose (0.1 eq), gave the cycloadducts in identical yields and similar compositions.

[w] The nitrone was generated in situ from the alkene by cyclization of the oxime moiety.

[x] The nitrone was generated in situ via intramolecular Michael addition of the appropriate oxime.

[y] At least three (3) other unidentified adducts were formed in 5% overall yield.

[z] The nitrone was generated in situ by reaction of a mixture of (1*Z*)- and (1*E*)-hepta-5,6-dienal oxime with silver tetrafluoroborate (0.5–1.0 eq).

[aa] The nitrone was generated in situ by cyclization of 6,7-epoxyheptan-2-one oxime.

[bb] The nitrone was generated in situ from 5-chloro-2,2-dimethylpentanal and hydroxylamine hydrochloride.

[cc] A catalytic amount of (bis)[5-*t*-butyl)-4-hydroxy-2-methylphenyl] sulfide was added

[dd] A crude diastereomeric mixture (ca. 1:1) of the starting aldonitrone, together with minor amounts (5–10%) of the isomeric keto nitrone, which remained unreacted, obtained by oxidation of the appropriate hydroxypiperidine with HgO, was used.

[ee] The yields were determined by ^1H NMR analysis and based on nitrone.

[ff] 0.1 eq of catalyst was added.

[gg] The opposite enantiomer was formed.

[hh] Enantiomeric enhancement was negligible.

[ii] The absolute configuration is arbitrarily assigned.

[jj] The product was dissociated from its Rh complex by adding an excess of *n*-Bu_4NBr.

[kk] The ketene was generated in situ by reaction of Meldrum's acid with *i*-Pr_2EtN.

[ll] The alkene contained ca 8% of the (*Z*)-isomer.

[mm] This cycloadduct was present in the reaction mixture in minor amounts.

[nn] The same thermodynamic mixture (**I**/**II** = 13:87) was obtained from pure **I** and **II** after 30 d at rt in C_6D_6.

[oo] The product was enantioenriched with er 57.0:43.0; the absolute configuration was not assigned.

[pp] The dipolarophile was generated in situ from 2,5-diazido-3,6-di-*tert*-butylcyclohexa-2,5-diene-1,4-dione.

[qq] Only one diastereoisomer was formed.

[rr] The nitrone was generated in situ by reaction of NH_2OH with the appropriate diethyl acetal followed by cyclization of the oxime.

[ss] The nitrone was generated in situ by cyclization of
(2*R*,2'*R*)-*N*-[10'-(*tert*-butyldiphenylsilyloxy)-2'-hydroxyaminodec-6'-ynoyl]bornane-10,2-sultam in toluene at 70° for 7 h.

[tt] The nitrone was generated in situ by oxidation of the corresponding isoxazolidine with *m*-CPBA.

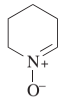
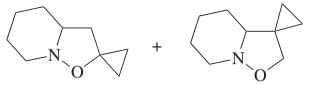
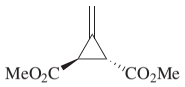
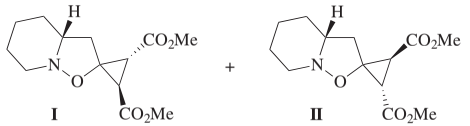
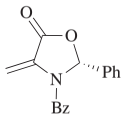
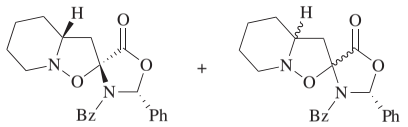
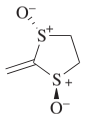
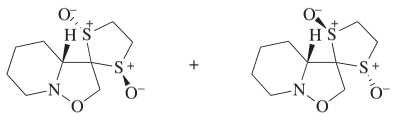
[uu] A non-separable mixture of three adducts was also recovered.

[vv] A non-separable mixture of three adducts in ratio of 89:8:~1 was formed. The stereochemistry of the two minor adducts was not assigned.

[ww] The nitrone was generated in three (3) steps starting from (9*S*)-1,1-diethoxy-9-hydroxytetradecan-5-one and used without purification.

[xx] The nitrone was generated in situ by oxidation of 3-acetyl-*N*-hydroxy-5-[(3',5'-di-*tert*-butyl-4'-hydroxy)phenyl]-4-hydroxy-2(1*H*)-pyridone with iodobenzene diacetate (1.1 eq) under the reaction conditions.

TABLE 4B. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH EXOCYCLIC ALKENES

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_5				
		Alkene (2 eq), sealed tube, neat, 60°, 2 d	 **I** + **II** (69), **I/II** = 94:10	61
		Alkene (0.9 eq), benzene, 80°, 3 h	 **I** + **II** (72), **I/II** = 5:3	617
	 non-racemic	Alkene (0.9 eq), CH_2Cl_2, 1.5 d	 **I** **II** + **III**	603
		Alkene (0.2 eq), CH_2Cl_2, −78°, 1 h	 **I** **I** + **II** (75), **I/II** = 20:1 **II**	270

Temp	**I** + **II** + **III**	**I/II/III**
rt	(25)	85:15:0
40°	(30)	70:15:15

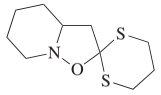
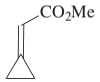
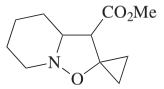
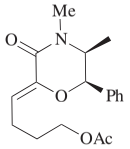
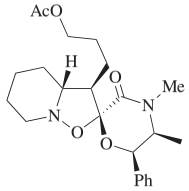
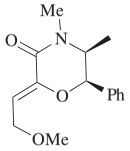
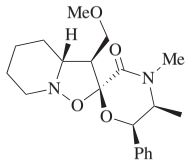
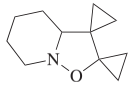
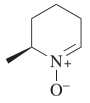
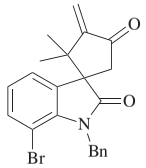
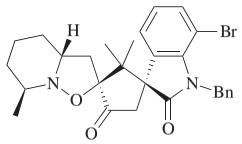
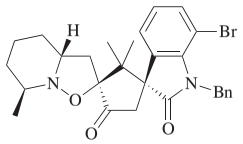
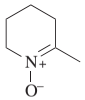
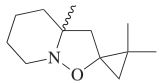
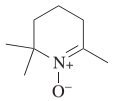
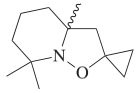
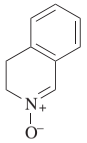
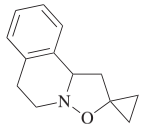
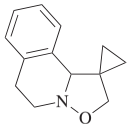
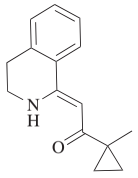
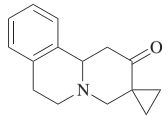
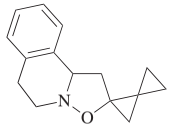
	Alkene (1.2 eq), dry THF, rt, 60 h		(88)	720
	Alkene (0.7 eq), toluene, reflux, 16 h		(78) dr 2.3:1	57
 non-racemic	Alkene (0.5 eq), toluene, MW, 0.5 h		(70)	480
 non-racemic	Alkene (0.5 eq), toluene, MW, 110°, 0.5 h		(61)	480
	Benzene, 60°, 7 d		(60)	604, 620

TABLE 4B. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH EXOCYCLIC ALKENES (*Continued*)

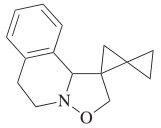
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_6				
 non-racemic		Alkene (0.3 eq), $MeCN/CH_2Cl_2$, rt, 9 d	 (36) +  (51)	406
		Alkene (1 eq), sealed vial, toluene, 100°, 7 d	 (36) dr 1.1:1	721
C_8				
		Alkene (xs), sealed vial, toluene, 100°, 7 d	 (28)	721
C_9				
		Alkene (3 eq), sealed tube, toluene, 60°, 2 d	 (59) +  (8)	722
		Alkene (1.5 eq), 1,2-dichlorobenzene or mesitylene, 160°, 2 h	 (48)[a] +  (30)[a]	298, 723



Alkene (1.2 eq), benzene, 60°, 4 d



+

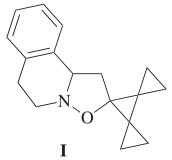


298, 723

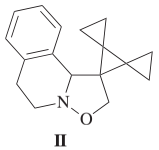
I **I + II** (54)[b], **I/II** = 80:20 **II**



Alkene (1.2 eq), benzene, 60°, 4 d



+



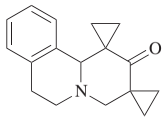
298

I **II**

I + II (60), **I/II** = 86:14

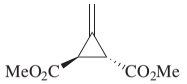


Alkene (1.5 eq), mesitylene, 160°, 3 h

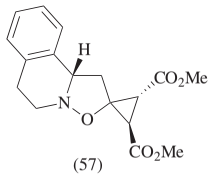


(19)[a]

298

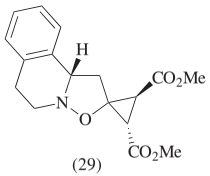


Alkene (0.9 eq), benzene, 80°, 30 h



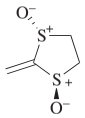
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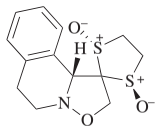


(29)

617



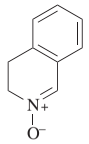
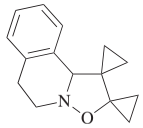
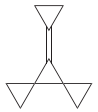
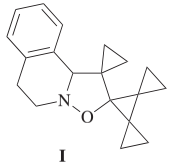
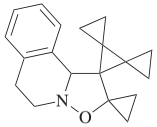
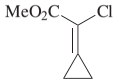
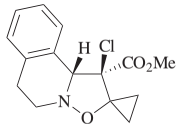
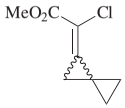
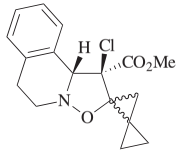
Alkene (0.2 eq), CH_2Cl_2, rt, 48 h

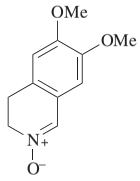


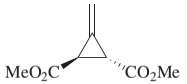
(81)

270

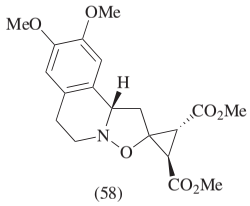
TABLE 4B. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH EXOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_9 		Alkene (0.8 eq), benzene, rt, 10 d	 (73)	604
		Alkene (1.25 eq), C_6D_6, rt, 7 d	 +  **I** **II** **I** + **II** (72), **I**/**II** = 52:48	607
		Alkene (0.76 eq), sealed tube, CH_2Cl_2, 38°, 1.5 h	 (91)	286
		Alkene (0.95 eq), sealed tube, CH_2Cl_2, 38°, 1.5 h	 (93) dr 1:1	286

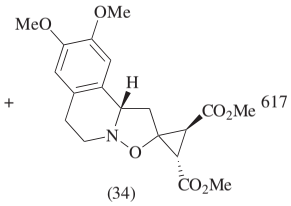




Alkene (0.9 eq), benzene, 80°, 30 h

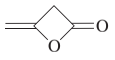


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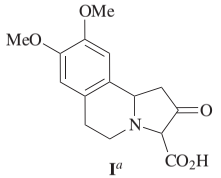


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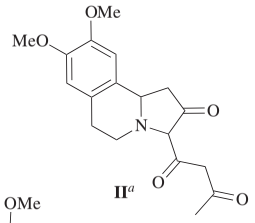
617



Alkene (*x* eq), solvent, 2 h

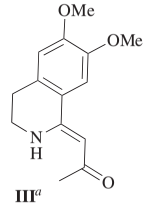


I[a]



II[a]

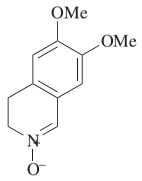
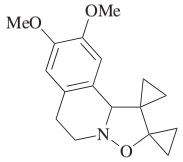
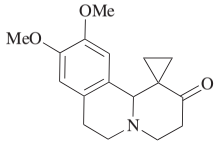
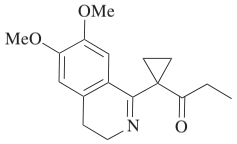
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III[a]

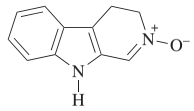
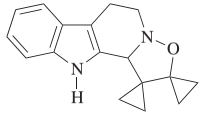
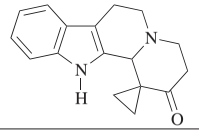
x	Solvent	Temp	**I**	**II**	**III**
0.1	MeCN	rt	(45)	(16)	(—)
1	MeCN	rt	(38)	(9)	(—)
1	MeCN	reflux	(—)	(—)	(53)
1	CH_2Cl_2	82°[c]	(50)	(8)	(—)
1	CH_2Cl_2	reflux	(37)	(5)	(—)
10	CH_2Cl_2	rt	(31)	(23)	(—)
10	CH_2Cl_2	reflux	(33)	(39)	(—)

TABLE 4B. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH EXOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_9 		Alkene (1.55 eq), CH_2Cl_2, 45°, 5 d	 (32)	298
		Alkene (*x* eq), xylenes, 125°	 + 	298, 612

I[a] **II**[a]

x	Time (h)	**I**	**II**
0.6	64	(51)	(20)
0.83	64	(72)	(23)
1.5	48	(31)	(—)

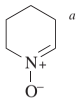
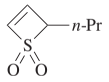
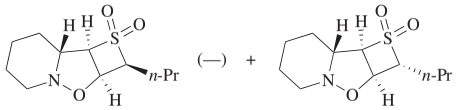
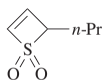
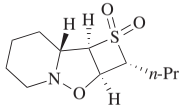
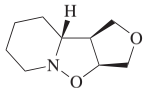
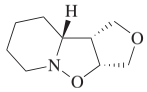
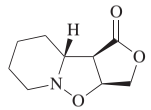
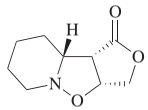
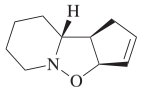
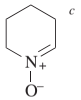
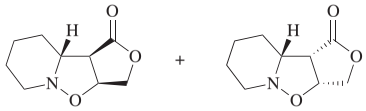
C_{11} 		Alkene (1.5 eq), benzene, 60°, 24 h	 (72)	298
		Alkene (1.49 eq), xylenes, 125°, 2 d	 (65)[a]	298

[a] The primary adduct was not isolated.

[b] The cycloadducts were equimolar mixtures of two diastereoisomers.

[c] The reaction was carried out in a sealed vessel.

TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_5				
 [a]		Neat, 90°	 (—) + (—)	724
 [b]		Alkene (0.79 eq), dioxane, 70°, 2 h	 (23)	724
 [c]		Alkene (xs), $CHCl_3$, 20°, 7 d	 (44) +  (2)	725
			+  (13)[d] +  (2)[d]	
		Alkene (1 eq), benzene, rt, 15 h	 (65)	279
 [c]		Alkene (0.85 eq), solvent	 **I** **II**	725, 726

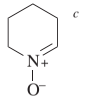
Solvent	Temp (°)	Time	**I + II**	**I/II**
$CHCl_3$	4	30 d	(90)	31:1
toluene	110	15 h	(79)	6:1

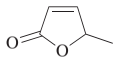
TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

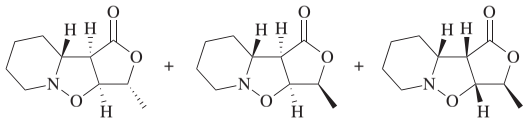
Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

C_5





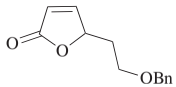
Alkene (1 eq), solvent



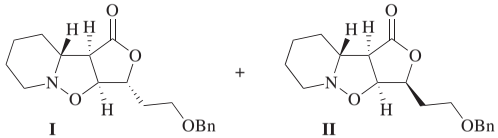
I **II** **III**

Solvent	Temp (°)	Time (h)	**I + II + III**	**I/II/III**
$CHCl_3$	40	17	(73)	19:2:1
toluene	110	15	(84)	4.5:2.5:1

686,725, 726

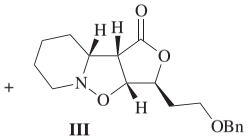


Alkene (0.47 eq), solvent



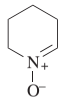
I **II**

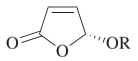
Solvent	Temp	Time	**I + II + III**	**I/II/III**
$CHCl_3$	rt	18 d	(70)	10:1:tr
toluene	110°	15 h	(78)	12:2:1



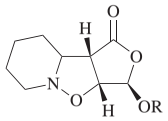
III

725, 726





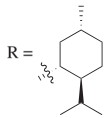
CH_2Cl_2 or benzene



(81)

628

R =



non-racemic

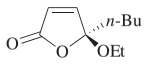
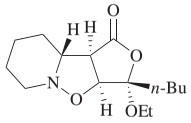
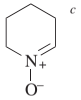
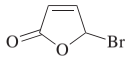
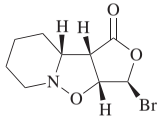
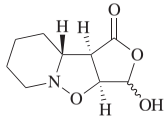
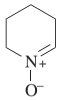
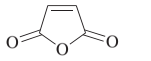
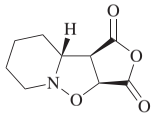
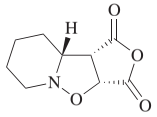
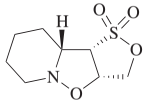
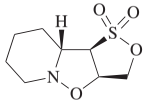
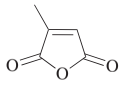
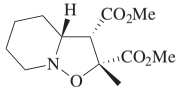
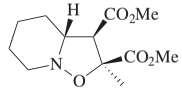
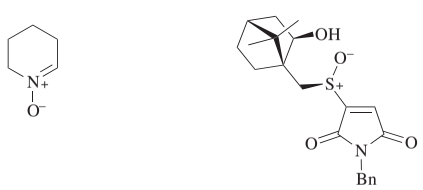
	 non-racemic	Alkene (0.08 eq), toluene, reflux, 3 h		(78)		629
 [c]		Alkene (0.43 eq), CH_2Cl_2, rt, 7 d		(27) +		(17)[e] 509
		CH_2Cl_2, rt, 0.1 h		+		506, 675a
			I	**I + II** (98), **I/II** = 81:19	**II**	
		Alkene (0.45 eq), toluene, 40°, 12 h		+		**I + II** (86) **I/II** = 68:32 630
			I		**II**	
		1. Alkene (1.3 eq), CH_2Cl_2, 20°, 6 h 2. MeOH/HCl		+		515
			I	**I + II** (84), **I/II** = 78:22	**II**	

TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

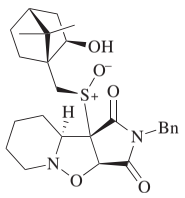
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_5

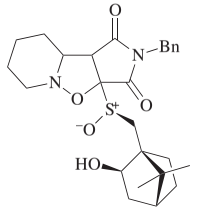


non-racemic

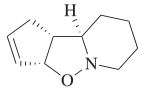
Alkene (0.26 eq), dry CH_2Cl_2, –78°, 5 min



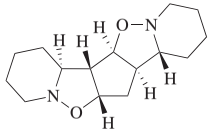
(33) [j] +



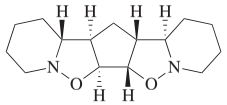
(1) [j] 727



Alkene (0.6 eq), toluene, reflux, 3 h

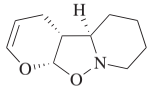


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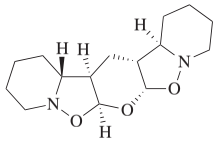


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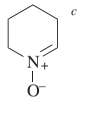
I **I + II** (61), **I/II** = 3:1 **II**



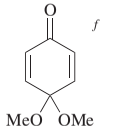
Alkene (0.5 eq), sealed vial, benzene, 190°, 10 h



(22) 279



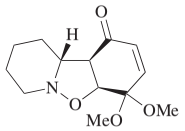
[c]



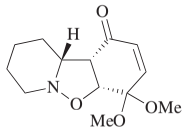
[f]

MeO OMe

Alkene (*x* eq), MeOH



+

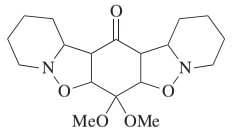


633, 634

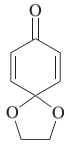
I **II**

x	Temp	Time (d)	**I**	**II**	**III**
1.1	–18°	195	(38)	(—)	(21)
1.1	4°	17	(39)	(—)	(33)
1.1	rt	7	(41)	(0.6)	(40)
1.8	rt	5	(51)	(1.3)	(30)

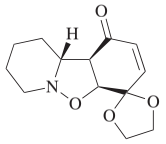
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III

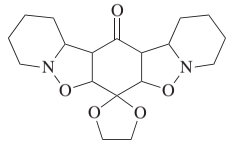


Alkene (*x* eq), $CHCl_3$



I

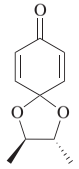
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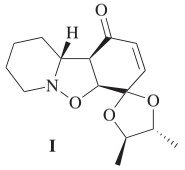
II

633, 634

x	Temp	Time (d)	**I**	**II**
1.2	4°	16	(9)	(72)
1.2	rt	7	(16)	(70)
4	rt	7	(24)	(39)

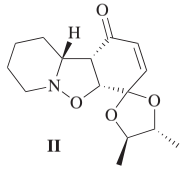


Alkene (*x* eq), solvent



I

+

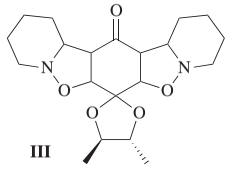


II

634

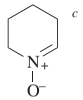
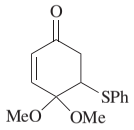
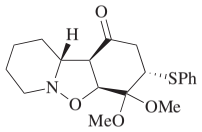
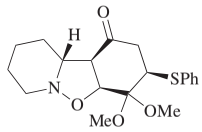
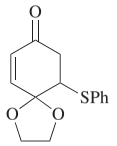
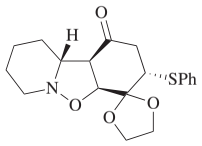
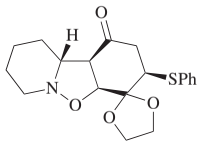
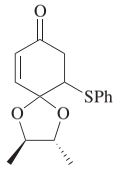
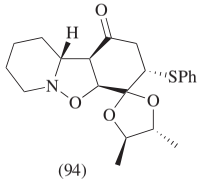
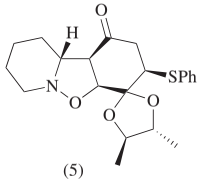
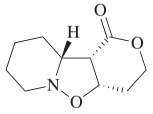
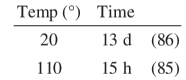
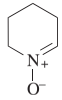
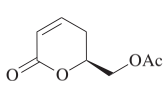
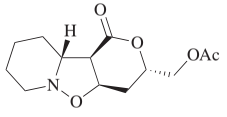
x	Solvent	Temp (°)	Time	**I**[g]	**II**	**III**
1.4	$CHCl_3$	rt	6 d	(11)	(—)	(80)
4.5	toluene	110	1 h	(33)	(—)	(62)
12.2	toluene	110	1.5 h	(51)	(<11)	(30)
23	neat	110	10 min	(83)	(—)	(—)

+



III

TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_5  [c]		Alkene (0.67 eq), $CHCl_3$, reflux, 24 h	 (39) +  (42)	633, 634
		Alkene (0.67 eq), $CHCl_3$, reflux, 5.5 h	 (98) +  (2)	633, 634
		Alkene (0.67 eq), $CHCl_3$, reflux, 9 h	 (94) +  (5)	634
		Alkene (0.77 eq), CH_2Cl_2	 	725
	 non-racemic	Alkene (0.7 eq), dry toluene, rt, 3 d	 (68)[h]	728

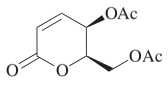
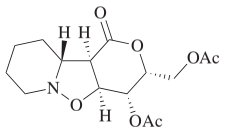
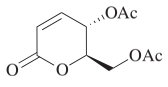
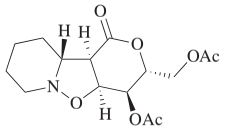
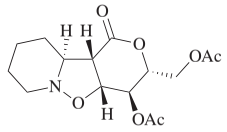
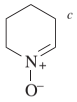
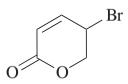
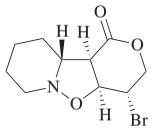
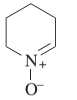
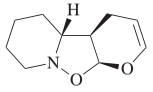
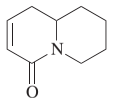
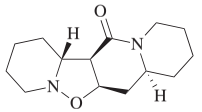
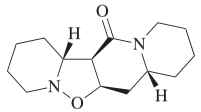
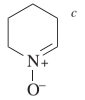
 non-racemic	Alkene (0.7 eq), dry toluene, rt, 3 d; then reflux, 2 h		(86)[h]		728
 non-racemic	Alkene (0.7 eq), dry toluene, rt, 3 d	 (47)[h]	+	 (32)[h]	728
 [c]		Alkene (0.8 eq), $CHCl_3$, 60°, 17 h		(87)	509
		Alkene (0.5 eq), sealed vial, benzene, 140°, 10 h		(70)	279
		$CHCl_3$, N_2, reflux, overnight	 **I**	+ **I** + **II** (99), **I/II** = 57:10	 **II**	675

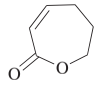
TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

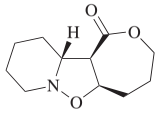
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_5

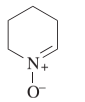


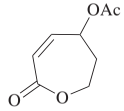


Alkene (1 eq), solvent

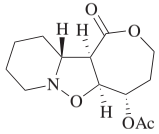


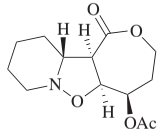
Solvent	Temp (°)	Time		Refs.
$CHCl_3$	20	24 d	(31)	725, 729, 730
$CHCl_3$	60	38 h	(46)	
toluene	100	9 h	(59)[i]	



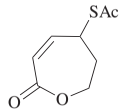


Alkene (0.11 eq), toluene, 100°, 2 h

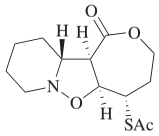


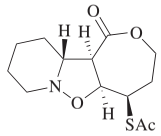
(72) + 

(26) 730

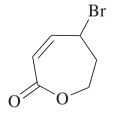


Alkene (0.08 eq), toluene, 100°, 1.5 h

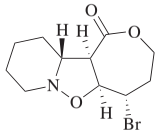


(75) + 

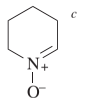
(17) 730

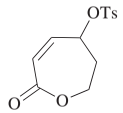


Alkene (0.11 eq), toluene, 100°, 5 h

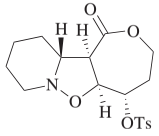


(70) 730

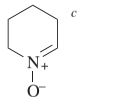


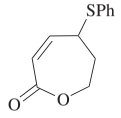


Alkene (0.3 eq), toluene, 110°, 0.75 h

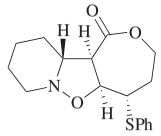


(12) 290

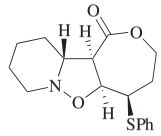




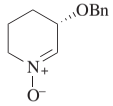
Alkene (0.5 eq), toluene, 110°, 9 h



(72) + (8)



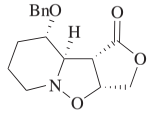
290



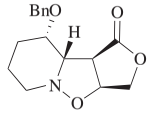
non-racemic



Alkene (0.8 eq), toluene, rt, 50 h

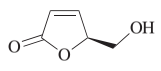


+

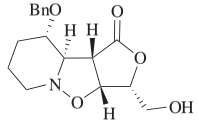


731

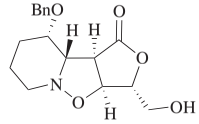
I **I + II** (73), **I/II** = 93:7 **II**



Alkene (0.8 eq), toluene, rt, 48 h

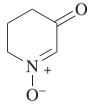


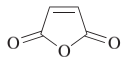
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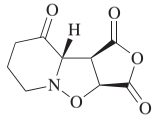
731

I **I + II** (72), **I/II** = 93:7 **II**

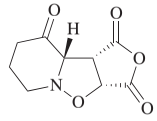




Alkene (1.5 eq), CH_2Cl_2, rt



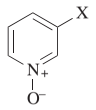
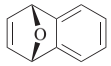
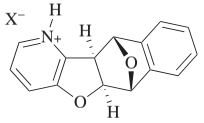
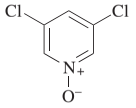
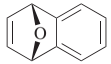
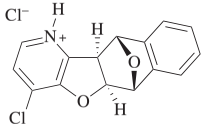
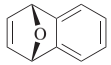
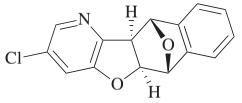
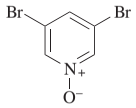
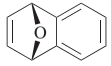
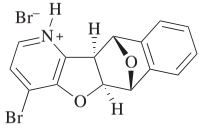
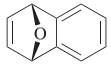
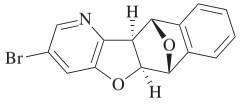
+



675a

I **I + II** (—), **I/II** = 70:30 **II**

TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*				
C_5 		Alkene (1 eq), toluene, reflux, 24 h	 X: Cl (23)[e], Br (20)[e]	326
		Alkene (1 eq), benzene, reflux, 2 h	 (29)[e]	326
		Alkene (1 eq), NEt_3, benzene, reflux, 2 h	 (23)[e]	326
		Alkene (1 eq), benzene, reflux, 2 h	 (43)[e]	326
		Alkene (1 eq), NEt_3, benzene, reflux, 2 h	 (32)[e]	326

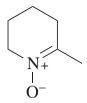
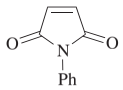
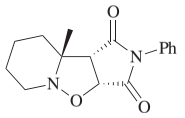
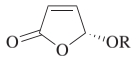
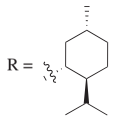
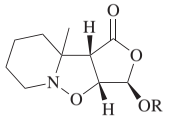
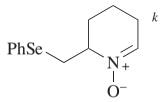
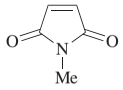
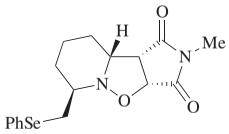
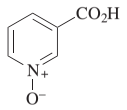
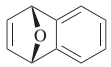
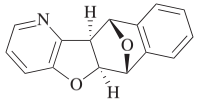
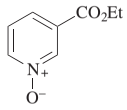
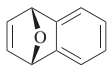
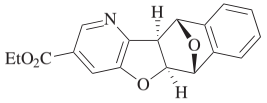
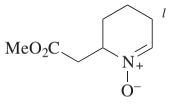
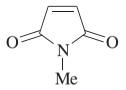
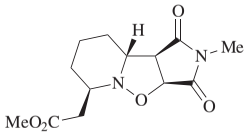
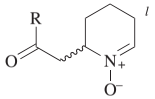
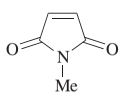
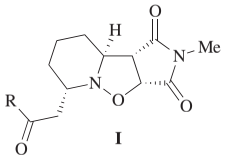
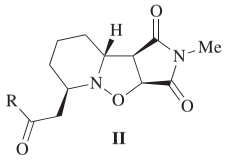
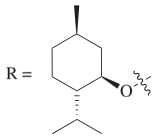
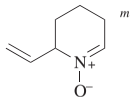
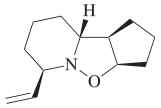
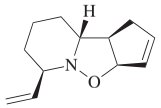
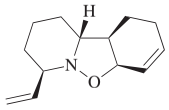
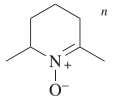
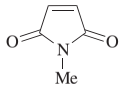
C_6 		Alkene (1.1 eq), toluene, 80°, 4 h		(56)	164
	  non-racemic	CH_2Cl_2 or benzene		(60)	628
 *k*		Alkene (2 eq), MeCN, 80°, 5 h		(61)	199, 201
		Alkene (1 eq), DMF, 130°, 24 h		(13)[e]	326
		Alkene (1 eq), toluene, reflux, 34 h		(20)[e]	326

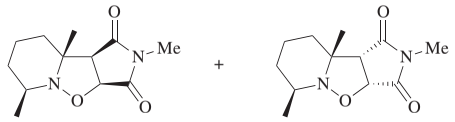
TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_7				
 *l*		Toluene, 110°, 3 h	 (90)	183, 351
 *l*		Alkene (1 eq), toluene, 110°, 5 h	 **I** +  **II**	183
 non-racemic			**I** + **II** (61), **I**/**II** = 1:1	
 *m*		Alkene (2–5 eq), CH_2Cl_2, rt, 48–72 h	 (29)	207, 568
		Alkene (2–5 eq), CH_2Cl_2, rt, 48–72 h	 (43)	207, 568
		Alkene (2–5 eq), CH_2Cl_2, rt, 48–72 h	 (35)	207, 568



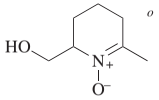


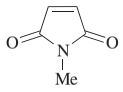
Alkene (1 eq), benzene, 80°, 7 h



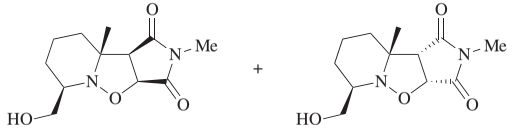
I **I + II** (85), **I/II** = 3:1 **II**

370, 371



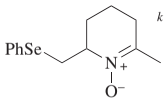


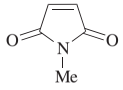
Alkene (1 eq), xylene, 140°, 0.75 h



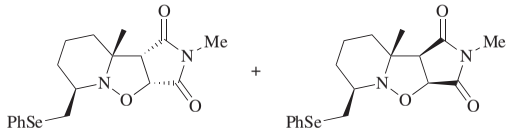
I **I + II** (85), **I/II** = 6:1 **II**

701, 702



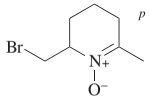


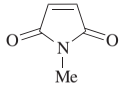
Alkene (1.2 eq), MeCN, 80°, 9 h



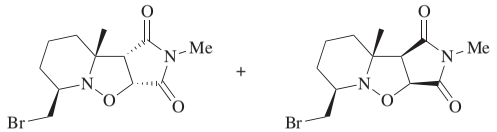
I **I+II** (72), **I/II** = 3:2 **II**

199, 201





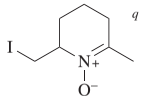
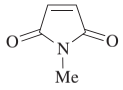
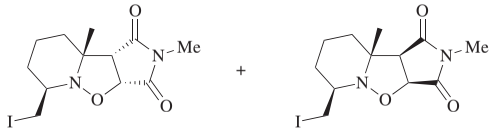
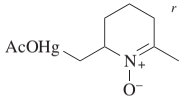
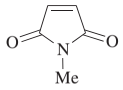
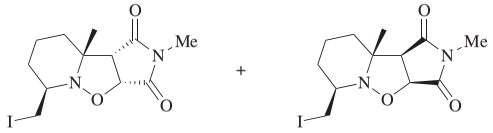
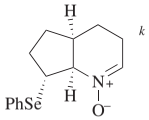
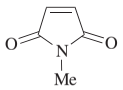
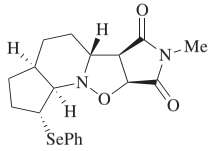
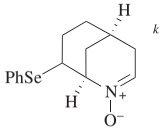
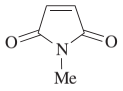
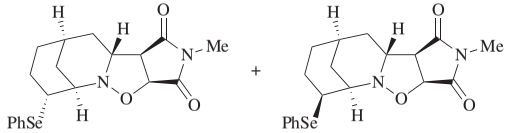
Alkene (1.5 eq), benzene, 60°, 13 h

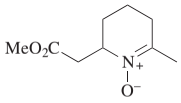


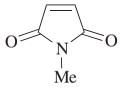
I **I + II** (33), **I/II** = 2.3:1 **II**

191, 647

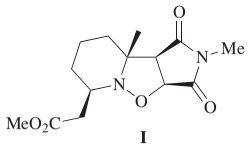
TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_7				
 *q*		Alkene (1.5 eq), benzene, 80°, 5 h	 **I** **I** + **II** (50), **I**/**II** = 2:1 **II**	647
 *r*		1. Alkene (1 eq), THF, 60° 2. I_2, CH_2Cl_2, 16 h	 **I** **I** + **II** (40), **I**/**II** = 2:1 **II**	197
C_8				
 *k*		Alkene (1.2 eq), MeCN, reflux, 16 h	 (71)[s]	196
 *k*		MeCN, rt, 5 h	 **I** **I** + **II** (67), **I**/**II** = 4:1 **II**	202, 336

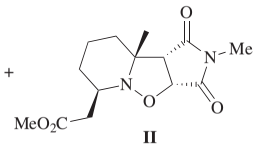




Alkene (1 eq), solvent



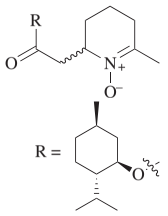
I



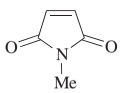
II

183, 351

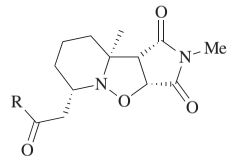
Solvent	Temp	Time (h)	**I** + **II**	**I**/**II**
$CHCl_3$	rt	50	(100)	3:1
C_6D_6	rt	—	(100)	3:1
toluene	reflux	—	**I** (>90)	—



non-racemic

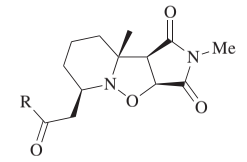


Alkene (1 eq), toluene, 110°, 5 h



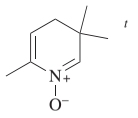
I

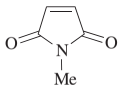
I + **II** (—), **I**/**II** = 1:1



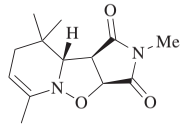
II

183



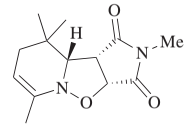


$CHCl_3$, 60°, 23 h



I

I + **II** (84), **I**/**II** = 1:1



II

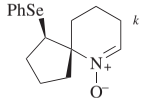
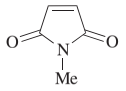
323

TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

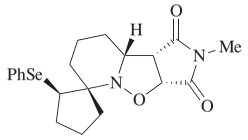
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

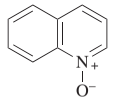
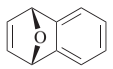
C_9

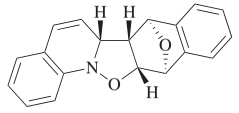
THF, 40°, 6 h



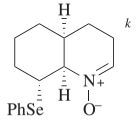
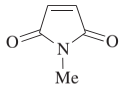
(63) 336

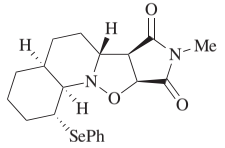
Alkene (1 eq), benzene, reflux, 7 h



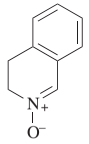
(25) 326

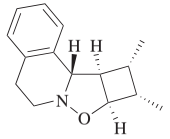
Alkene (1.2 eq), MeCN, reflux, 16 h



(71) 196

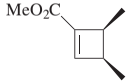



Alkene (16.4 eq), sealed vial, benzene

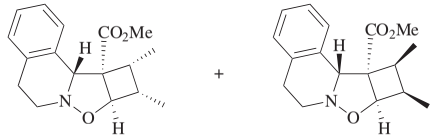


Temp	Time (d)	
rt	6	(30)
80°	2	(95)

622

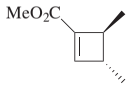


Alkene (0.78 eq), benzene, 20–23°, 5 d

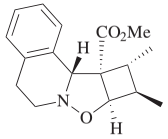


I **I** + **II** (98), **I**/**II** = 94:6 **II**

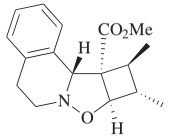
284



Alkene (0.78 eq), benzene, 20–23°, 5 d



+

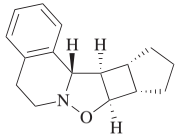


284

I **I + II** (92), **I/II** = 54:46 **II**

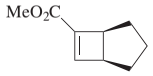


Alkene (0.5 eq), benzene, 20–23°, 5 d

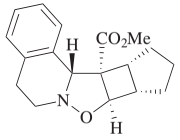


(79)

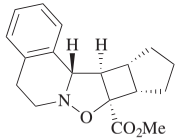
284, 732



Alkene (0.7 eq), benzene, 20–23°, 5 d



+

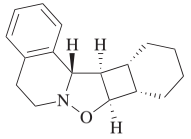


284

I **I + II** (97), **I/II** = 96:4 **II**



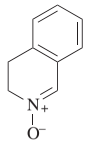
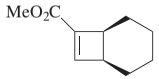
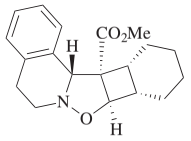
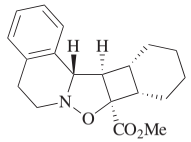
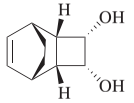
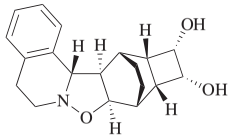
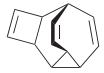
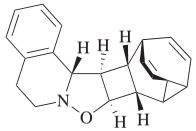
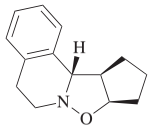
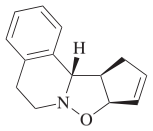
Alkene (4.3 eq), benzene

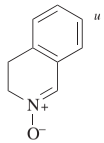


Temp (°)	Time (h)	
20–23	96	(85)
80	8	(98)

284

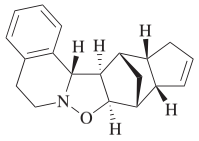
TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*				
C_9				
		Alkene (0.65 eq), benzene, 20–23°, 5 d	 +  **I** **I + II** (97), **I/II** = 95:5 **II**	284
		Toluene, 110°, 10 d	 (14)	642
		Alkene (1.8 eq), benzene, reflux, overnight	 (83)	733
		Alkene (64 eq), neat, rt, 6 d	 (85)	710
		Alkene (32 eq), CH_2Cl_2, rt, 3 d	 (38)	710

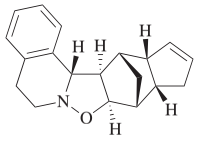




Freshly dstd alkene (xs), hydroquinone (cat.), sealed tube, 70°, 15 h

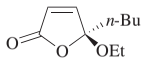


+



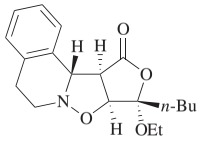
I **I + II** (91)[y] **II**

581



non-racemic

Alkene (0.1 eq), toluene, reflux, 3 h

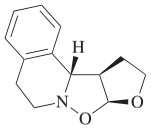


(87)

629



Alkene (xs), catalyst (0.2 eq), neat, rt, 20 h

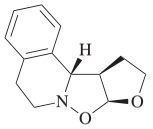


Catalyst	Pressure	
4a	1 bar	(53)[x]
ZnI_2	1 bar	(53)
4a	2 kbar	(91)[x]

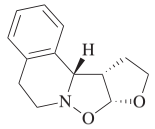
278



Alkene (*x* eq), catalyst (*y* eq), proton sponge **2** (*z* eq), CD_2Cl_2, rt



+



I **II**

344

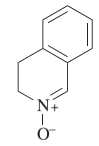
x	Catalyst	*y*	*z*	Time (h)	Conv (%)	**I**	**II**	**I/II**
1.2	—	—	0.1	500	29	(—)	(—)	>98:2
1.34	**7**	0.07	0.18	40	>95	(81)	(10)	88:12

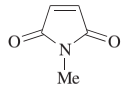
TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

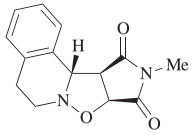
Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

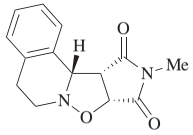
C_9

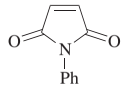




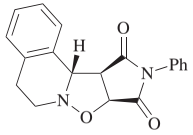
Alkene (1 eq), benzene, rt, 3 min

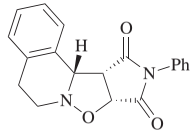


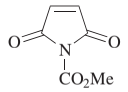
(98) +  (2)[w] 581



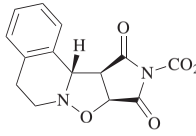
Alkene (0.95 eq), benzene, rt, 9d



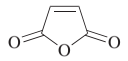
(96) +  (4)[w] 710



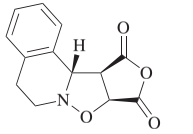
Benzene, rt



(90) 710



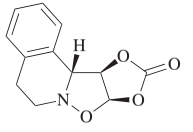
Benzene, rt

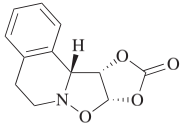


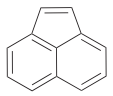
(—) 710



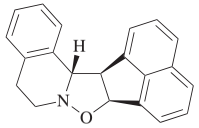
Alkene (0.6 eq), benzene, 35°, 20 d



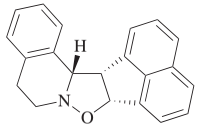
(67) +  (3.5) 710



Alkene (0.95 eq), benzene, rt, 30 d



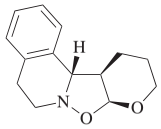
(65) +



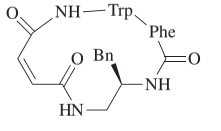
(17) 710



Alkene (xs), neat, 15 kbar, rt, 3 d



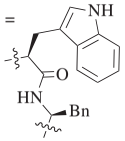
(48) 278



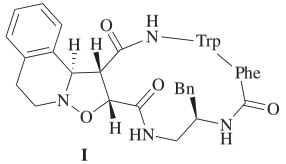
Alkene (0.8), solvent

637

–Trp–Phe– =

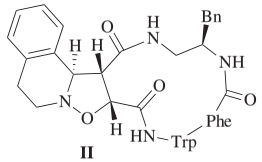


non-racemic



I

+



II + **III**[y]

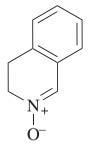
Solvent	Temp (°)	Time (h)	**I** + **II** + **III**	**I**/**II**/**III**
DMSO	84	5	(93)	7:3:1
toluene	87	11	(100)	30:4:1

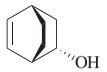
TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

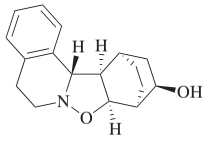
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_9



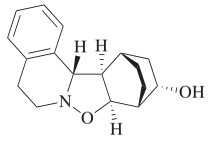


Toluene, 110°



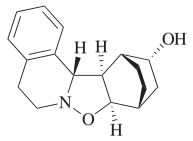
I

+



II

+



III

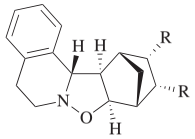
I + **II** + **III** (96)
I/II/III = 80:10:10

642



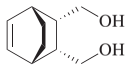
R = CO_2Me, OH, OAc

—

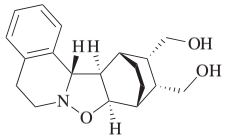


(—)

642



Alkene (0.77 eq), toluene, reflux, 3 d

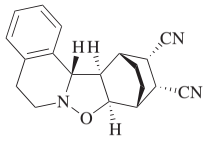


(87–95)

642

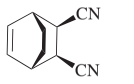


Alkene (0.77 eq), toluene, reflux, 3 d

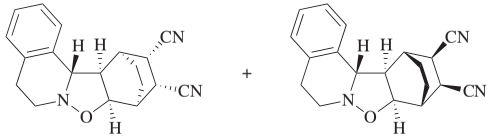


(87–95)

642

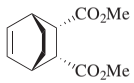


Toluene, 120°, 36 h

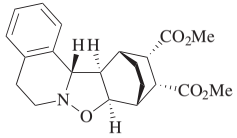


I + **II** (60), **I/II** = 52:48

642, 734

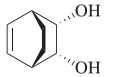


Alkene (0.77 eq), toluene, reflux, 3 d

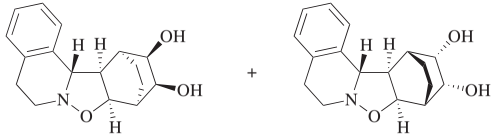


(87–95)

642



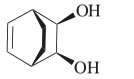
Alkene (0.77 eq), solvent



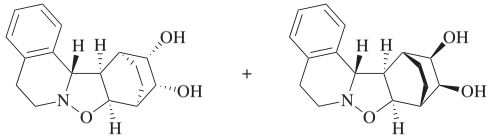
I **II**

Solvent	Temp	Time (d)	**I** + **II**	**I/II**
toluene	reflux	3	(>87)	93:7
MeOH	—	—	(—)	41:59
DMF	—	—	(—)	27:73

642



Toluene, 120°, 36 h



I **I** + **II** (60), **I/II** = 48:52 **II**

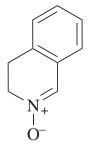
642, 734

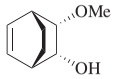
TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

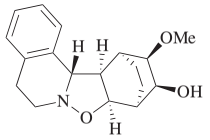
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_9



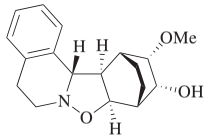


Toluene, 110°



I

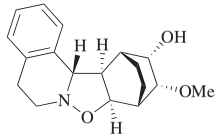
\+



II

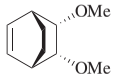
642

\+

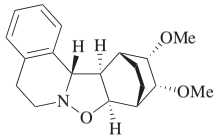


III

I + **II** + **III** (95)
I/II/III = 72:14:14

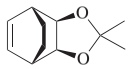


Alkene (0.77 eq), toluene, reflux, 3 d

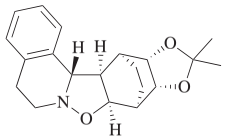


(87–95)

642



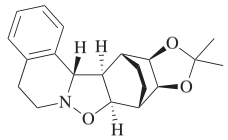
Toluene, 120°, 36 h



I

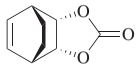
I + **II** (60), **I/II** = 58:42

\+

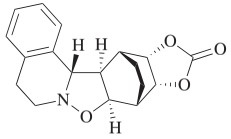


II

734

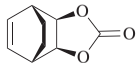


Alkene (0.77 eq), toluene, reflux, 3 d

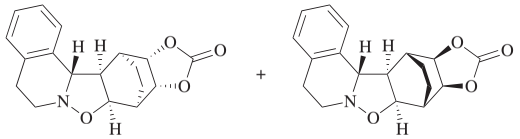


(87–95)

642

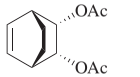


Toluene, 120°, 36 h

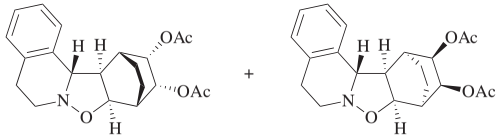


I **I** + **II** (60), **I/II** = 51:49 **II**

734

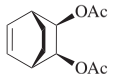


Alkene (0.77 eq), toluene, reflux, 3 d

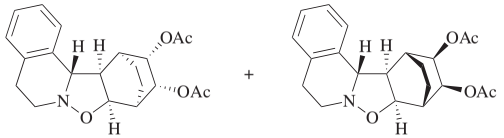


I **I** + **II** (87–95), **I/II** 98:2 **II**

642



Toluene, 120°, 36 h



I **I** + **II** (60), **I/II** = 46:54 **II**

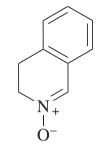
642, 734

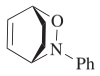
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Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

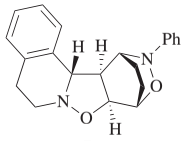
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_9



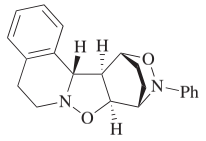


Benzene, rt, 49 d



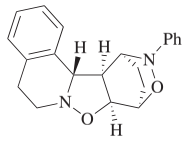
I

+



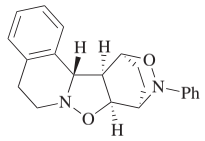
II

+



III

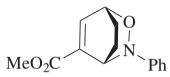
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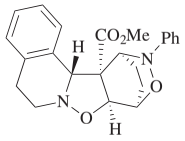
IV

I + **II** + **III** + **IV** (83), **I/II/III/IV** = 34:34:21:11

735

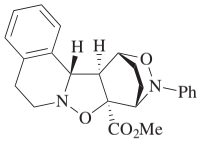


Benzene, rt, 8 d



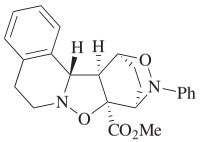
I

+



II

+



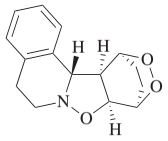
III

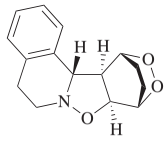
I + **II** + **III** (83)
I/II/III = 92:5.5:2.5

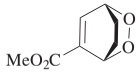
735



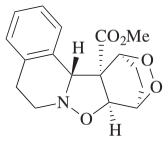
Alkene (0.9 eq), benzene, 35°, 4 d

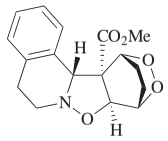


(20) +  (9) 736



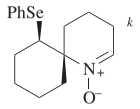
Benzene, rt

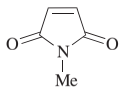


+  735

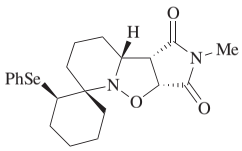
I **I + II** (90), **I/II** = 95:5 **II**

C_{10}

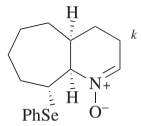


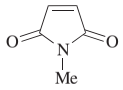


THF, 40°, 6 h

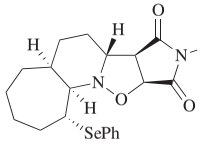


(61) 336





Alkene (1.3 eq), MeCN, reflux, 16 h



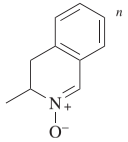
(58)[s] 196

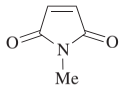
TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

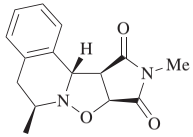
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_{10}

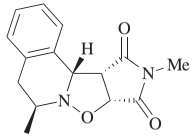




THF, 60°, 6 h

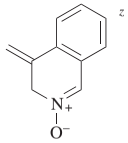


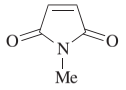
+



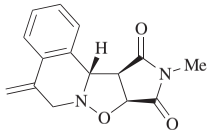
370

I **I + II** (81), **I/II** = 10:1 **II**



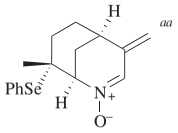


Alkene (1.2 eq), toluene, 100°, 24 h

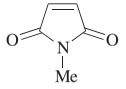


(62)

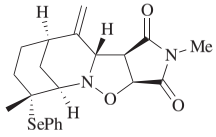
237



non-racemic

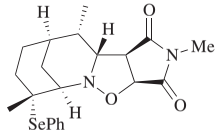


MeCN, 40°, 16 h



(41)

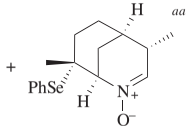
+



(18)

202

+



non-racemic

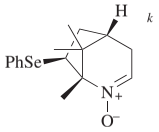
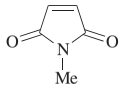
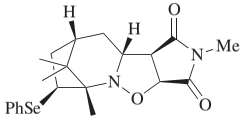
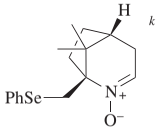
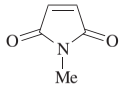
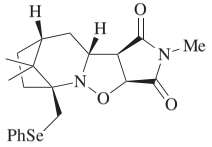
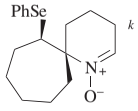
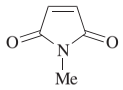
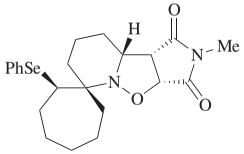
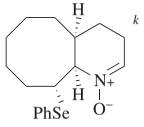
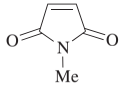
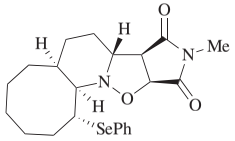
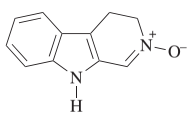
	 non-racemic		MeCN, rt, 5 h		(72)	202
	 non-racemic		MeCN, rt, 5 h		(74)	202
C_{11}						
			THF, 40°, 6 h		(59)	336
			Alkene (1.2 eq), MeCN, reflux, 16 h		(32)	196

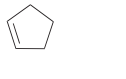
TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

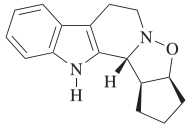
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_{11}

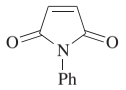




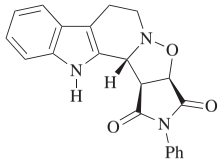
Alkene (3 eq), 1,4-dioxane, 100°, 3 h



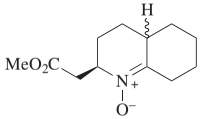
(79) 59



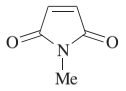
Alkene (3 eq), 1,4-dioxane, 100°, 1 h



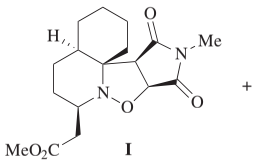
(85) 59



dr 3.3:1

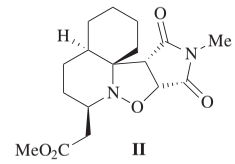


Alkene (1 eq), solvent



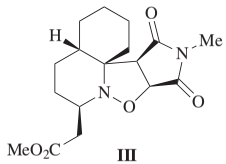
I

+



II

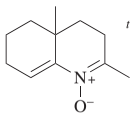
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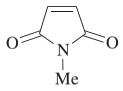


III

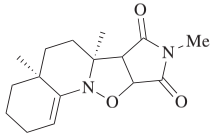
183, 351

Solvent	Temp	Time (h)	**I + II + III**	**I/II/III**
$CHCl_3$	reflux	36	(100)	4:3:2
toluene	110°	25	(100)	16:4:3



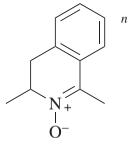


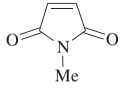
$CHCl_3$, rt, 48 h



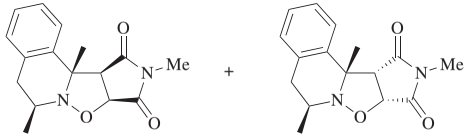
(75) dr 2:1

323





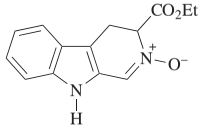
Alkene (1 eq),
THF, 66°, 16 h



371

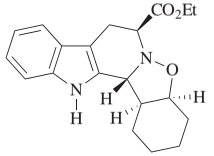
I **I + II** (82), **I/II** = 10:1 **II**

C_{12}



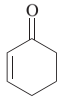


Alkene (50 eq),
toluene, 110°, 6 d

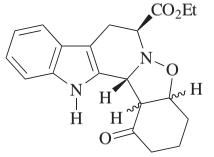


(86)

719



Alkene (10 eq),
toluene, 70°, 1 h



(93)

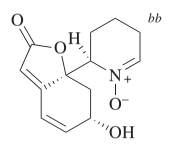
719

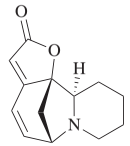
TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

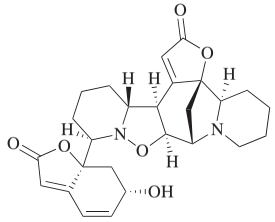
*Please refer to the chart preceding the tables for structures indicated by the **bold** numbers.*

C_{13}





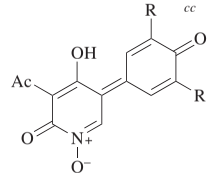
Alkene (0.88 eq), toluene, reflux, 12 h

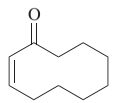


(61)

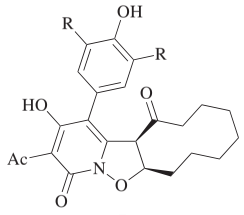
142

C_{19}

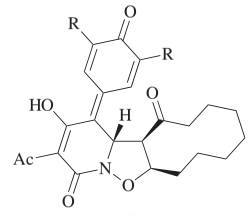




Alkene (1 eq), CH_2Cl_2, reflux, 24 h

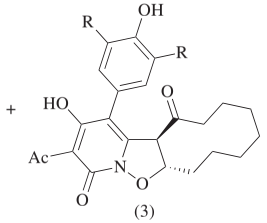


+

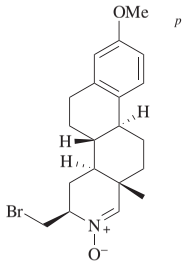


330

+

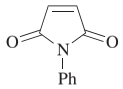


I + **II** (30)
I/II = 1:1.5

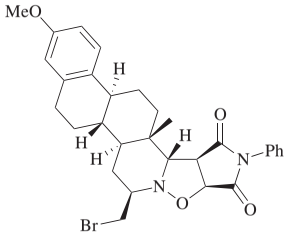


p

non-racemic

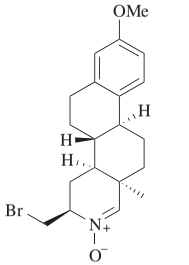


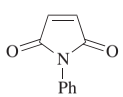
Alkene (1 eq), benzene, 50°, 2 h



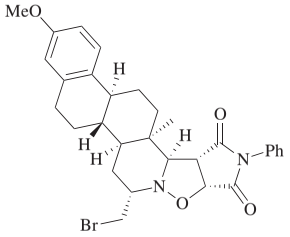
(67–85)[p]

324, 325



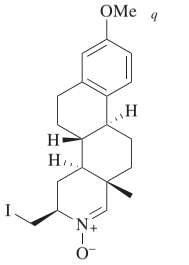


Alkene (1 eq), benzene, 50°, 2 h



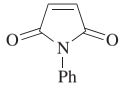
(77–81)[p]

324, 325

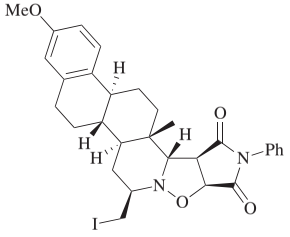


q

non-racemic



Alkene (1 eq), benzene, 50°, 2 h



(84–93)[q]

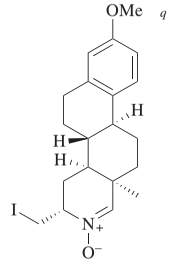
324, 325

TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

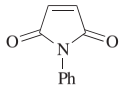
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

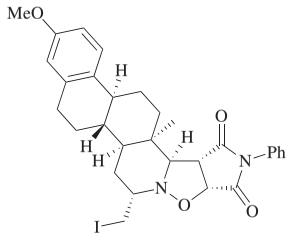
C_{19}



non-racemic



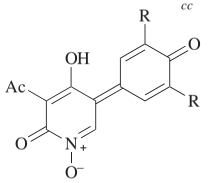
Alkene (1 eq), benzene, 50°, 2 h



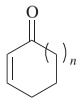
(85–92)[q]

324, 325

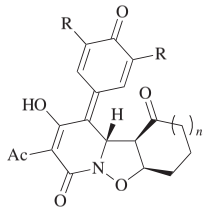
C_{21}



R = *t*-Bu

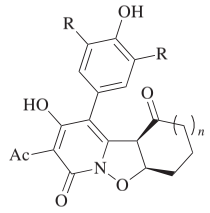


Alkene (1 eq), CH_2Cl_2, rt, 2 h; then reflux, 24 h



I

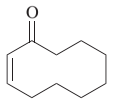
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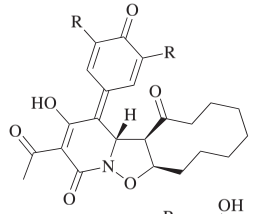
II

329

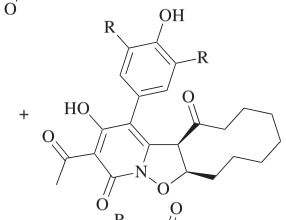
n	**I**	**II**
0	(tr)	(—)
1	(tr)	(—)
4	(29)	(3)



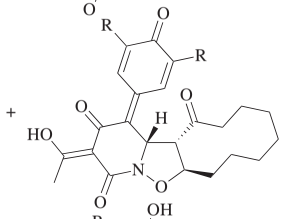
Alkene (1 eq),
CH_2Cl_2, rt, 2 h;
then reflux, 24 h



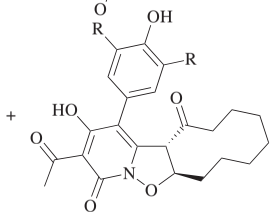
(35)



(25)



(3)



(2)

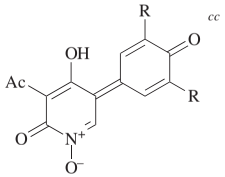
329, 330,
737

TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

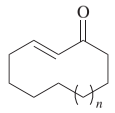
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.

Please refer to the chart preceding the tables for structures indicated by the ***bold*** *numbers.*

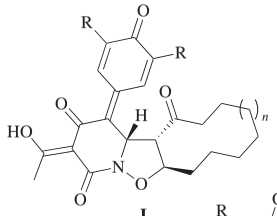
C_{21}



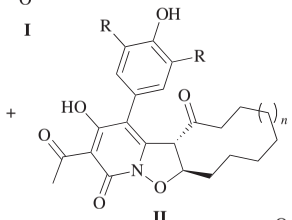
R = *t*-Bu



Alkene (1 eq),
CH_2Cl_2, rt, 2 h;
then reflux, 24 h

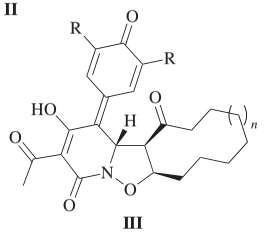


I



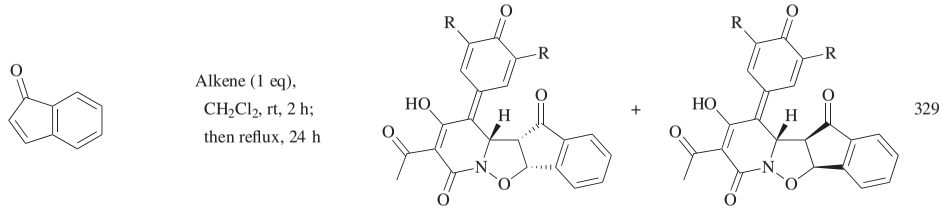
II

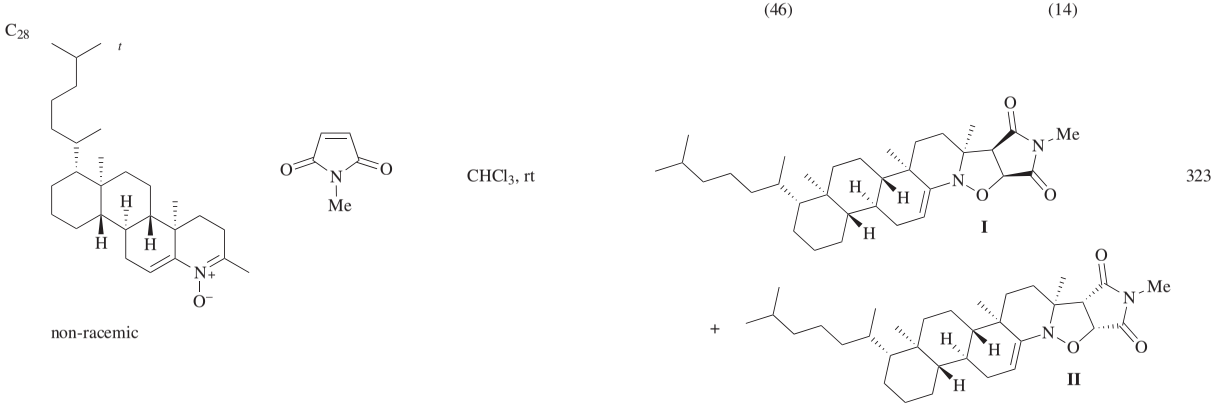
n	**I**	**II**	**III**
2	(55)	(20)	(5)
3	(41)	(14)	(2)
6	(45)	(25)	(—)



III

329





[a] The nitrone was generated in situ by thermolysis of 1[(2*S**,3*R**)-1,1-dioxido-2-propylthietan-3-yl]-1-piperidine-1-oxide.

[b] The nitrone was generated in situ by oxidation of the corresponding amine with selenium oxide and hydrogen peroxide.

[c] The nitrone was generated in situ by oxidation of the corresponding hydroxylamine with HgO.

[d] These compounds derive from cycloaddition to lactones formed by oxidation of the alkene by HgO.

[e] The primary cycloadduct was not isolated.

[f] The alkene was generated from 4-methoxyphenol and diacetoxyiodobenzene in MeOH and used without purification through evaporation and solvent exchange.

TABLE 4C. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH ENDOCYCLIC ALKENES (*Continued*)

[g] The nitrone was a mixture of two diastereoisomers.

[h] The product was a mixture of two nitrogen invertomers.

[i] The yield was calculated based on the recovered nitrone.

[j] The crude reaction mixture contained 4 adducts in a 64:20:10:6 ratio (ca 90% yield).

[k] The nitrone was generated in situ by addition of PhSeBr to the appropriate oxime followed by treatment with a base (K_2CO_3 or tertiary amine).

[l] The nitrone was generated in situ via intramolecular Michael addition of the appropriate oxime.

[m] The nitrone was generated in situ by reaction of a mixture of (1*Z*)- and (1*E*)-hepta-5,6-dienal oxime with silver tetrafluoroborate (0.5–1.0 eq).

[n] The nitrone was generated in situ by cyclization of the appropriate oxime catalyzed by $PdCl_2$ or $PdCl_2(MeCN)_2$ (0.1 eq).

[o] The nitrone was generated in situ by cyclization of 6,7-epoxyheptan-2-one oxime.

[p] The nitrone was generated in situ by reaction of the appropriate oxime with *N*-bromosuccinimide (NBS) or 1,3-dibromo-5,5-dimethylhydantoin (DDH).

[q] The nitrone was generated in situ by reaction of the appropriate oxime with I_2 or *N*-iodosuccinimide (NIS) in CH_2Cl_2.

[r] The nitrone was generated in situ by $Hg(OAc)_2$ addition to the oxime of 6-hepten-2-one.

[s] The product was contaminated with trace amounts (<5%) of the *endo* diastereoisomer.

[t] The nitrone was generated in situ by rearrangement of the appropriate oxime.

[u] The nitrone was generated in situ by 1,3-dipolar cycloreversion of (1*S**,2*R**,10b*S**)-1-nitro-2-phenyl-2,5,6,10b-tetrahydro-1*H*-isoxazolo[3,2-a]isoquinoline (thermodynamic adduct of the nitrone with (*E*)-nitrostyrene). Under similar conditions, isomeric (1*S**,2*S**,10b*S**)-1-nitro-2-phenyl-2,5,6,10b-tetrahydro-1*H*-isoxazolo[3,2-a]isoquinoline (adduct of the nitrone with (*Z*)-nitrostyrene) was only partially converted (28%) and afforded the product in 25% yield.

[v] The observed cycloadducts is derived from cycloaddition of the nitrone to cyclopentadiene dimer.

[w] The *endo*-adduct was converted into the *exo*-isomer upon heating.

[x] The enantiomeric enhancement was found to be negligible.

[y] A third adduct of undetermined structure was also isolated.

[z] The nitrone was generated in situ by reaction of 2-iodobenzaldehyde with hydroxylamine hydrochloride (1.2 eq), allene (1 bar), Pd_2dba_3 (0.025 eq), tris-2-furylphosphine (0.1 eq), potassium acetate (2 eq), and 4 Å MS under the reaction conditions.

[aa] The nitrones were generated in situ starting from a 1.2:1 mixture of (*R*)- and (*S*)-2-((*R*)-4-methylcyclohex-3-enyl)propanal oxime by addition of PhSeBr followed by treatment with K_2CO_3.

[bb] The starting nitrone was used as the crude product obtained by reaction of the precursor tetrahydro-1,2-oxazine with *m*-CPBA (1.23 eq) in CH_2Cl_2 at 0° for 0.25 h followed by treatment with excess K_2CO_3.

[cc] The nitrone was generated in situ by oxidation of the appropriate pyridinone with iodobenzene diacetate.

TABLE 5. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING

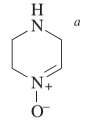
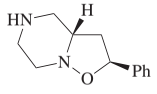
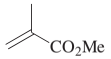
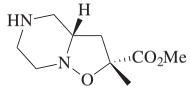
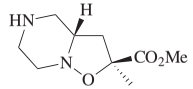
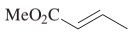
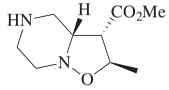
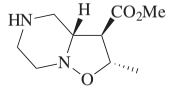
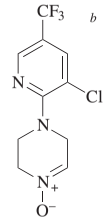
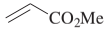
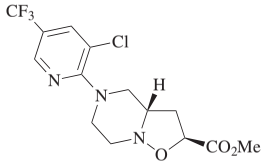
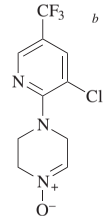
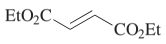
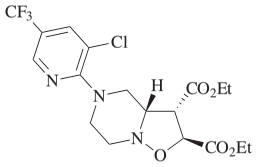
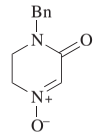
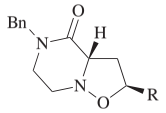
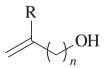
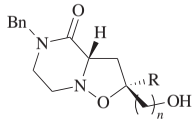
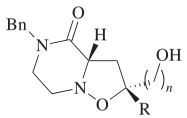
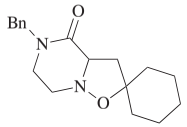
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_4				
 *a*		Alkene (8.7 eq), MeOH, 50°, 24 h	 (73)	738
		Alkene (10 eq), MeOH, 20°, 4 h	 +  **I** **II** **I** + **II** (85), **I/II** = 96:4	738
		Alkene (9.4 eq), MeOH, 50°, 3 h	 +  **I** **II** **I** + **II** (75), **I/II** = 93:7	738
 *b*		CH_2Cl_2, rt, 16 h	 (89)	514

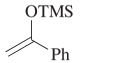
TABLE 5. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_4				
		CH_2Cl_2, rt, 19 h	 (55)	514
		Alkene (3 eq), CH_2Cl_2, rt		739
		Alkene (3 eq), CH_2Cl_2, rt, 48 h	 + 	739
		THF, reflux, 24 h	 (68)	740

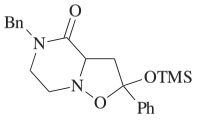
R	Time (h)	
n-Bu[c]	90	(91)
Ph	72	(87)
Bn	72	(91)
4-$MeOC_6H_4$	90	(90)

I **II**

R	*n*	**I**	**II**
H	1	(85)	(7)
H	2	(91)	(4)
Me	1	(11)	(79)

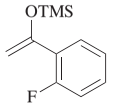


THF, reflux, 42 h

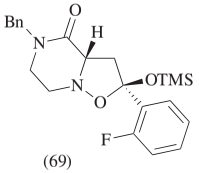


(70) dr 3:1

740

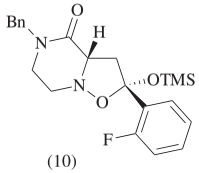


Alkene (0.3 eq),
THF, reflux, 24 h



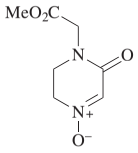
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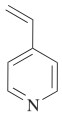
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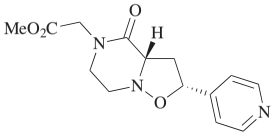
(10)

741



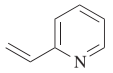


Alkene (3 eq),
THF, rt, 22 h

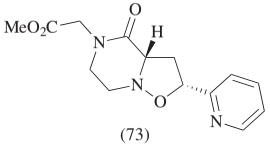


(75)

478



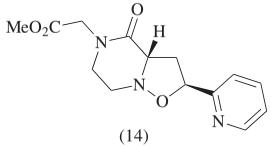
Alkene (3 eq),
THF, rt, 23 h



(73)

478

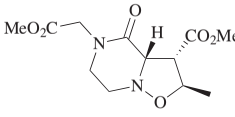
+



(14)



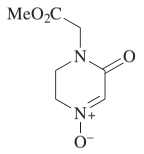
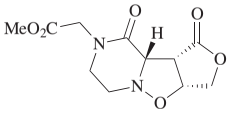
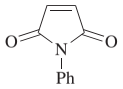
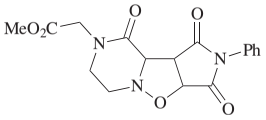
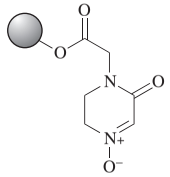
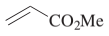
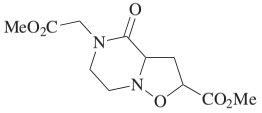
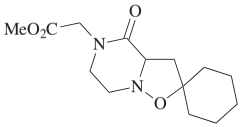
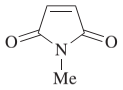
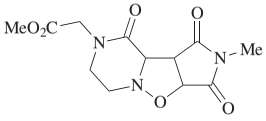
Alkene (3 eq),
$Yb(OTf)_3 \cdot H_2O$ (x eq),
THF, rt

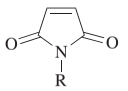


x	Time (h)	
—	42	(98)
0.2	14	(—)

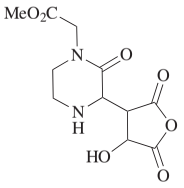
478

TABLE 5. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_4				
		Alkene (3 eq), $Yb(OTf)_3 \cdot H_2O$ (*x* eq), THF, rt		*x* Time (h) — 56 (—) 0.2 4 (—)	478
		Alkene (3 eq), THF, rt, 2 h		(66)	478
		1. Alkene (16–17 eq), THF, 65°, 1–3 h 2. NaOMe, MeOH/THF (1:4), rt		(27)[d]	477
		1. Alkene (59 eq), THF, 65°, 8 h 2. NaOMe, MeOH/THF (1:4), rt		(82)[d]	477
		1. Alkene (16–17 eq), THF, 65°, 1–3 h 2. NaOMe, MeOH/THF (1:4), rt		(28)[d]	477

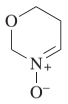


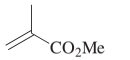
1. Alkene (15 eq), dioxane, 65°, 2 h
2. $Mo(CO)_6$ (4 eq), $MeCN/H_2O$, heat
3. NaOMe



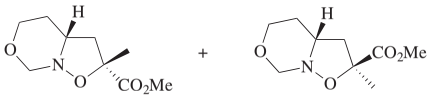
R	
Me	(56)[d]
Et	(62)[d]
Pr	(75)[d]
c-C_6H_{11}	(81)[d]
Ph	(65)[d]
3,5-$Cl_2C_6H_3$	(90)[d]
Bn	(70)[d]

478



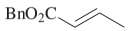


Alkene (4.7 eq), $CHCl_3$, 20°, 2 h



I + **II** (72), **I/II** = 95:5

742

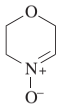


Alkene (4 eq), $CHCl_3$, 60°, 2 h



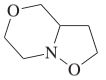
I + **II** (70), **I/II** = 85:15

742



$H_2C{=}CH_2$

Alkene (xs), pressure bottle, EtOH, 3 atm, 100°, 10 h

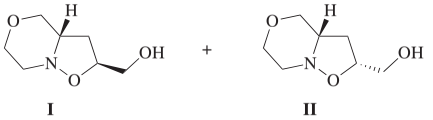


(55)

487



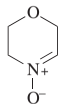
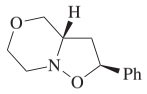
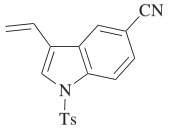
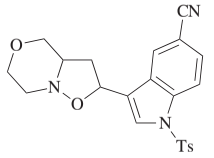
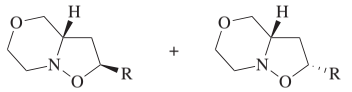
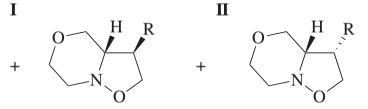
Alkene (14.7 eq), CH_2Cl_2, 20°, 72 h



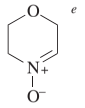
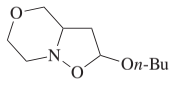
I + **II** (88), **I/II** = 88:12

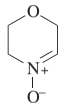
743

TABLE 5. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_4				
	 Ph	Alkene (5 eq), CH_2Cl_2, 20°, 18 h	 (83)	743
		—	 (57)	497
	 R	Alkene (*x* eq), $CHCl_3$, 10 min	 **I** + **II**	743
			 **III** + **IV**	

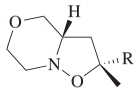
R	*x*	Temp (°)	**I + II + III + IV**	**I/II/III/IV**
CHO	4.5	0	(67)	48:29:12:11
MeO_2C	6.6	20	(81)	80:8:7:5

 [e]	 O*n*-Bu	Alkene (2.1 eq), H_2O, 90°, 1 h	 (—)	91



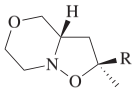


Alkene (*x* eq), CH_2Cl_2, 20°



I

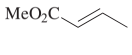
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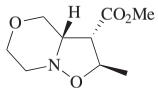
II

743

R	*x*	Time (h)	**I** + **II**	**I/II**
$HOCH_2$	12	72	(82)	91:9
MeO_2C	5.6	3	(86)	95:5

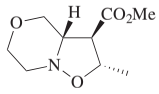


Alkene (5.6 eq), CH_2Cl_2, 20°, 18 h



I

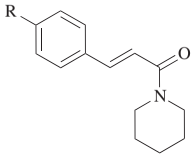
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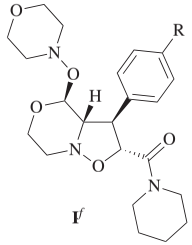
II

743

I + **II** (84), **I/II** = 96:4

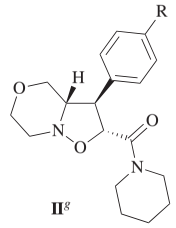


Alkene (1 eq), toluene, 110°, 16 h



I[f]

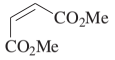
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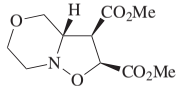
II[g]

744

R	**I**	**II**
H	(58)	(—)
Cl	(51)	(—)
MeO	(49)	(22)
O_2N	(44)	(—)

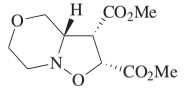


Alkene (1.4 eq), CH_2Cl_2, 20°, 12 h



I

+

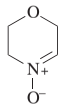
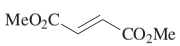
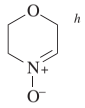
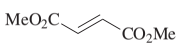
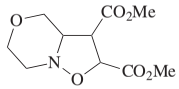
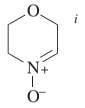
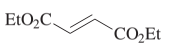
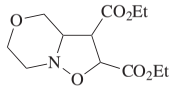
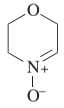
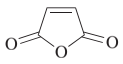
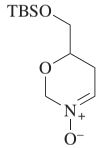
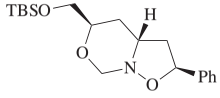


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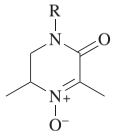
743

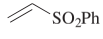
I + **II** (82), **I/II** = 96:4

TABLE 5. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

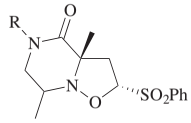
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_4				
		Alkene (1.2 eq), CH_2Cl_2, 20°, 0.5 h	 **I** + **II** **I** + **II** (80), **I/II** = 82:18	743
 *h*		Alkene (1 eq), Ar, MeCN/H_2O, reflux, 2 h	 (60)	247
 *i*		Alkene (1 eq), $CHCl_3$, reflux, 1 h	 (51)	107
		Alkene (0.8 eq), CH_2Cl_2, 20°, 0.33 h	 **I** + **II** **I** + **II** (73), **I/II** = 92:8	743
C_5				
		Alkene (13 eq), $CHCl_3$, 50°, 3 h	 (70)	742

C_6



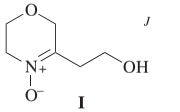


Alkene (1.2 eq), toluene, reflux, 48 h



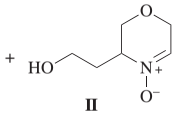
R		
H	(59)	
Me	(49)	

745



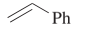
I

+

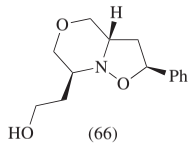


II

I/II = 1.2:1

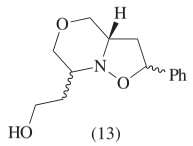


Alkene (xs), $CHCl_3$, 20°, 24 h; then 50°, 6 h



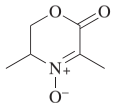
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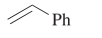
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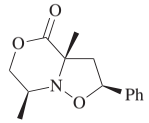
(13)

487





Alkene (xs), neat, 100°, 5.5 h

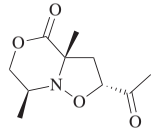


(90)

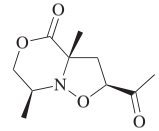
746



Alkene (12 eq), xylene, reflux, 32 h



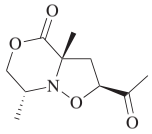
(36) +



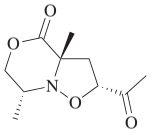
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746

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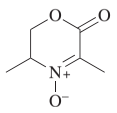
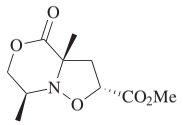
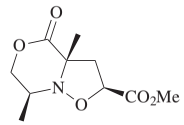
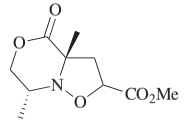
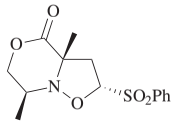
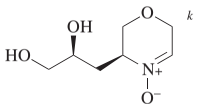
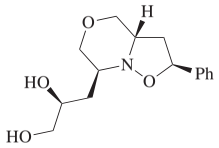
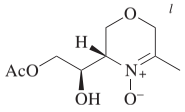
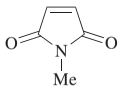
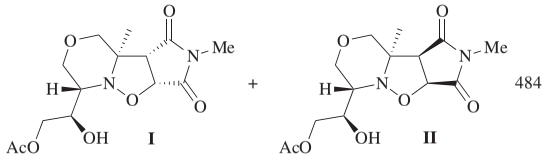


(10) +



(5)

TABLE 5. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_6				
		Alkene (18 eq), toluene, reflux, 45 h	 (39) +  (25) +  (7)	746
		Alkene (1.25 eq), xylene, reflux, 36 h	 (85)	746
C_7				
 *k*		Alkene (18 eq), solvent, 50°, 24 h	 Solvent: CH_2Cl_2/MeOH (6:1) (65); CH_3CO_2H (24)	747
 *l* non-racemic		Alkene (1 eq), EtOH, 80°, 24 h	 **I** + **II** (60), **I**/**II** = 3:1	484

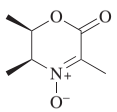
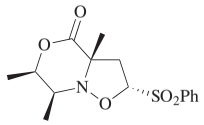
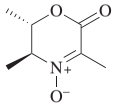
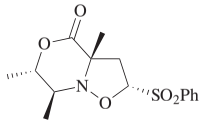
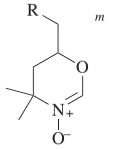
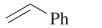
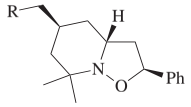
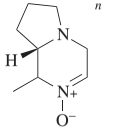
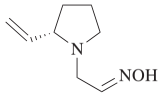
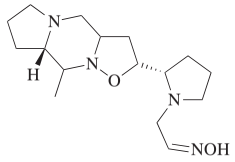
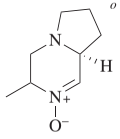
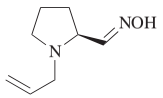
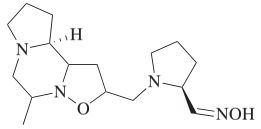
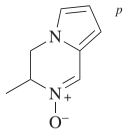
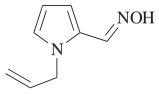
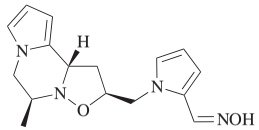
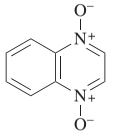
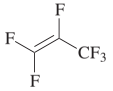
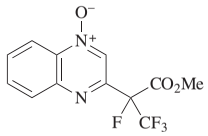
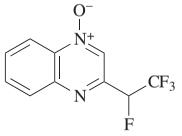
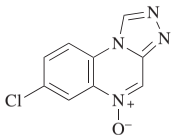
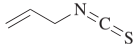
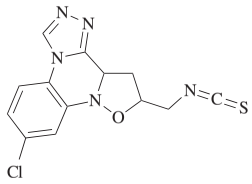
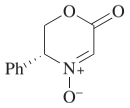
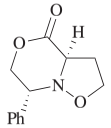
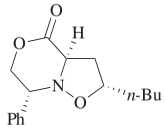
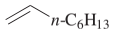
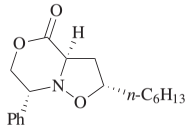
		Alkene (1.25 eq), toluene, reflux, 192 h		(29)	746
		Alkene (1.25 eq), toluene, reflux, 72 h		(30)	746
C_{7-8}					
 *m*		Alkene (xs), neat, 80°, 2 h		R HO (65) AcO (75) $HOCH_2$ (55)	110
C_8					
 *n*		Sealed ampule, toluene, 180°, 15 h		(24)	748
non-racemic	non-racemic				
 *o*		Sealed ampule, toluene, 180°, 18 h		(19)	748
non-racemic	non-racemic				

TABLE 5. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

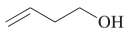
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_8				
		Xylene, 140°, 16 h	 (52)	183, 699
		Alkene (4.2 eq), MeOH (10 eq), pressure vial, DMF, 80°, 5 h	 (38)[d,q] +  (33)[d]	245
C_9				
		Alkene (1.2 eq), dioxane, reflux, 2 h	 (63)	327
C_{10}				
 non-racemic	$H_2C{=}CH_2$	Alkene (xs), sealed tube, $CHCl_3$, rt, 7 d	 (>90)	749
		Alkene (10 eq), benzene, 60°, 8 h	 (86) dr 85:15[r]	64, 331



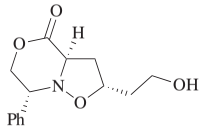
Alkene (3 eq), $CHCl_3$, rt, 20 h



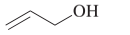
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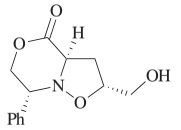
Alkene (2 eq), CH_2Cl_2, rt, 41 h



(50) 750

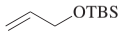


Alkene (1.5 eq), Lewis acid (1.5 eq), solvent, rt

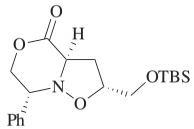


751

Lewis Acid	Solvent	Time (h)		dr
none	benzene	72	(99)	75:19:5[r]
BF_3•OEt_2	DCE	96	(49)	only isomer
Ti(O*i*-Pr)$_4$	DCE	120	(60)	only isomer
Eu(fod)$_3$	DCE	72	(71)	only isomer
$MgBr_2$•OEt_2	DCE	3	(89)	only isomer

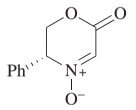
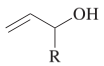
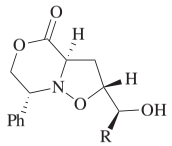
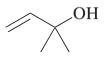
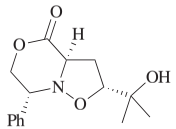
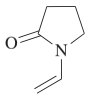
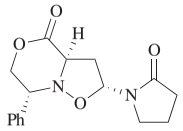
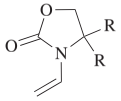
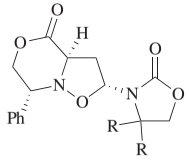


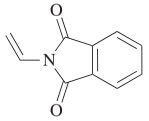
Alkene (10 eq), benzene, 60°, 12 h



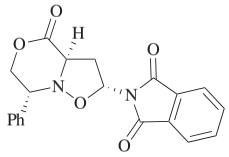
(89) dr 75:25[r] 64, 331

TABLE 5. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{10}				
 non-racemic		Alkene (3 eq), $MgBr_2 \cdot OEt_2$ (3 eq), DCE		751
			R Temp Time (h) dr[r] Me rt 4 (89) 79:15:6 Et rt 4 (93) 82:18 *c*-C_6H_{11} rt 4 (92) 83:17 Ph 50° 3.5 (59) 80:20	
		Alkene (1.5 eq), $MgBr_2 \cdot OEt_2$ (3 eq), DCE, 50°, 24 h	 (30)	751
		Alkene (1 eq), neat, 110°, 10 min	 (93) dr 88:12[r]	752
		Alkene (1 eq), neat, 110°, 10 min		752
			R (97) dr[r] H (97) 86:14 Me (94) 95:5	



Alkene (1 eq),
neat, 110°, <1 min

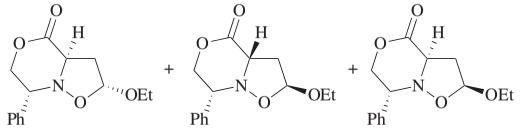


(87)

752



Alkene (*x* eq),
$Eu(fod)_3$ (*y* eq),
solvent, rt

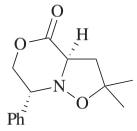


I **II** **III**

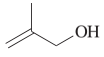
x	*y*	Solvent	Time (h)	**I + II + III**	**I/(II + III)**	**I/II/III**	
—	0	—	16	(87)	83:17	—	64, 331
2.9	1	benzene	15	(88)	13:87	13:48:39	345



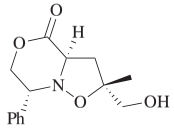
Alkene (10 eq),
benzene



Temp	Time (h)		
rt to 50°	32	(87)	64, 331
60°	25	(95)	



Alkene (1.5 eq),
$MgBr_2 \cdot OEt_2$ (1.5 eq),
DCE, 50°, 16 h

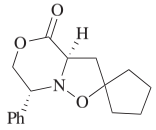


(84)

751

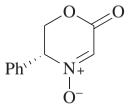
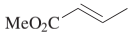
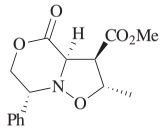
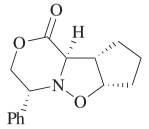
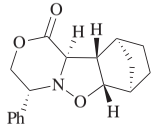
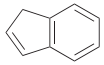
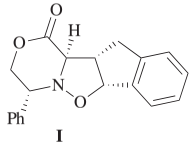
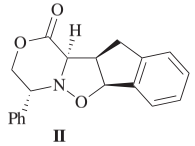
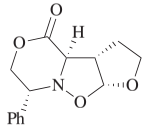
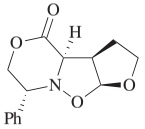


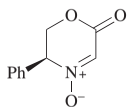
Alkene (3 eq), benzene



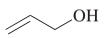
Temp	Time (h)		
rt to 50°	32	(87)	64, 331
60°	25	(95)	

TABLE 5. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

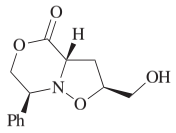
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{10}  non-racemic		Alkene (2–3 eq), $CHCl_3$, rt, 3 h		(96)	749
		Alkene (*x* eq), solvent, rt		*x* — 30 (90); 2 $CHCl_3$ 23 (>90); 10 benzene 30 (90)	331, 749, 64
		Alkene (10 eq), benzene, rt, 9 h		(92)	64, 331
		Alkene (6.5 eq), $CHCl_3$, reflux, 3 h	 **I** +  **II** **I + II** (46), **I/II** = 5:1	753
		Alkene (10 eq), benzene, rt to 50°, 19 h	 **I** +  **II** **I + II** (83), **I/II** = 87:13	64, 331



non-racemic

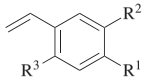


Alkene (1.5 eq),
$MgBr_2 \cdot OEt_2$ (1.5 eq),
DCE, rt, 3 h

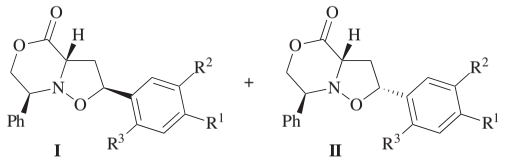


(89)

751



Alkene (1.5–5 eq),
$CHCl_3$, reflux, 3–5 h



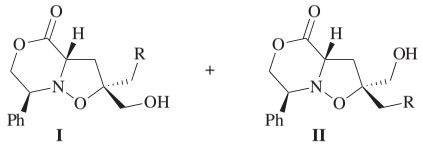
I **II**

754

R^1	R^2	R^3	**I + II**	**I/II**
H	H	H	(73)	10:1[s]
AcO	H	H	(84)	5:1
Me	H	H	(71)	10:1
H	Me	Me	(55)	5:1
Me	H	Me	(49)	>20:1
t-Bu	H	H	(85)	7:1



Alkene (1.5 eq),
CH_2Cl_2, rt

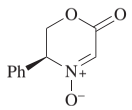
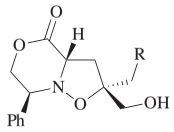


I **II**

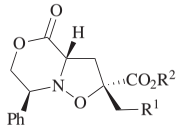
755, 756

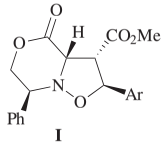
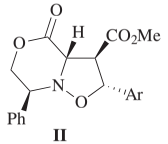
R	Time (d)	**I + II**	**I/II**
H	9	(92)	87:13
2-indolyl	15	(97)	86:14

TABLE 5. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

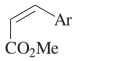
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{10}				
 non-racemic		Alkene (*x* eq), $MgBr_2 \cdot OEt_2$ (1.5 eq), CH_2Cl_2, rt		755, 756

R	*x*	Time (h)		dr
H	1.5	10	(88)	>98:2
EtO_2CCH_2	1.2	72	(94)	91:9
i-Pr	1.5	18	(quant)	95:5
4-$MeOC_6H_4$	1.5	20	(98)	>98:2
2-indolyl	1.5	84	(98)	>98:2
1-Np	1.5	96	(98)	96:4
2-Np	1.5	84	(97)	>98:2

								
	Alkene (*x* eq), CH_2Cl_2, rt, 2 d		R^1	R^2	*x*		dr	755
			H	Me	1.5	(98)	>98:2	
			EtO_2CCH_2	Et	1.2	(87)	96:4	
			2-indolyl	H	1.2	(83)	>98:2	
			2-indolyl	Me	1.5	(99)	>98:2	
			2-indolyl	Et	1.5	(89)	>98:2	
			2-indolyl	Bn	1.5	(89)	95:5	

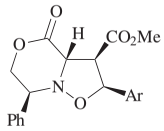
Ar = 4-$MeOC_6H_4$	Toluene, reflux	 **I**	+	 **II**	757

I + **II** (25), **I**/**II** = 1:1



Ar = 4-MeOC$_6$H$_4$

Toluene, reflux

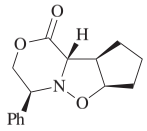


(60)

757



Alkene (10 eq), benzene, rt , 30 h

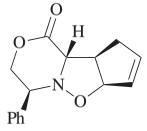


(88)

64

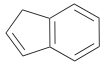


Alkene (10 eq), benzene, rt , 4 h

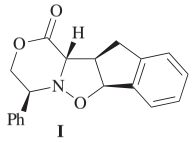


(78)

64

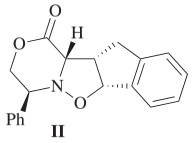


Alkene (1.5–5 eq), $CHCl_3$, reflux, 3–5 h



I

+

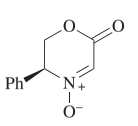
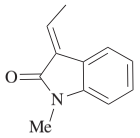
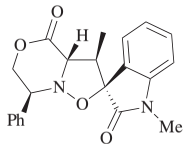
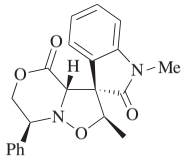


II

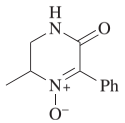
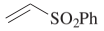
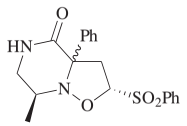
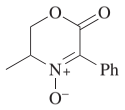
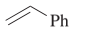
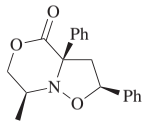
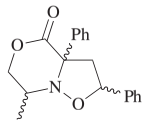
754

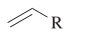
I + **II** (70), **I/II** = 10:1

TABLE 5. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

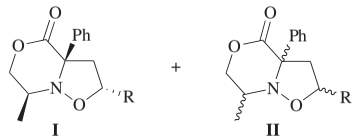
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{10}				
 non-racemic		Alkene (*x* eq), solvent	 **I** +  **II**	333

x	Solvent	Temp	Time (h)	**I** + **II**	**I**/**II**[f]
1	neat	–25°	11	(40)	47:53
1	neat	rt	11	(93)	45:55
1	neat	60°	11	(96)	22:78
1	MeCN	rt	11	(46)	42:58
1	THF	rt	11	(54)	50:50
3	MeOH	rt	11	(55)	26:74
3	hexane	rt	8	(100)	47:53
3	hexane	50°	2.5	(100)	50:50

C_{11}							
		Alkene (1.2 eq), toluene, reflux, 72 h		(65)			745
		Alkene (xs), neat, 110°, 8 h		(86)	+ 	(10)[r]	746



Alkene (*x* eq),
toluene, reflux



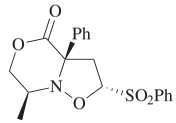
I **II**

R	*x*	Time (h)	**I**	**II**	dr **II**
Ac	30	100	(67)	(21)	12:7:2[*u*]
MeO_2C	120	110	(67)	(22)[*r*]	—

746



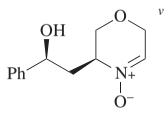
Alkene (1.25 eq),
xylene, reflux, 42 h



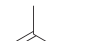
(44)

746

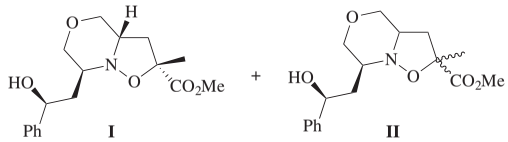
C_{12}



v



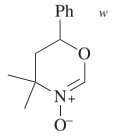
Alkene (*x* eq),
solvent, 20°, 24 h



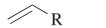
I **II**

x	Solvent	**I**	**II**	**I + II**
4.7	CH_2Cl_2	(63)	(9)	(—)
17	AcOH	(—)	(—)	(30)

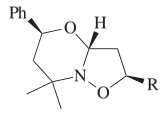
747



w



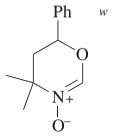
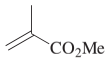
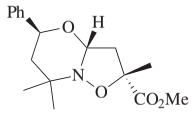
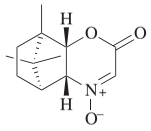
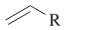
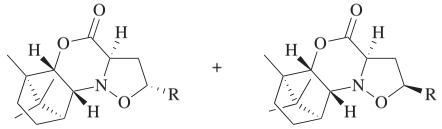
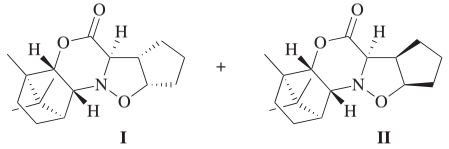
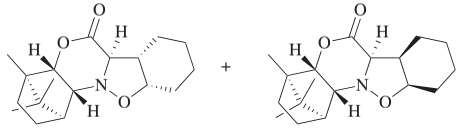
Alkene (xs),
neat, 80°, 2 h

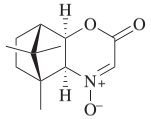


R	
n-Bu	(65)
Ph	(71)

110

TABLE 5. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

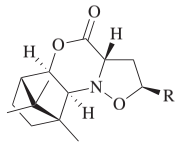
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{12}				
		Alkene (xs), neat, 80°, 2 h	 (90)	110
 non-racemic		Alkene (10 eq), toluene, 60°, 19 h	 **I** + **II**	758
			R **I** + **II** **I/II** *n*-Bu (99) >20:1 Ph (100) >20:1	
		Alkene (10 eq), toluene, 30°, 46 h	 **I** + **II** (99), **I/II** = >20:1	758
		Alkene (10 eq), toluene, 30°, 77 h	 **I** + **II** (93), **I/II** = >20:1	758



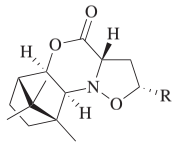
non-racemic



Alkene (10 eq), toluene, 60°



I

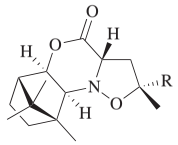


II

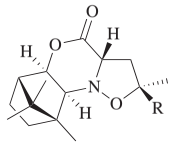
758

R	Time (h)	**I** + **II**	**I/II**
n-Bu	32	(95)	>20:1
$HOCH_2$	5	(100)	5:1
Ph	8	(98)	>99:1

Alkene (10 eq), toluene, 60°



I



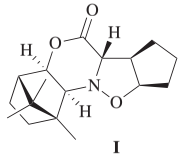
II

758

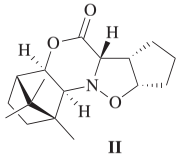
R	Time (h)	**I** + **II**	**I/II**
Ph	67	(100)	5:2
MeO_2C	15	(100)	>20:1



Alkene (10 eq), toluene, 30°, 25 h



I



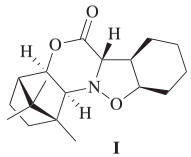
II

758

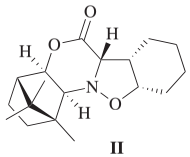
I + **II** (99), **I/II** = >99:1



Alkene (10 eq), toluene, 60–80°, 89 h



I

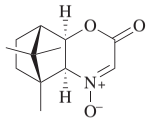
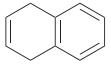
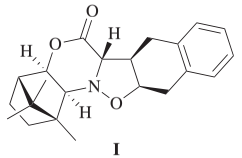
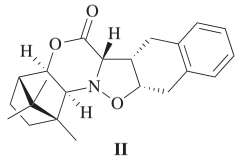
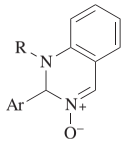
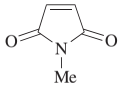
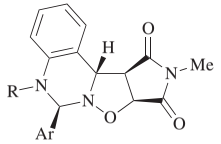
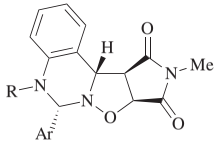
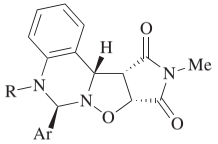


II

758

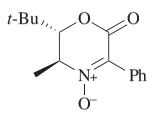
I + **II** (100), **I/II** = >99:1

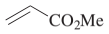
TABLE 5. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{12}				
 non-racemic		Alkene (10 eq), toluene, 60°, 25 h	 **I** +  **II** **I + II** (100), **I/II** > 20:1	758
C_{14}				
		Alkene (1 eq), CH_2Cl_2, rt, 18 h	 **I** +  **II** +  **III**	211

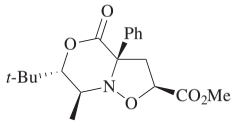
Ar	R	I	II	III
Ph	Me	(37)	(32)	(tr)
Ph	Ph	(55)	(35)	(10)
Ph	4-$MeOC_6H_4$	(46)	(27)	(3)
Ph	4-NCC_6H_4	(50)	(tr)	(30)
4-$O_2NC_6H_4$	4-$MeOC_6H_4$	(67)	(10)	(13)

C_{15}





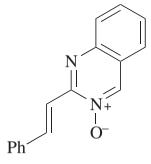
Alkene (30 eq), toluene, reflux, 110 h

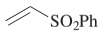


(68)

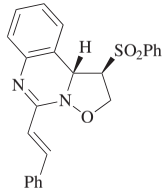
746

C_{16}



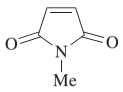


Alkene (2 eq), THF, reflux, 24 h

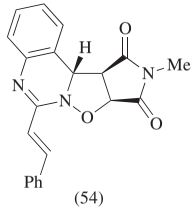


(49)

328

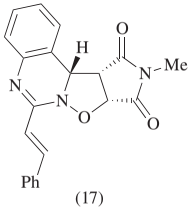


THF, rt, 80 min



(54)

+



(17)

328

TABLE 5. INTERMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES WITH A HETEROATOM IN THE RING (*Continued*)

[a] The nitrone was generated by oxidation of *N*-hydroxypiperazine with yellow HgO and used without purification.

[b] The nitrone was generated in situ by oxidation of the corresponding hydroxylamine with polymer-supported perruthenate.

[c] Additional 1-hexene (3 eq) was added after 42 h.

[d] The primary cycloadduct was not isolated.

[e] The nitrone was generated in situ by oxidation of morpholine with H_2O_2/Na_2WO_4 (cat.).

[f] Product **I** was proposed to derive from reaction of primary adduct **II** with the nitrone.

[g] Minor amounts of regio- and stereoisomers were detected.

[h] The nitrone was prepared by photolysis of *N*-hydroxymorpholine and then directly trapped with dimethyl fumarate.

[i] The nitrone was generated by electrochemical oxidation of *N*-hydroxymorpholine and used without purification.

[j] The mixture of nitrones was obtained by *m*-CPBA oxidation of perhydro[1,2]oxazolo[3,2-*c*][1,4]oxazine and reacted *in situ* with styrene.

[k] The nitrone was generated in situ by oxidation of (2*S**,3a*R**)-hexahydroisoxazolo[3,2-*c*][1,4]oxazin-2-yl-methanol with *m*-CPBA.

[l] The nitrone was generated in situ by cyclization of (6*R*,7*S*)-8-acetoxy-6,7-epoxy-4-oxa-2-octanone oxime.

[m] The nitrone was used as a 1:1 complex with hydroquinone that resulted from the oxidation of the hydroxylamine precursor with 4-benzoquinone.

[n] The nitrone was generated in situ from (2*S*)-2-vinylpyrrolidin-1-yl-acetaldehyde oxime.

[o] The nitrone was generated in situ from (2*S*)-1-allylpyrrolidine-2-carboxaldehyde oxime.

[p] The nitrone was generated in situ by intramolecular addition of *N*-allylpyrrol-2-carboxaldehyde oxime.

[q] The isolated product results from the primary cycloadduct that undergoes isoxazolidine ring opening followed by MeOH insertion and elimination of two equivalents of HF.

[r] The relative configuration of the minor isomers was not assigned.

[s] Essentially the same dr was obtained when the reaction was carried out at rt for several days.

[t] Cycloreversion/re-cycloaddition processes are demonstrated to occur to favor formation of regioisomer **I**.

[u] Three minor diastereoisomers were isolated in 12, 7 and 2% yield, respectively, but their stereochemistry was not determined.

[v] The nitrone was generated in situ by oxidation of (2S*,3aR*)-2-phenylhexahydroisoxazolo[3,2-c][1,4]oxazine with *m*-CPBA.

[w] The nitrone was used as a 1:1 complex with hydroquinone, resulting from the oxidation of the precursor hydroxylamine with 4-benzoquinone.

TABLE 6. INTERMOLECULAR CYCLOADDITIONS OF *n*-MEMBERED CYCLIC NITRONES ($n > 6$)

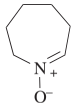
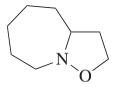
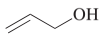
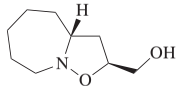
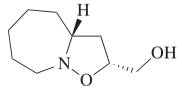
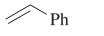
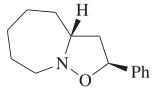
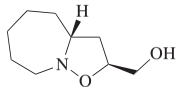
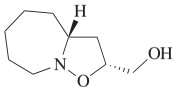
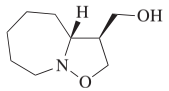
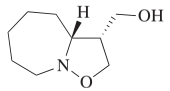
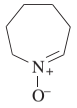
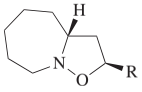
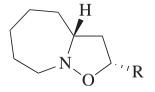
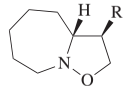
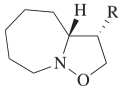
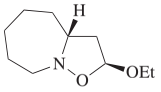
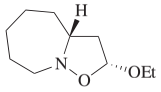
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_6				
	$H_2C{=}CH_2$	Alkene (xs), pressure bottle, EtOH, 3 atm, 120°, 14 h	 (42)	487
		Alkene (10.5 eq), CH_2Cl_2, 20°, 24 h	 +  **I** **II** **I** + **II** (74), **I/II** = 70:30	759
		Alkene (8 eq), CH_2Cl_2, 20°, 48 h	 (80)	759
		1. Alkene (5.6 eq), CH_2Cl_2, 0°, 0.25 h 2. $NaBH_4$, MeOH	 +  **I** **II** +  +  **III** **IV** **I** + **II** + **III** + **IV** (71), **I/II/(III+IV)** = 10:70:20	759

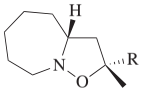
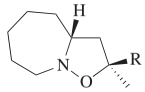
TABLE 6. INTERMOLECULAR CYCLOADDITIONS OF *n*-MEMBERED CYCLIC NITRONES ($n > 6$) (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_6				
		Alkene (*x* eq), CH_2Cl_2, 20°, 1 h	 **I** +  **II** +  **III** +  **IV**	759

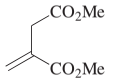
R	*x*	I + II + III + IV	I/II/III/IV
NC–	9	(86)	54:30:9:7
MeO_2C	6.5	(87)	43:50:4:3

		Alkene (15.7 eq), CH_2Cl_2, 20°, 48 h	 **I** +  **II**	759

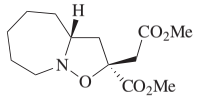
I + **II** (70), **I/II** = 93:7

		Alkene (*x* eq), solvent, 24 h	 **I** +  **II**	275

R	*x*	Solvent	Temp	I	II	I + II	I/II
$HOCH_2$	10	CH_2Cl_2	20°	(—)	(—)	(70)	93:7
$TBSOCH_2$	2.7	EtOH	reflux	(35)	(19)	(—)	—
$HO(CH_2)_2$	10	EtOH	reflux	(—)	(—)	(70)	60:40
$TBSO(CH_2)_2$	3	EtOH	reflux	(—)	(—)	(51)	55:45
MeO_2C	10	CH_2Cl_2	20°	(81)	(5)	(—)	—

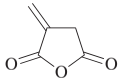


Alkene (1.7 eq), CH_2Cl_2, 20°, 5 h

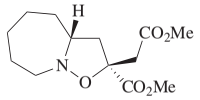


(83)

275

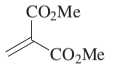


1. Alkene (1.1 eq), CH_2Cl_2, 20°, 5 h
2. MeOH/HCl, 20°, 12 h

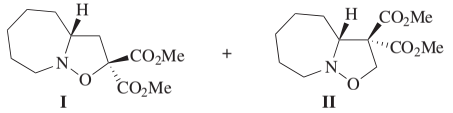


(79)

275

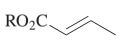


Alkene (1 eq), CH_2Cl_2, –10°, 10 min

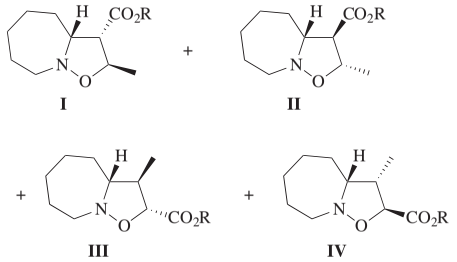


I + **II** (67), **I/II** = 50:50

759



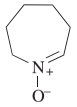
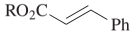
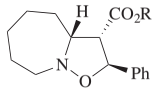
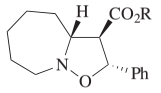
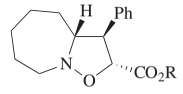
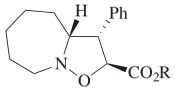
Alkene (3 eq), solvent



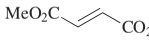
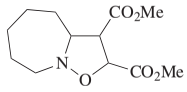
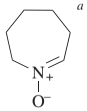
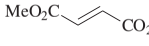
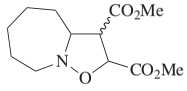
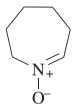
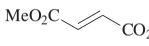
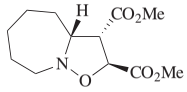
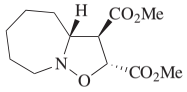
275, 504, 505, 506

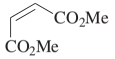
R	Solvent	Temp (°)	Time (h)	**I + II + III + IV**	**I/II/III/IV**
Me	CH_2Cl_2	20	5	(79)	80:12:7:1
Me	C_6D_6	128	8	(—)	22:73:5:0
i-Pr	CH_2Cl_2	50	48	(90)	79:13:7:1
t-Bu	CH_2Cl_2	50	48	(76)	72:16:11:1
t-Bu	C_6D_6	128	8	(—)	52:40:7:1

TABLE 6. INTERMOLECULAR CYCLOADDITIONS OF *n*-MEMBERED CYCLIC NITRONES ($n > 6$) (*Continued*)

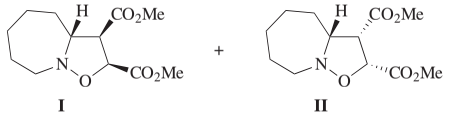
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_6				
		Alkene (2 eq), solvent	 +  **I** **II** +  +  **III** **IV**	275, 504, 505, 506

R	Solvent	Temp (°)	Time (h)	**I+II+III+IV**	**I/II/III/IV**
Me	EtOH	80	20	(83)	36:28:31:5
Me	CH_2Cl_2	20	72	(51)	50:13:31:6
i-Pr	CH_2Cl_2	50	48	(90)	64:15:17:4
t-Bu	CH_2Cl_2	50	48	(76)	59:18:20:3
t-Bu	C_6D_6	128 (sealed tube)	8	(—)	10:82:8:0

		Alkene (1 eq), $CHCl_3$, reflux, 1 h	 (36)	107
 *a*		Alkene (1 eq), Ar, MeCN/H_2O, reflux, 2 h	 (78)	247
		Alkene (1.2 eq), CH_2Cl_2, 20°	 +  **I** **II** **I** + **II** (88), **I/II** = 67:33	759

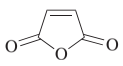


Alkene (1.6 eq), CH_2Cl_2, 20°, 24 h

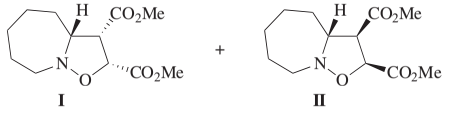


I + **II** (73), **I/II** = 63:37

759

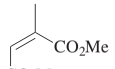


1. Alkene (1.2 eq), CH_2Cl_2, 0°, 5 min
2. MeOH/HCl, 20°, 24 h

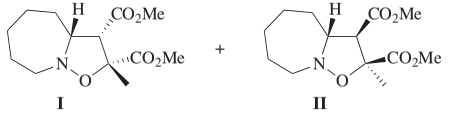


I + **II** (72), **I/II** = 65:35

759

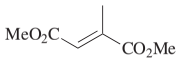


Alkene (1.5 eq), CH_2Cl_2, reflux, 20 h

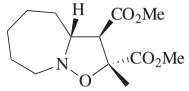


I + **II** (51), **I/II** = 75:25

275

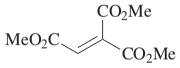


Alkene (1.1 eq), CH_2Cl_2, 20°, 12 h

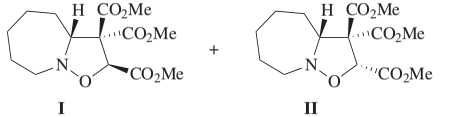


(88)

275

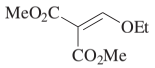


Alkene (1.1 eq), –15°

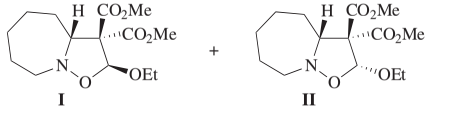


I + **II** (—), **I/II** = 64:36

275



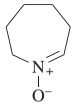
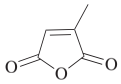
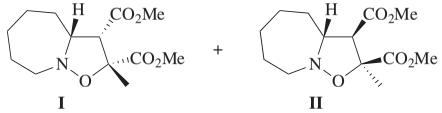
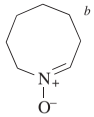
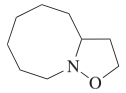
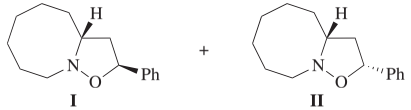
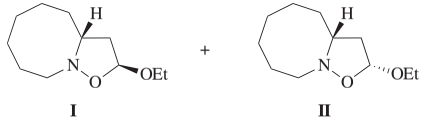
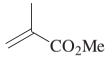
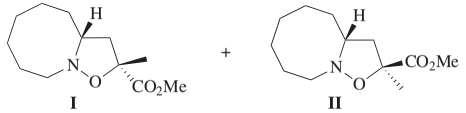
Alkene (1.2 eq), CH_2Cl_2, 20°, 24 h



I + **II** (79), **I/II** = 50:50

759

TABLE 6. INTERMOLECULAR CYCLOADDITIONS OF *n*-MEMBERED CYCLIC NITRONES ($n > 6$) (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_6				
		1. Alkene (1.5 eq), CH_2Cl_2, 20°, 4 h 2. MeOH/HCl, 20°, 12 h	 **I** + **II** (76), **I/II** = 92:8	275
C_7				
	$H_2C{=}CH_2$	Alkene (xs), pressure bottle, EtOH, 4 atm, 130°, 12 h	 (59)	487
		Alkene (5.8 eq), CH_2Cl_2, reflux, 24 h	 **I** + **II** (86), **I/II** = 91:9	334
		Alkene (8.5 eq), closed vessel, CH_2Cl_2, 57°, 18 h	 **I** + **II** (70), **I/II** = 88:12	334
		Alkene (6.3 eq), CH_2Cl_2, 20°, 6 h	 **I** + **II** (73), **I/II** = 95:5	334

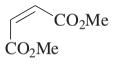
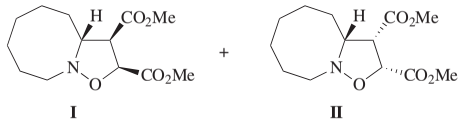
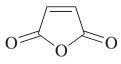
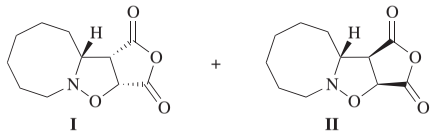
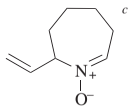
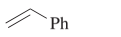
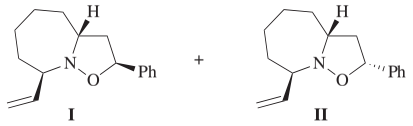
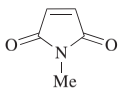
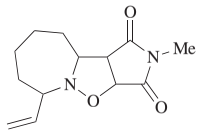
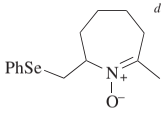
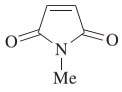
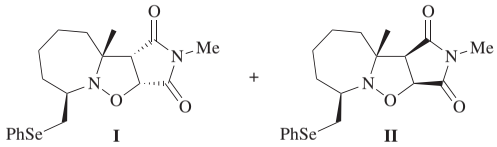
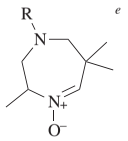
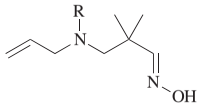
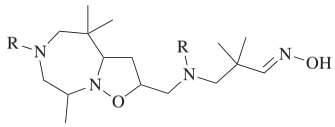
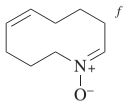
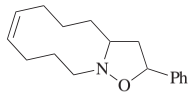
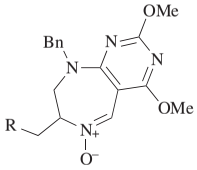
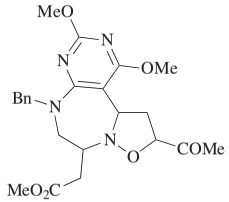
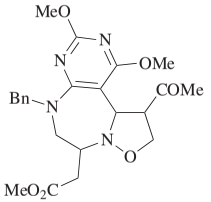
		Alkene (6.7 eq), closed vessel, CH_2Cl_2, 57°, 6 h	 **I** + **II** (69), **I/II** = 60:40	334
		Alkene (6.3 eq), CH_2Cl_2, 20°, 6 h	 **I** + **II** (77), **I/II** = 70:30	334
C_8				
		DCE, 80°, 12 h	 **I** + **II** (20), **I/II** = 5:1	760
		DCE, 80°, 12 h	 (60) dr 2:2:1	760
		Alkene (1 eq), MeCN, 80°, 16 h	 **I** + **II** (55), **I/II** = 3:1	201

TABLE 6. INTERMOLECULAR CYCLOADDITIONS OF *n*-MEMBERED CYCLIC NITRONES ($n > 6$) (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_8				
 *e*		Solvent, reflux		189

R	Solvent	Conc. (M)	Time (h)	
Bn	toluene	0.02	50	(28)
Bn	toluene	0.1	50	(44)
Bn	toluene	0.2	24	(44)
Ts	toluene	0.2	12	(62)
Ts	*n*-BuOH	0.2	108	(10)
Ms	toluene	0.2	18	(66)
Ms	*n*-BuOH	0.2	10	(12)

C_9				
 *f*		Alkene (xs), THF, heat, 24 h	 (59) dr 93:7	229
 $R = CO_2Me$		Alkene (1.2 eq), THF, rt, 3 d	 (28) dr 2:1.7:1 +  (22)	761

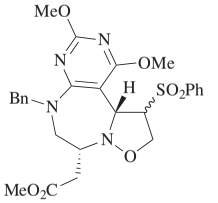
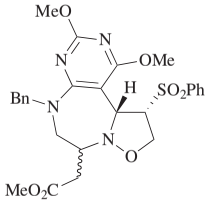
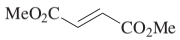
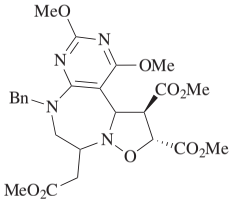
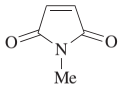
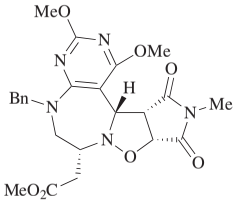
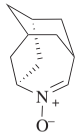
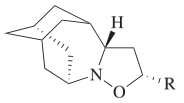
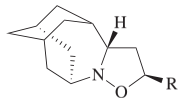
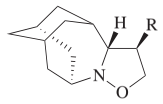
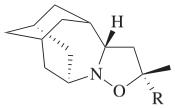
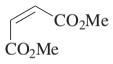
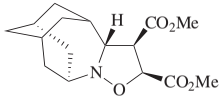
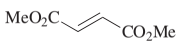
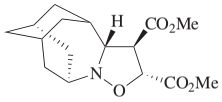
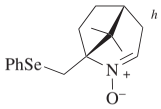
	Alkene (2 eq), THF, rt, 3 d	 (35) +  (21)		761
	Alkene (5 eq), THF, 0°, 24 h		(—)[g]	761
	Alkene (1.2 eq), THF, rt, 24 h		(73)	335

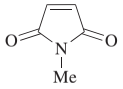
TABLE 6. INTERMOLECULAR CYCLOADDITIONS OF *n*-MEMBERED CYCLIC NITRONES ($n > 6$) (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{10}				
		Alkene (2 eq), toluene, rt	 +  **I** **II** +  **III**	335

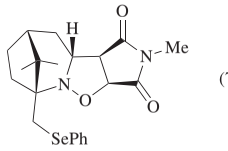
R	Time (h)	I	II	III
NC–	0.5	(26)	(23)	(20)
MeO_2C	2	(33)	(20)	(15)

		Alkene (xs), neat, rt		R Time (h) NC– 4 (65) MeO_2C 2 (74)	335
		Alkene (2 eq), toluene, rt, 15 h		(89)	335
		Alkene (2 eq), toluene, rt, 1 h		(86)	335





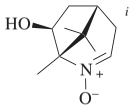
MeCN, rt, 5 h

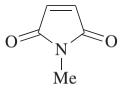


(74)

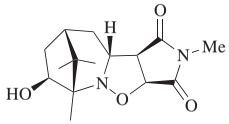
336

non-racemic





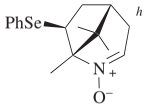
Alkene (1 eq),
MeCN, 20°, 24 h

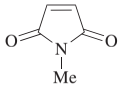


(34)

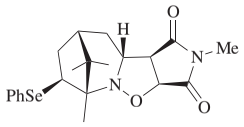
484

non-racemic





MeCN, rt, 5 h

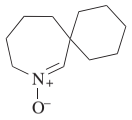


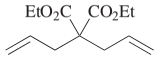
(72)

336

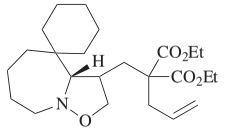
non-racemic

C_{11}



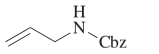


Alkene (3 eq),
toluene, reflux, 12 h

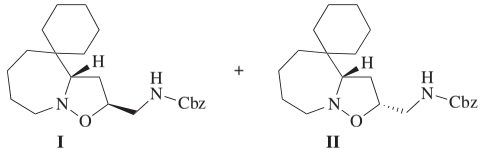


(56) dr 1.3:1

762



Alkene (3 eq),
toluene, reflux, 12 h

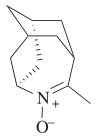
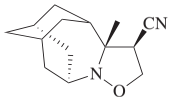
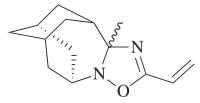
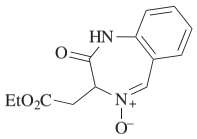
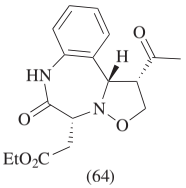
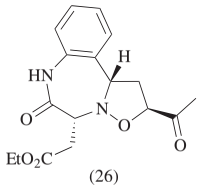
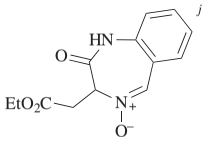
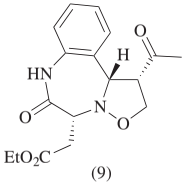
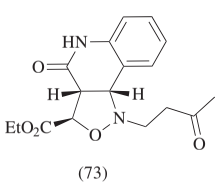
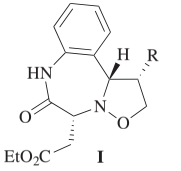
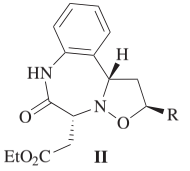


I **II**

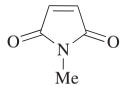
I + **II** (88), **I/II** = 1.3:1

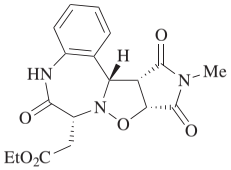
762

TABLE 6. INTERMOLECULAR CYCLOADDITIONS OF *n*-MEMBERED CYCLIC NITRONES ($n > 6$) (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{11} 		Alkene (xs), sealed tube, neat, 110°, 10 d	 (23) +  (19)	335, 763, 764
		Alkene (1 eq), THF, 66°, 18 h	 (64) +  (26)	187, 338
 *j*		Alkene (1 eq), toluene, 110°, 18 h	 (9) +  (73)	187, 338
		Alkene (1 eq), toluene, 110°, 18 h	 **I** +  **II**	187, 338

R	**I**	**II**
MeO_2C	(65)	(31)
PhO_2S	(64)	(24)

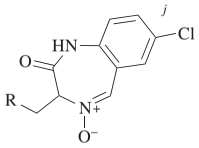




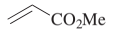
Alkene (1 eq), xylene, 138°, 8 h

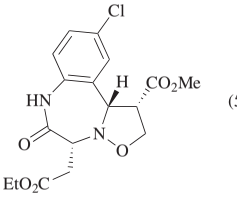
(89)

187, 338



R = CO_2Et

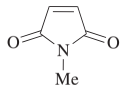


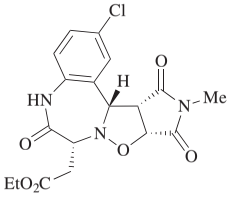


Alkene (1 eq), toluene, 110°, 18 h

(53)

187, 338

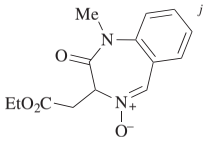


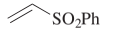


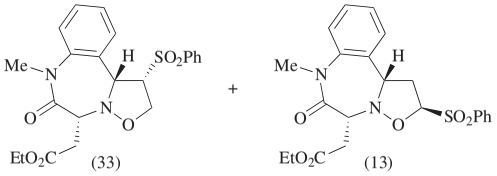
Alkene (1 eq), xylene, 138°, 8 h

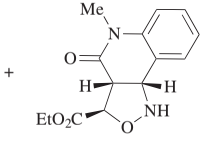
(69)

187, 338







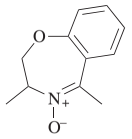
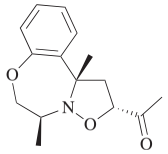
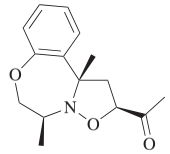
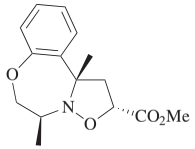
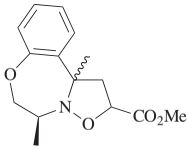
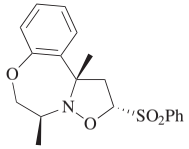
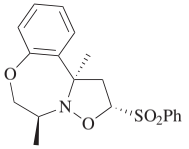
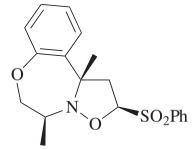


Alkene (1 eq), toluene, 110°, 18 h

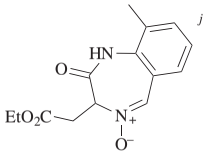
(33) + (13) + (53)

187

TABLE 6. INTERMOLECULAR CYCLOADDITIONS OF *n*-MEMBERED CYCLIC NITRONES ($n > 6$) (*Continued*)

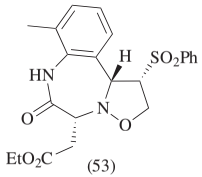
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{11}				
		Alkene (21 eq), hydroquinone (0.2 % w/v), toluene, reflux, 110 h	 (69) +  (17)	339
		Alkene (100 eq), hydroquinone (0.2 % w/v), toluene, reflux, 110 h	 (56) +  (20)	339
		Alkene (1.3 eq), toluene, reflux, 120 h	 (20) +  (14) +  (8)	339

C_{12}

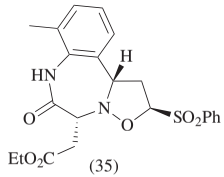




Alkene (1 eq), toluene, 110°, 18 h



(53) +

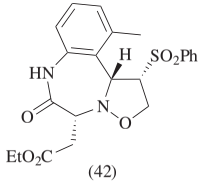


(35)

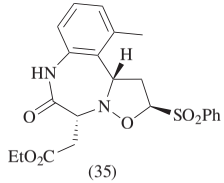
187



Alkene (1 eq), toluene, 110°, 18 h



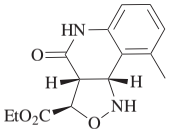
(42) +



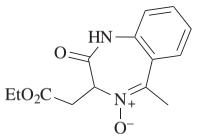
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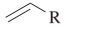
187

+

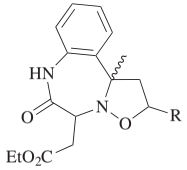


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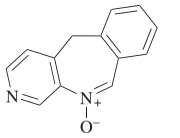
Alkene (xs), neat



R	Temp (°)		
Ac	81	(77)	
MeO_2C	80	(73)	

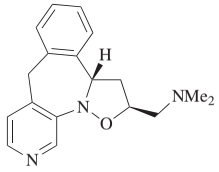
338

C_{13}





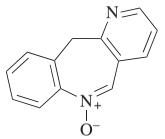
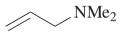
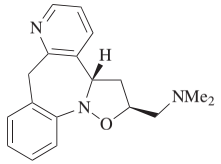
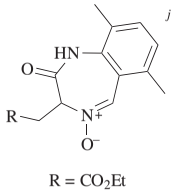
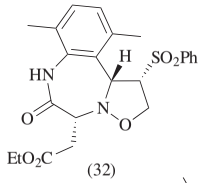
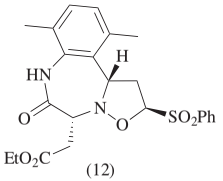
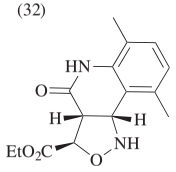
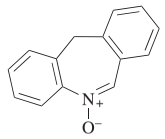
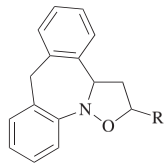
Sealed tube, THF, 80°, overnight



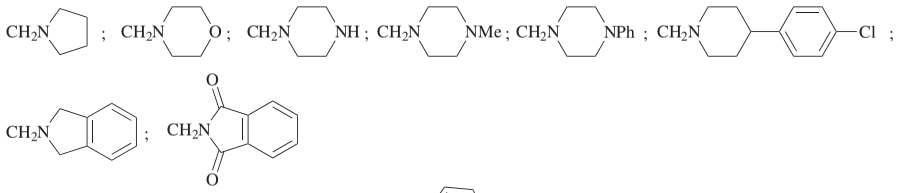
(70)

765

TABLE 6. INTERMOLECULAR CYCLOADDITIONS OF *n*-MEMBERED CYCLIC NITRONES ($n > 6$) (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{13}				
		Sealed tube, THF, 65°, 5 h	 (52)	765
 R = CO_2Et		Alkene (1 eq), toluene, 110°, 18 h	 (32) +  (12) +  (49)	187
C_{14}				
		Sealed tube, toluene, 100–120°, 16 h	 (28–79)	337

R = CH_2NMe_2; $(CH_2)_2NMe_2$; $(CH_2)_3NMe_2$; $(CH_2)_4NMe_2$; CH_2NEt_2; $CH_2Ni\text{-}Pr_2$; $CH_2N(COCF_3)Me$; $CONMe_2$;



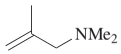
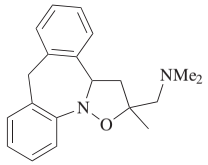
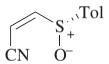
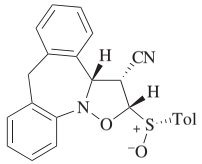
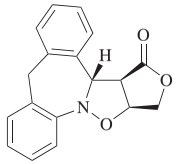
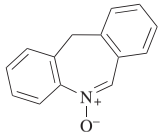
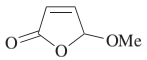
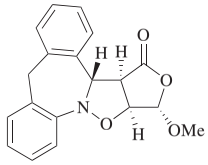
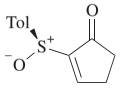
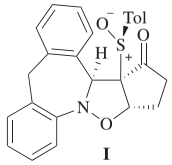
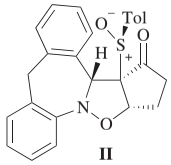
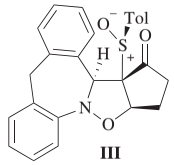
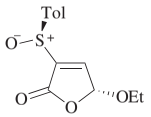
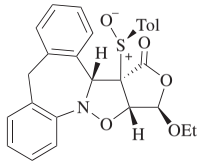
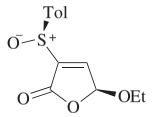
	Sealed tube, toluene, 100–120°, 16 h		(—)	337
 non-racemic	$MgBr_2$, NH_4Cl, rt, 30 min		(50)	518
	Alkene (1 eq), Ar, $CHCl_3$, rt, 18 h		(92)	766

TABLE 6. INTERMOLECULAR CYCLOADDITIONS OF *n*-MEMBERED CYCLIC NITRONES ($n > 6$) (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{14}				
		$CHCl_3$, rt, 2 h	 (84)	766, 767
	 non-racemic	Alkene (0.8 eq), $CHCl_3$	 **I** +  **II**	631
			 **III**	

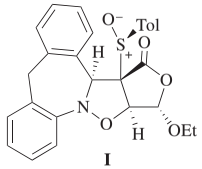
Temp	Time (h)	**I + II + III**	**I/II/III**
rt	2.5	(—)	62:30:8
rt	20	(76)	57:32:11
60°	2.5	(93)	55:33:14

	 non-racemic	$CHCl_3$, rt, 5 min	 (85)	767



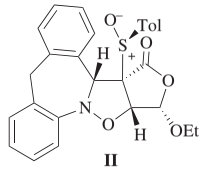
non-racemic

See table.



I

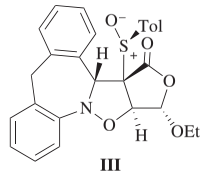
+



II

767

+

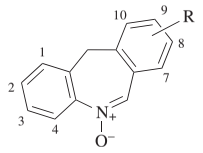


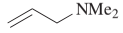
III

I + **II** + **III** (—)

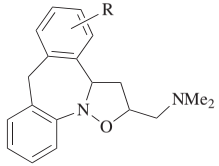
Solvent	Temp	Time	**I/II/III**
$CHCl_3$	rt	10 min	43:38:19
$CHCl_3$	rt	1 h	54:34:12
$CHCl_3$	rt	18 h	70:22:8
toluene	100°	5 min	72:19:9

$C_{14–15}$





Sealed tube,
toluene, 100°, 16 h

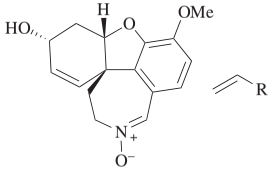
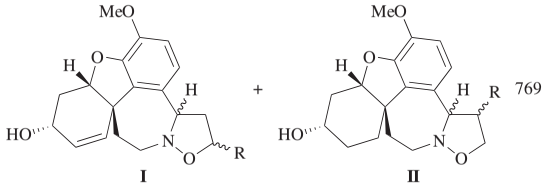
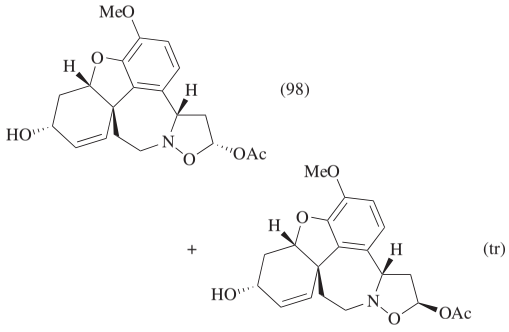


(30–65)

768

R = 1-F; 2-F; 3-F; 7-F; 8-F; 10-F; 3,8-F_2; 3-Cl; 4-Cl; 9-Cl; 10-Cl; 3-Br; 8-OMe; 1-Me; 3-Me; 7-Me; 9-Me; 7-CF_3; 8-CF_3; 10-CF_3

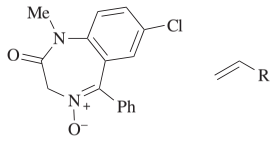
TABLE 6. INTERMOLECULAR CYCLOADDITIONS OF *n*-MEMBERED CYCLIC NITRONES ($n > 6$) (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{15}				
 non-racemic		Alkene (1 eq), toluene, reflux	 **I** + **II**	769
		Alkene (4 eq), toluene, rt, 96 h		769

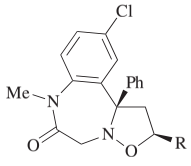
R	Time (h)	**I** + **II**
NC–	2	(97)
MeO_2C	48	(99)

(98)

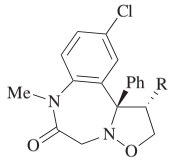
\+ (tr)



Alkene (30 eq), 70°



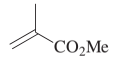
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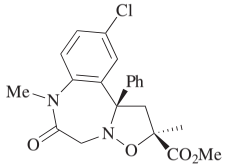
770

I **II**

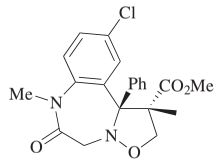
R	Time (h)	**I + II**	**I/II**
NC–	3	(60)	42:58
NC–	15	(70)	50:50
NC–	24	(90)	60:40
NC–	48	(90)	73:37
MeO_2C	3	(54)	30:70
MeO_2C	15	(65)	40:60
MeO_2C	24	(70)	50:50
MeO_2C	48	(80)	65:35



Alkene (30 eq), 70°



+

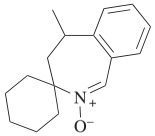
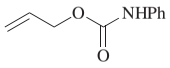
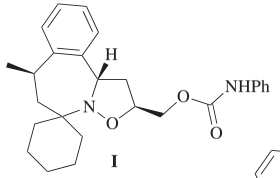
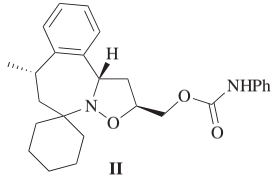
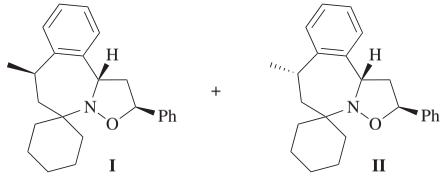
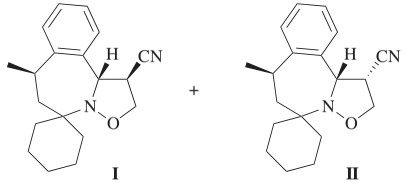


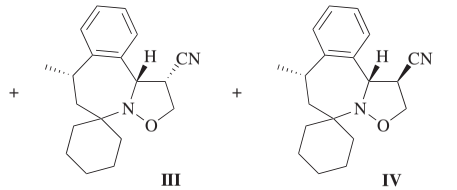
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I **II**

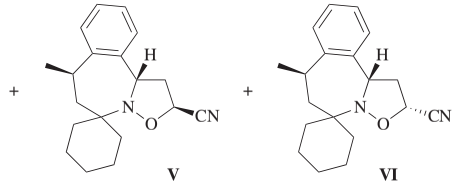
Time (h)	**I + II**	**I/II**
3	(50)	70:30
15	(70)	77:23
24	(90)	97:3
48	(95)	**I** only

TABLE 6. INTERMOLECULAR CYCLOADDITIONS OF *n*-MEMBERED CYCLIC NITRONES ($n > 6$) (*Continued*)

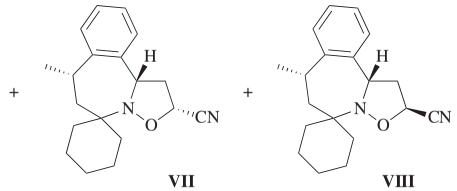
Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{16}				
		Alkene (1 eq), toluene, 105°, 5 h	 **I** +  **II** **I** (63), **I** + **II** (89)	771
		Alkene (5 eq), toluene, 105°, 4 h	 **I** + **II** **I** + **II** (93), **I**/**II** = 1.2:1	772
		Alkene (*x* eq), solvent	 **I** + **II**	773



III **IV**



V **VI**

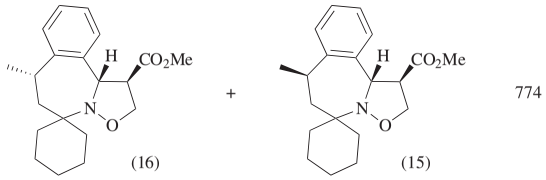


VII **VIII**

x	Solvent	Temp (°)	Time (d)	**I – VIII**	**I/II/III/IV/V/VI/VII/VIII**
1.1	C_6D_6	20	7	(93)	16:15:5:17:16:3:17:11
3	toluene	105	1	(85)	34:6:2:25:7:7:7:12



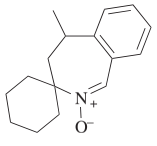
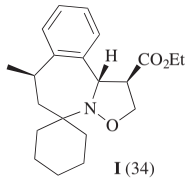
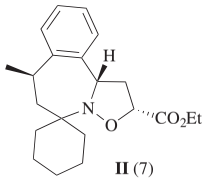
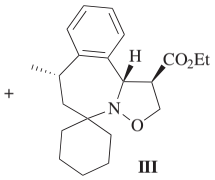
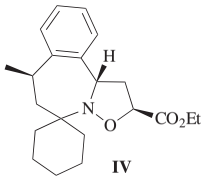
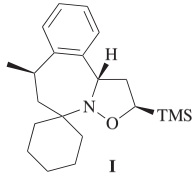
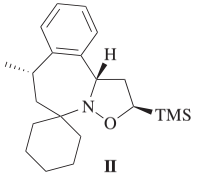
Alkene (10 eq), toluene, 110°



(16) (15)

774

TABLE 6. INTERMOLECULAR CYCLOADDITIONS OF *n*-MEMBERED CYCLIC NITRONES ($n > 6$) (*Continued*)

Nitrone	Alkene	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{16}				
		Alkene (10 eq), benzene, 80°	 **I** (34) +  **II** (7)	774
			+  **III** +  **IV**	
			III + **IV** (23), **III/IV** = 55:45	
		Alkene (xs), benzene, 80°, 14 h	 **I** +  **II**	775
			I + **II** (76), **I/II** = 1.7:1	

[a] The nitrone was generated by photolysis of azepan-1-ol and then directly trapped with dimethyl fumarate.

[b] The nitrone was employed as generated, by oxidation of the corresponding hydroxylamine with HgO, in dilute CH_2Cl_2 solution (0.12 M) to avoid polymerization.

[c] The nitrone was prepared by Ag(I)-catalysed cyclization of (*E*)/(*Z*)-octa-6,7-dienal oxime (1:1 mixture) and then directly trapped with the dipolarophile.

[d] The nitrone was produced by addition of PhSeBr to the oxime of 7-octen-2-one, followed by treatment with K_2CO_3, and was reacted with the dipolarophile without purification.

[e] The starting nitrone was generated in situ, together with its isomeric acyclic *N*-unsubstituted nitrone, by cyclization of the substrate *N*-allylamino-2,2-dimethylpropionaldehyde oxime acting also as the dipolarophile.

[f] The starting nitrone was generated in situ by reaction of 1-hydroxy-*cis,cis*-5-[(4-tolylsulfonyl)oxy]decahydroquinoline with sodium hydride in the presence of styrene.

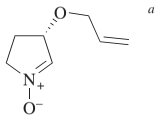
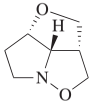
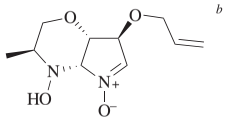
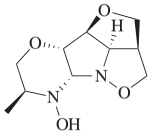
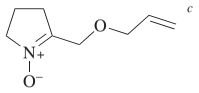
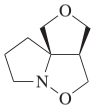
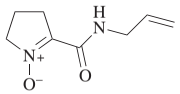
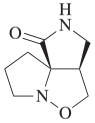
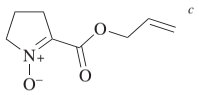
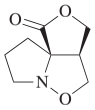
[g] The isoxazolidine was unstable and under went retrocycloaddition on standing at rt.

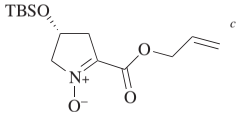
[h] The nitrone was generated in situ by PhSeBr-catalyzed cyclization of the alkenyloxime precursor and neutralization of the nitrone•HBr salt with Hünig's base.

[i] The nitrone was generated in situ by treatment of epoxycampholenaldoxime with $LiBF_4$.

[j] The nitrone was generated in situ by intramolecular Michael addition of the corresponding hydroxyimino methylacrylate precursor.

TABLE 7. INTRAMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES

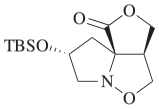
Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.
Three-atom tether			
C_7			
 *a*	CH_2Cl_2, rt, 14 h	 (90)	67
non-racemic			
 *b*	Toluene, reflux, 40 h	 (24)	776, 777
non-racemic			
C_8			
 *c*	MeCN, rt, 1 h	 (100)	349
	MeCN, reflux, 2 d	 (91)	778
 *c*	MeCN, rt, 4 h	 (79)	778

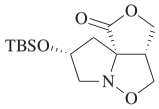


[c]

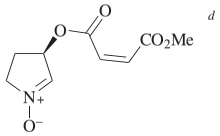
non-racemic

MeCN, rt, 4 h



(71) + 

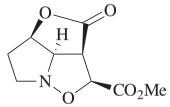
(28) 778



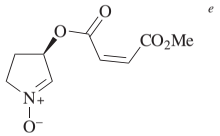
[d]

non-racemic

See table.[d]



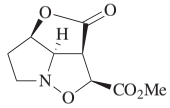
	Solvent	Temp (°)	Time (h)		
A	xylenes	140	6.5	(80)	354
B	1,2-dichlorobenzene	reflux	14	(70)	220
C	1,2-dichlorobenzene	170	1	(42)	354
D	1,2-dichlorobenzene	160	6.5	(81)	354
E	1,2-dichlorobenzene	160	7	(21)	354
F	xylenes	reflux	7	(42)	354



[e]

non-racemic

THF, 0°, 2 h



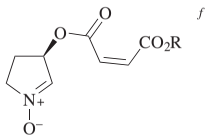
(70) er 77.0:23.0–85.0:15.0 220

TABLE 7. INTRAMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES (*Continued*)

Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.

Three-atom tether

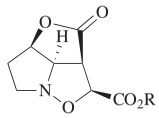
C_8



[f]

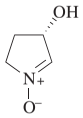
non-racemic

CAL-B (*x* wt %),[f] solvent



I

+

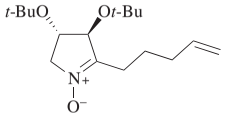


II

355, 357

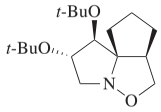
R	*x*	Solvent	Temp (°)	Time (h)	**I**	er **I**	**II**	er **II**
Me	150	toluene	10	12	(44)	88.0:12.0	(52)	62.0:38.0
Me	150	toluene	30	12	(65)	75.0:25.0	(tr)	—
Me	150	*i*-Pr_2O	30	24	(64)	73.0:27.0	(tr)	—
Me	150	THF	30	12	(45)	80.0:20.0	(tr)	—
Me	150	acetone	30	12	(21)	80.0:20.0	(21)	—
Me	150	MeCN	0	12	(53)	96.0:4.0	(43)	87.0:13.0
Me	150	MeCN	30	12	(27)	94.0:6.0	(tr)	94.0:6.0
Et	300	MeCN	0	8	(49)	97.0:3.0	(33)	89.0:11.0
Et	300	MeCN	5	12	(60)	95.0:5.0	(28)	98.0:2.0
Et	300	MeCN	10	17	(69)	93.0:7.0	(tr)	—

C_9



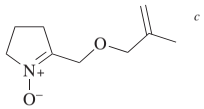
non-racemic

Toluene, 110°, 3 h



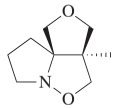
(98)

77



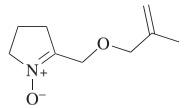
[c]

MeCN, rt, 36 h



I

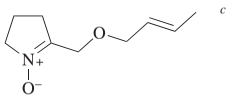
+



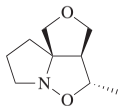
II

I + **II** (—), **I**/**II** = 4:1.5

349

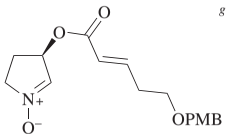


MeCN, rt



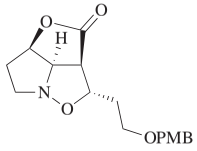
(66)

349



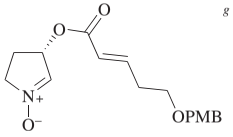
non-racemic

1,2-Dichlorobenzene[g]



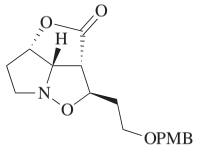
	Temp	Time (h)	
A	reflux	64	(71)
B	150°	3	(73)

60, 219



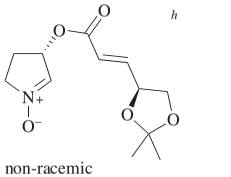
non-racemic

See table.



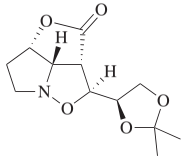
60

	Solvent	Temp	Time (h)	
A	1,2-dichlorobenzene	reflux	14	(31)
B	1,2-dichlorobenzene	150°	3	(53)
C	2-xylene	reflux	1	(84)



non-racemic

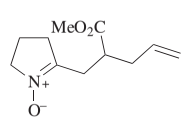
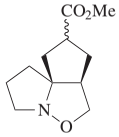
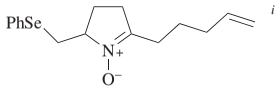
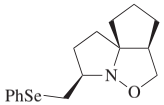
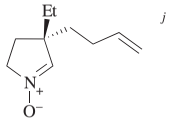
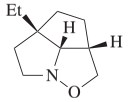
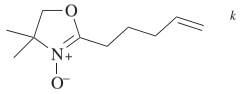
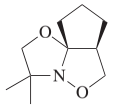
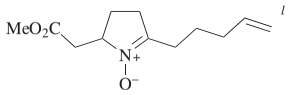
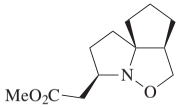
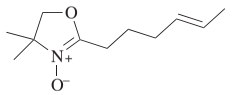
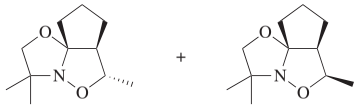
Xylenes, reflux, 10 min



(84)

356

TABLE 7. INTRAMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES (*Continued*)

Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.
Three-atom tether			
C_{10} 	Xylene, 140°, 20 h	 (69) dr 55:45	547
 *i*	MeCN, 90°, 6 h	 (35)	201
 *j*	Toluene, 110°, 2h	 (89)	779
 *k*	THF, 66°, 4 h	 (85)	133
C_{11}  *l*	Wet xylene, 140°, 16 h	 (82)	350, 351
 *k*	Toluene, 110°, 1.5 h	 **I** + **II** **I + II** (62), **I/II** = 90:10	133

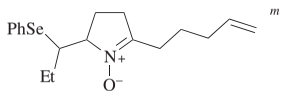
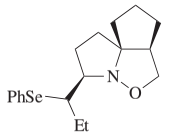
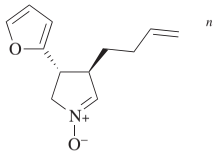
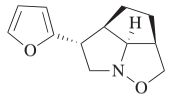
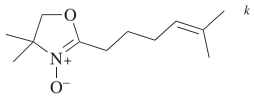
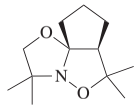
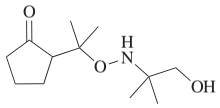
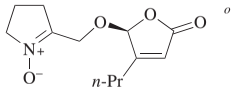
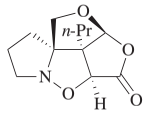
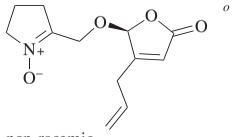
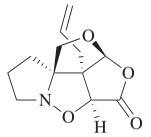
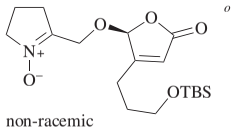
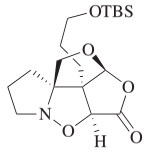
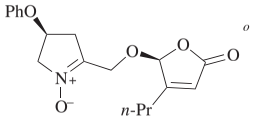
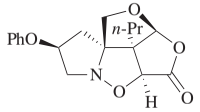
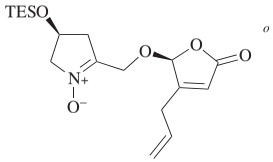
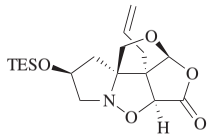
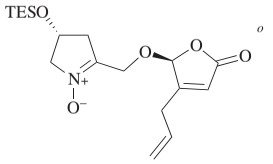
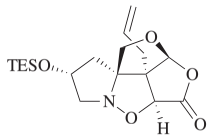
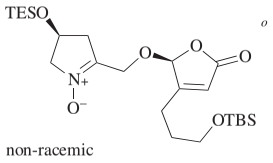
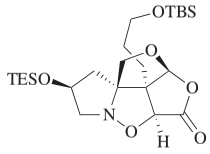
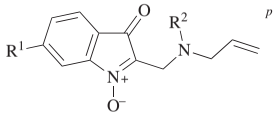
C_{12}	 *m*	MeCN, 80°, 5 h	 (61)	199, 201
	 *n* non-racemic	H_2O, $NaHCO_3$ (pH 6), rt, 12 h	 (62)	170
	 *k*	Toluene, 110°, 2.5 h	 (35) +  (53)	133
	 *o* non-racemic	CH_2Cl_2, 0°, 10 min; then rt, 12 h	 (65)	353
	 *o* non-racemic	CH_2Cl_2, 0°, 10 min; then rt, 12 h	 (68)	353
	 *o* non-racemic	CH_2Cl_2, 0°, 10 min; then rt, 12 h	 (57)	353

TABLE 7. INTRAMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES (*Continued*)

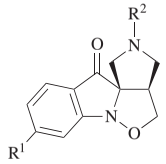
	Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.
	Three-atom tether			
C_{12}	 non-racemic	CH_2Cl_2, 0°, 10 min; then rt, 12 h	 (63)	353
	 non-racemic	CH_2Cl_2, 0°, 10 min; then rt, 12 h	 (57)	353
	 non-racemic	CH_2Cl_2, 0°, 10 min; then rt, 12 h	 (65)	353
	 non-racemic	CH_2Cl_2, 0°, 10 min; then rt, 12 h	 (68)	353

$C_{12–13}$



p

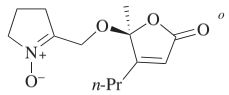
CH_2Cl_2, rt, 4 h



R^1	R^2	
H	Boc	(71)
H	Ac	(65)
H	Ms	(13)
H	Ts	(26)
MeO	Boc	(79)
Cl	Boc	(22)
Me	Boc	(73)

253

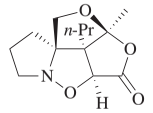
C_{13}



o

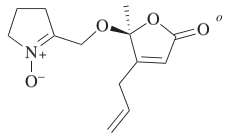
non-racemic

CH_2Cl_2, 0°, 10 min; then rt, 12 h



(70)

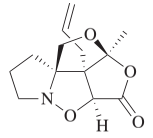
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o

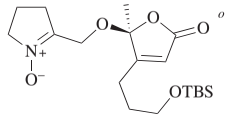
non-racemic

CH_2Cl_2, 0°, 10 min; then rt, 12 h



(70)

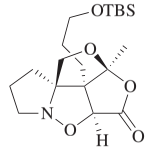
353



o

non-racemic

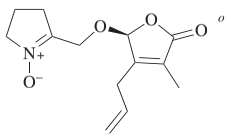
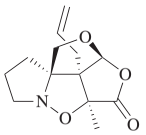
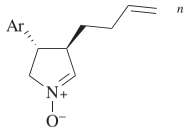
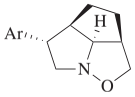
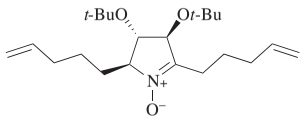
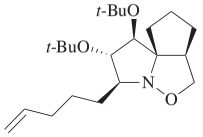
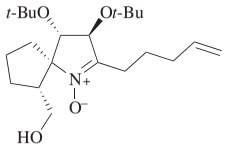
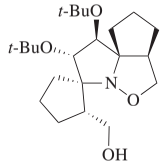
CH_2Cl_2, 0°, 10 min; then rt, 12 h

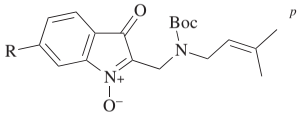


(68)

353

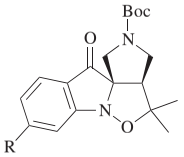
TABLE 7. INTRAMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES (*Continued*)

	Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.
	Three-atom tether			
C_{13}	 non-racemic	CH_2Cl_2, 0°, 10 min; then rt, 12 h	 (60)	353
C_{14}	 non-racemic	H_2O, $NaHCO_3$ (pH 6), rt, 12 h	 Ar: Ph (68); 4-$MeOC_6H_4$ (65); 4-BrC_6H_4 (70)	170
	 non-racemic	Toluene, 110°, 6 h	 (96)	77
	 non-racemic	Toluene, 110°, 10 h	 (75)	77



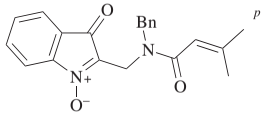
p

CH_2Cl_2, rt, 4 h



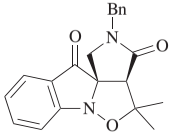
R	
H	(77)
MeO	(79)

253



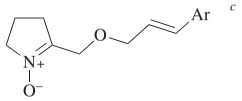
p

CH_2Cl_2, rt, 4 h



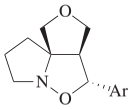
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253



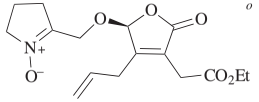
c

MeCN, rt



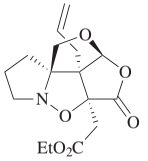
Ar	
Ph	(100)
4-BrC_6H_4	(100)

349



o

CH_2Cl_2, 0°, 10 min; then rt, 12 h

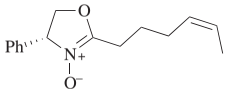


(60)

353

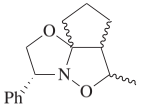
non-racemic

C_{15}



q

Toluene, 80°

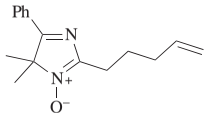
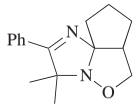
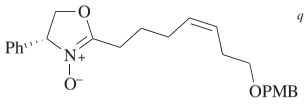
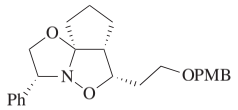
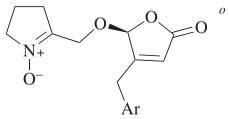
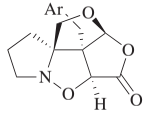
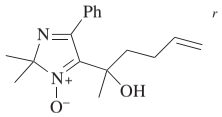
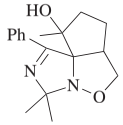
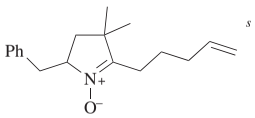
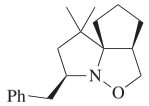


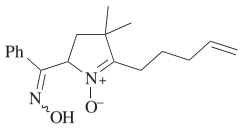
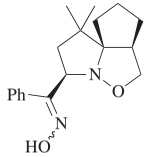
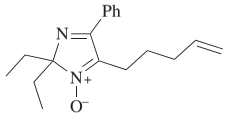
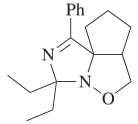
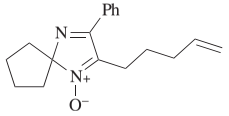
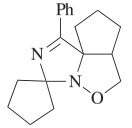
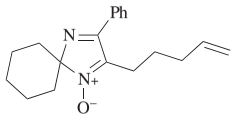
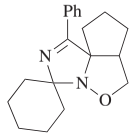
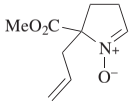
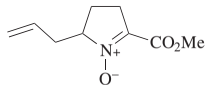
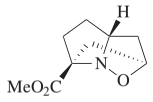
(50)

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non-racemic

TABLE 7. INTRAMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES (*Continued*)

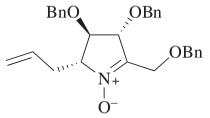
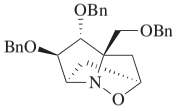
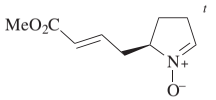
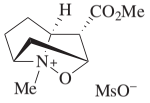
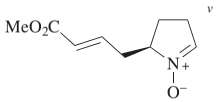
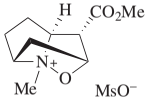
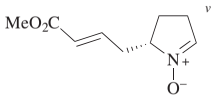
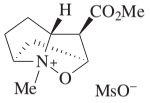
	Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.
	Three-atom tether			
C_{16}		Toluene, 110°, 50–70 h; or MW, 170°, 0.5–1 h	 (70)	780
	 *q*	Toluene, 75°, 18 h	 (56)	352, 781
	non-racemic			
	 *o*	CH_2Cl_2, 0°, 10 min; then rt, 12 h	 Ar: Ph (62); 3,4-$(MeO)_2C_6H_3$ (58)	353
	non-racemic			
C_{17}	 *r*	$CHCl_3$, rt, 3 d	 (72)	223
C_{18}	 *s*	Chlorobenzene, 120°, 36 h	 (83)	190

 (*Z*)/(*E*) = 0.78:1	Chlorobenzene, 120°, 10 h		(80) (*Z*)/(*E*) = 1.37:1	205
	Toluene, 110°, 50–70 h; or MW, 170°, 0.5–1 h		(90)	780
	Toluene, 110°, 50–70 h; or MW, 170°, 0.5–1 h		(81)	780
C_{19}				
	Toluene, 110°, 50–70 h; or MW, 170°, 0.5–1 h		(75)	780
Four-atom tether				
	Sealed tube, solvent	 + 		249

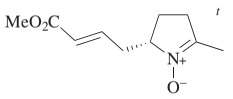
I **II**

Solvent	Temp (°)	Time (h)	**I** + **II**	**I**/**II**
DMSO	70	6	(100)	60:40
toluene	120	36	(100)	**II** only

TABLE 7. INTRAMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES (*Continued*)

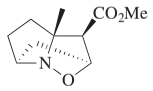
	Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.
	Four-atom tether			
C_8	 non-racemic	Sealed tube, toluene, 120°, 14 h	 (97)	248
	 non-racemic	1. Al(O*t*-Bu)$_3$ (0.5 eq), dry toluene, rt, 6 h; then reflux, 96 h 2. $MeSO_3Me$ (xs), Ar, CH_2Cl_2, reflux, 24 h	 (98)[a]	129
	 non-racemic	1. Al(O*t*-Bu)$_3$ (0.5 eq), sealed vial, toluene, rt, 4 h; then 150°, 64 h 2. $MeSO_3Me$ (xs), Ar, CH_2Cl_2, reflux, 24 h	 (45)[a]	367
	 non-racemic	1. Al(O*t*-Bu)$_3$ (0.5 eq), sealed vial, toluene, rt, 4 h; then 150°, 64 h 2. $MeSO_3Me$ (xs), Ar, CH_2Cl_2, reflux, 24 h	 (44)[a]	367

C_9



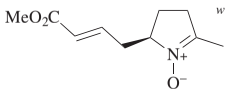
non-racemic

$Al(Ot\text{-}Bu)_3$ (*x* eq), toluene, 110°



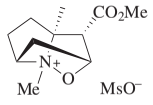
x	Time (h)	
0	24	(20)
0	48	(50)
0.1	24	(25)
0.5	72	(70)
1	72	(40)

129, 366



non-racemic

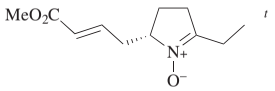
1. $Al(Ot\text{-}Bu)_3$ (0.5 eq), sealed vial, toluene, rt, 4 h; then 150°, 64 h
2. $MeSO_3Me$ (xs), Ar, CH_2Cl_2, reflux, 24 h



(72)[a]

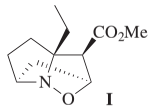
367

C_{10}



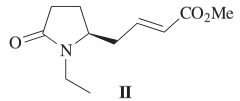
non-racemic

$Al(Ot\text{-}Bu)_3$ (*x* eq), toluene, 110°



I

+

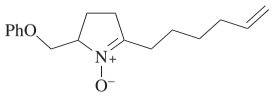


II

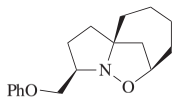
x	Time (h)	**I**	**II**
0	48	(—)	(32)[x]
0.5	96	(64)	(—)

366

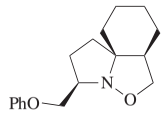
C_{11}



3-Xylene, 150°, 48 h

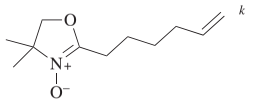
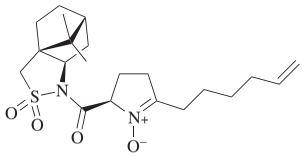
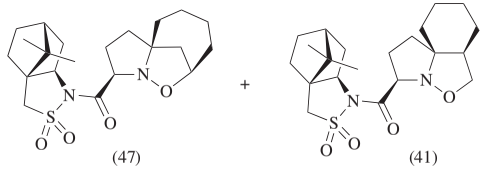
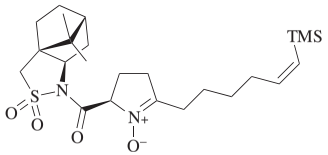
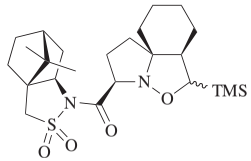
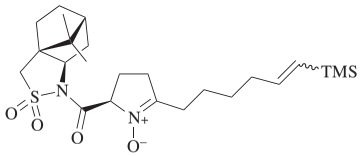
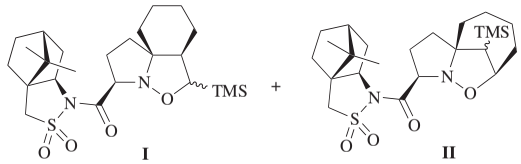


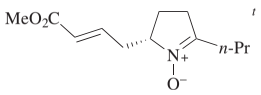
(47) + (22)



153, 359

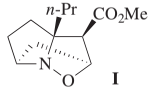
TABLE 7. INTRAMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES (*Continued*)

	Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.
	Four-atom tether			
C_{11}		Toluene, 110°, 10 h	 (49) + (16)	133
	 non-racemic	Toluene (0.01 M), reflux, 16 h	 (47) + (41)	360
	 non-racemic	Benzene, 80°, 144 h	 (62)	361
	 non-racemic (*E*)/(*Z*) = 75:25	Benzene, 80°, 208 h	 **I** + **II** **I** + **II** (63), **I**/**II** = 85:15[y]	361



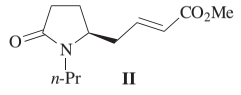
non-racemic

Al(O*t*-Bu)$_3$ (*x* eq), toluene, 110°



I

+

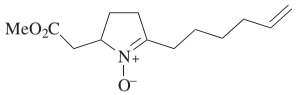


II

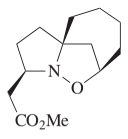
129, 366

x	Time (h)	**I**	**II**
0	48	(—)	(40)[x]
0.5	72	(68)	(—)

C_{12}

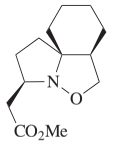


DMF, 110°, 30 h



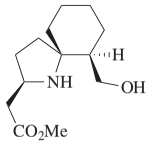
I

+



II

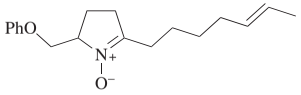
+



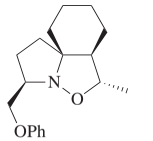
III

350

I + II + III (65), **I/II/III** = 6:4:1

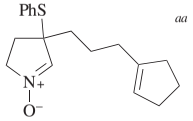


Toluene, 120°, 72 h

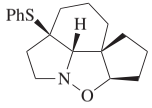


(15)[z]

359



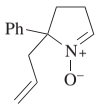
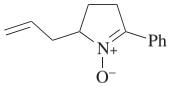
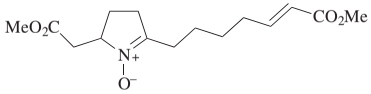
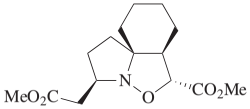
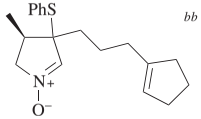
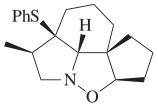
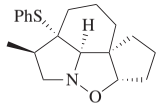
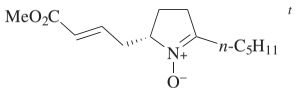
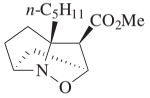
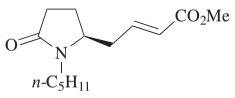
Toluene, 110°, 16 h

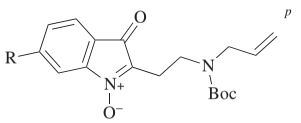


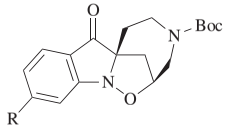
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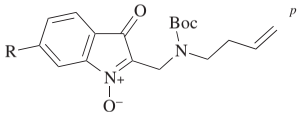
362

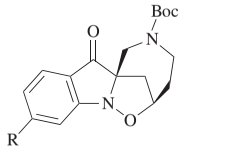
TABLE 7. INTRAMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES (*Continued*)

Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.
Four-atom tether			
C_{13} 	Sealed tube, solvent	 +  **I** **II**	249
		Solvent / Temp (°) / Time (h) / **I + II** / **I/II**: DMSO / 70 / 6 / (100) / 86:14; toluene / 120 / 36 / (100) / **II** only	
	MeCN, reflux, 16 h	 (75)	350
 *bb* non-racemic	Toluene, 110°, 16 h	 +  **I** **II** **I + II** (80), **I/II** = 70:30	362
 *t* non-racemic	Al(O*t*-Bu)$_3$ (*x* eq), toluene, 110°	 +  **I** **II**	366
		x / Time (h) / **I** / **II**: 0 / 48 / (—) / (62)[x]; 0.5 / 96 / (68) / (—)	

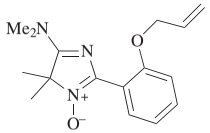


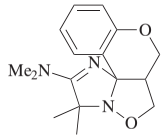
CH_2Cl_2, rt, 4 h		R H (47) MeO (53)	253

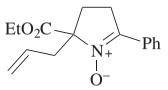


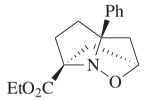
CH_2Cl_2, rt, 4 h		R H (73) MeO (77)	253

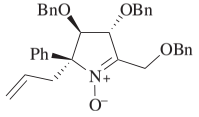
C_{14}

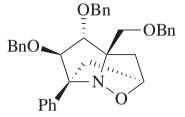
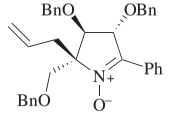


Toluene, 110°, 20 h		(96)	782



Toluene, reflux, 4 d		(79)	363, 364, 365



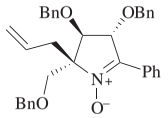
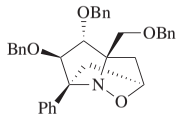
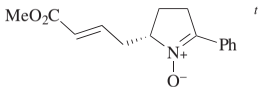
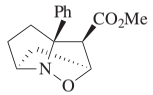
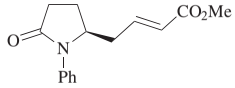
Sealed tube, toluene, 120°	 + 		248, 249

non-racemic

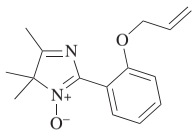
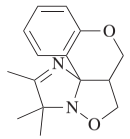
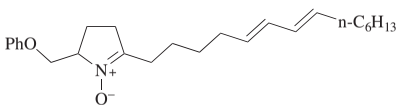
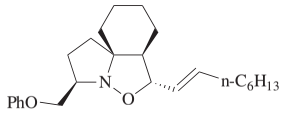
I **II**

Time (h)	**I**	**II**
14	(62)	(38)[cc]
36	(100)	(—)

TABLE 7. INTRAMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES (*Continued*)

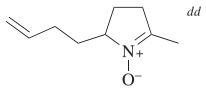
	Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.
	Four-atom tether			
C_{14}		Sealed tube, toluene, 120°, 36 h	 (100)	249
	non-racemic			
		$Al(O\textit{t}\text{-}Bu)_3$ (x eq), toluene, 110°	 + 	366
	non-racemic		**I** **II**	

x	Time (h)	**I**	**II**
0	48	(—)	$(50)^x$
0.5	72	(50)	(40)

C_{15}		Toluene, 110°, 20 h	 (95)	782
C_{19}		Sealed tube, DMSO, 195°, 16 h	 (63)	153, 359

Five-atom tether

C_9



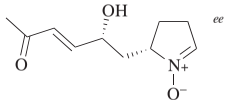
Sealed tube, degassed toluene, 140°, 20 h



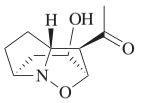
(52)

172

C_{10}



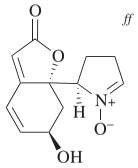
CH_2Cl_2, reflux, 18.5 h



(71)

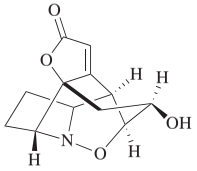
288

C_{12}



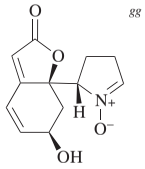
non-racemic

DCE, AcOH, 45°, 4 h



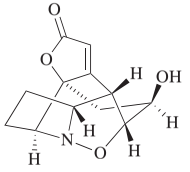
(76)

369



non-racemic

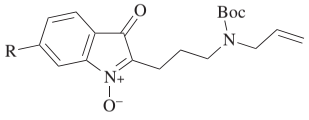
CH_2Cl_2, –78 to 0°, 2 h



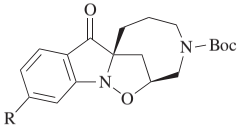
(92)

368

C_{14}



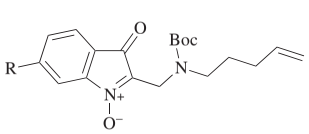
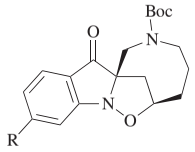
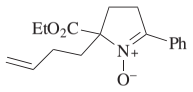
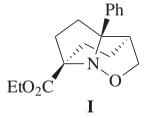
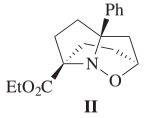
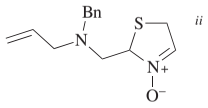
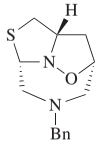
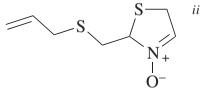
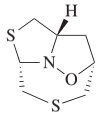
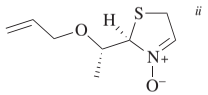
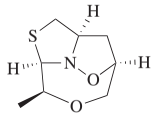
CH_2Cl_2, rt, 4–6 h



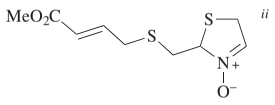
R	
H	(19)[hh]
MeO	(22)[hh]

253

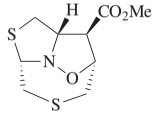
TABLE 7. INTRAMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES (*Continued*)

	Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.
	Five-atom tether			
C_{14}		CH_2Cl_2, rt, 4–6 h	 R: H (61)[hh]; MeO (64)[hh]	253
C_{15}		Solvent, reflux, 2 d	 +  **I** + **II**	363, 364
			Solvent: toluene **I** (84) **II** (5); xylene **I** (65) **II** (28)	
	Six-atom tether			
C_7	 *ii*	CH_2Cl_2, rt, 48 h	 (75)	783
	 *ii*	CH_2Cl_2, rt, 48 h	 (25)	783
C_8	 *ii* non-racemic	CH_2Cl_2, rt, 48 h	 (52)	783

C_8



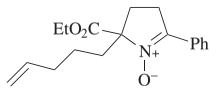
CH_2Cl_2, rt, 48 h



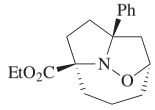
(39)

783

C_{16}



Toluene, reflux, 3 d



(77)

363, 364

---

[a] The nitrone was generated in situ, together with its regioisomer, by oxidation of *O*-allyl-*N*-hydroxypyrrolidine with yellow HgO in CH_2Cl_2.

[b] The nitrone was generated starting from (2*R*,3*R*)-diethyl 2,3-bis(allyloxy)succinate (2 steps).

[c] The nitrone was generated in situ by oxidation of the corresponding hydroxylamine with NMO/TPAP (cat.).

[d] The nitrone was generated in situ by cycloreversion of the corresponding cycloadducts with methyl acrylate (**A**), styrene (**B**), methyl cynnamate (**C**), dimethyl fumarate (**D**), REM resin (**E**), and monomethylmaleate supported on hydroxymethyl polystyrene (1% DVB) (**F**).

[e] The nitrone was generated in situ by reaction of (*S*)-3-hydroxypyrroline-1-oxide with maleic acid monomethyl ester, PPh_3, and DEAD.

[f] The nitrone was generated in situ by *Candida antarctica* lipase, fraction B (CAL-B) catalyzed esterification with kinetic resolution of racemic 3-hydroxypyrroline 1-oxide with the ethyl ketene acetal of the monomethyl or monoethyl ester of maleic acid.

[g] The nitrone was generated in situ by cycloreversion of an isomeric mixture of styrene adducts (**A**), ethyl acrylate adducts (**B**), and fumaro nitrile adducts (**C**).

[h] The nitrone was generated in situ by retrocycloaddition of (4*S*)-2,3-dicyanohexahydropyrrolo[1,2-*b*]isoxazol-4-yl(2*E*)-3-[(4*S*)-2,2-dimethyl-1,3-dioxolan-4-yl]acrylate.

[i] The nitrone was generated in situ by addition of PhSeBr to deca-1,9-dien-5-one oxime followed by treatment with K_2CO_3.

[j] The nitrone was generated in situ by reaction of 2-(2-chloroethyl)-2-ethylhex-5-enal with $NH_2OH{\bullet}HCl$ in the presence of DIPEA.

[k] The nitrone was generated in situ from the corresponding oxaziridine.

[l] The nitrone was generated in situ by reaction of methyl (2*E*)-6-oxoundeca-2,10-dienoate with $NH_2OH{\bullet}HCl$ in the presence of NaOAc.

TABLE 7. INTRAMOLECULAR CYCLOADDITIONS OF 5-MEMBERED CYCLIC NITRONES (*Continued*)

[m] The nitrone was generated in situ by addition of PhSeBr to dodeca-1,9-dien-6-one oxime followed by treatment with K_2CO_3.

[n] The nitrone was generated in situ by organocatalyzed Michael addition of 5-hexanal to the appropriate nitroalkene in H_2O, followed by reduction of the nitro group to the oxime by Zn/AcOH and cyclization.

[o] The nitrone was generated in situ by *m*-CPBA oxidation of the tricyclic hexahydro-3,4-dioxa-8a-aza-*as*-indacen-2-one precursor (Cope elimination) in the presence of K_2CO_3.

[p] The nitrone was generated in situ by treatment of the corresponding 2-nitroalkyne with catalytic $AuCl(PPh_3)$ (10 mol %) and $AgSbF_6$ (20 mol %) in CH_2Cl_2 at 0° and then at rt.

[q] The nitrone was generated in situ by condensation of the appropriate trimethyl orthoester with *N*-hydroxy-2-phenylglycinol hydrochloride, followed by neutralization with Et_3N.

[r] The nitrone was generated in situ by alkylation of lithiated 2,2-dimethyl-4-phenyl-2*H*-imidazole 1-oxide with allylacetone.

[s] The starting nitrone was generated in situ by intramolecular cyclization of (*E*,*E*)-4,4-dimethyl-1-phenyldeca-1,9-dien-5-one oxime by treatment with K_3PO_4 (0.1 eq) under the reaction conditions.

[t] The nitrone was generated by oxidation of the corresponding imine with UHP/$MeReO_3$ (cat.) and used without purification.

[u] The primary cycloadduct was not isolated.

[v] The nitrone was generated by intramolecular condensation of 5-hydroxyamino-8-oxo-oct-2-enoic acid methyl ester and used without purification.

[w] The nitrone was generated by intramolecular condensation of 5-hydroxyamino-8-oxo-non-2-enoic acid methyl ester and used without purification.

[x] This product is derived from a rearrangement of the nitrone via oxaziridine formation.

[y] Unreacted *E*-vinylsilane was recovered in 25% yield.

[z] The structure was tentatively assigned. The yield based on recovered nitrone was 38%.

[aa] The nitrone was generated in situ by cyclization of 2-(2-chloroethyl)-5-cyclopentenyl-2-(phenylthio)pentanal oxime.

[bb] The nitrone was generated in situ by cyclization of 2-[(*S*)-1-chloropropan-2-yl]-5-cyclopentenyl-2-(phenylthio)pentanal oxime.

[cc] Nitrone **II** derives from a 2-aza-Cope rearrangement of the original nitrone and was the only product formed after heating at 80°.

[dd] The nitrone was generated in situ by rearrangement of (2*R**,5*R**)-1-hydroxy-2-methyl-5(4-trimethylsilyl-3-butynyl)pyrrolidine.

[ee] The nitrone was generated in situ by oxidation of (*E*)-4-(hexahydropyrrolo[1,2-*b*]isoxazol-2-yl)-3-buten-2-ol with *m*-CPBA and K_2CO_3 in CH_2Cl_2.

[ff] The nitrone was generated in situ by oxidation of (6*R*,11a*R*,11b*R*)-9,10,11,11a-tetrahydro-6,11b-methanofuro[2,3-*d*]pyrrolo[1,2-*b*][1,2]-oxazocin-2(6*H*)one with *m*-CPBA, DCE, and AcOH at 45°.

[gg] The nitrone was generated in situ by reaction of the corresponding hydroxylamine with DBU (2 eq), *N*-*tert*-butylbenzenesulfinimidoyl chloride (1.5 eq) in DCM at –78°.

[hh] The yield was calculated over a two-step process from the 2-nitroalkyne precursor of the nitrone.

[ii] The nitrone was generated by reaction of 2,5-dihydroxy-l,4-dithiane with the appropriate oxime in the presence of 4 Å MS.

TABLE 8. INTRAMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES

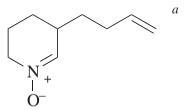
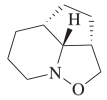
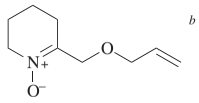
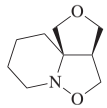
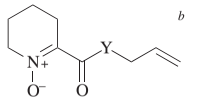
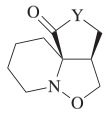
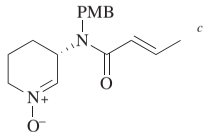
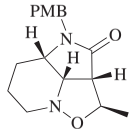
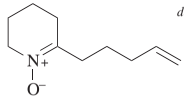
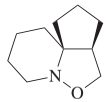
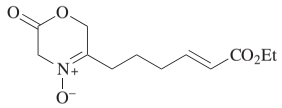
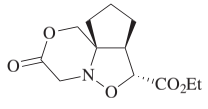
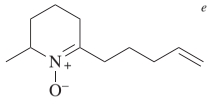
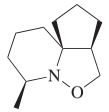
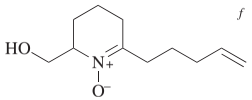
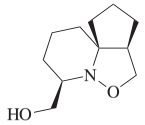
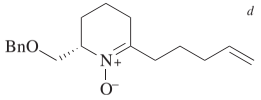
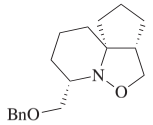
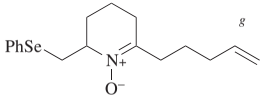
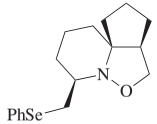
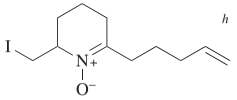
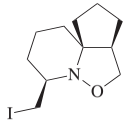
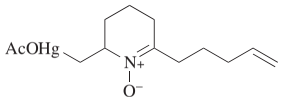
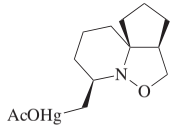
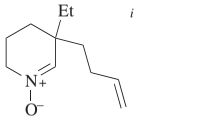
Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.
Three-atom tether			
C_9			
 *a*	Toluene, 110°, 1.5 h	 (71)	378
 *b*	MeCN, rt, 1 h	 (92)	349
 *b*	MeCN, rt, 4 h	 Y: HN (74), O (83)	778
 *c* non-racemic	THF, reflux, 0.5 h	 (84)	179
C_{10}			
 *d*	Sealed vial, toluene, 160°, 5 h	 (72)	431
	$MgSO_4$, K_2CO_3, toluene, 40°, 11 h	 (33)	784

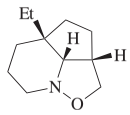
TABLE 8. INTRAMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES (*Continued*)

Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{11}			
 *e*	Benzene, 80°, 6 h	 (85)	370, 371
 *f*	Xylene, 140°, 6 h	 (90)	701, 702
 *d* non-racemic	Sealed tube, toluene, 190°, 9 h	 (100)	431
 *g*	MeCN, 80°, 5 h	 (65)	199, 201
 *h*	Benzene, reflux, 5 h	 (53)	191, 647
	MeCN, 80°, 6 h	 (65)	197

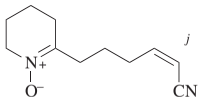


i

Toluene, reflux, 1 h

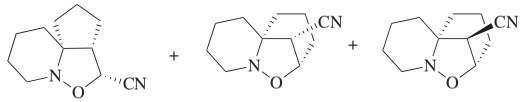


(67) 377

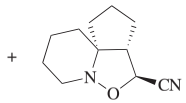


j

Toluene, 80°, 26 h

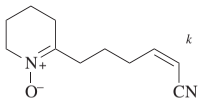


I + **II** + **III** 431



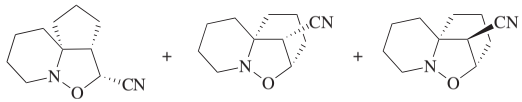
IV

I + **II** + **III** + **IV** (11)
I/II/III/IV = 36:23:23:18



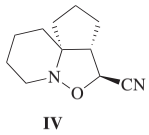
k

Sealed vial, solvent

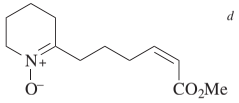


I + **II** + **III** 431

Solvent		Temp (°)	Time (h)	**I**	**II**	**III**	**II** + **III**	**IV**
toluene	—	100–160	5	(29)	(0)	(0)	(—)	(0)
toluene	—	185	3	(7)	(30)	(3)	(—)	(1)
ClC_6H_5	MW	150	0.5	(0)	(—)	(—)	(60)	(0)

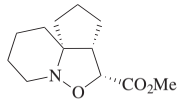


IV



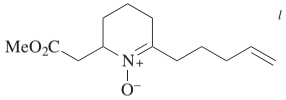
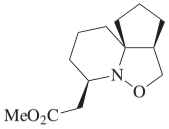
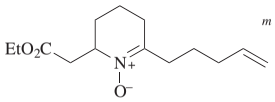
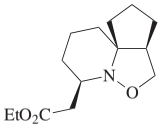
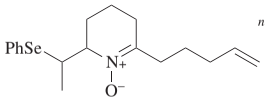
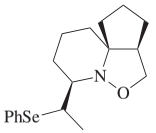
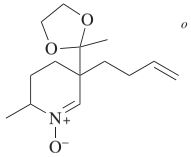
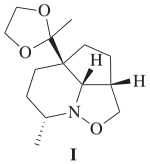
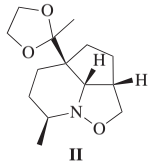
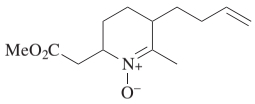
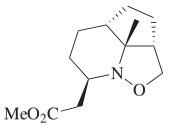
d

Sealed vial, toluene, MW, 140°, 1.6 h



(62) 431

TABLE 8. INTRAMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES (*Continued*)

	Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.
	Three-atom tether			
C_{12}	 *l*	DMF/H_2O (2:1), 100–105°, 1 h	 (70)	350
	 *m*	EtOH, reflux, 4 h	 (90)	785
	 *n*	MeCN, 80°, 5 h	 (25)	201
	 *o*	Xylene, reflux, 4 h	 **I** +  **II** **I + II** (58), **I/II** = 1.2:1	350, 699
		Toluene, reflux, 42 h	 (70)	350

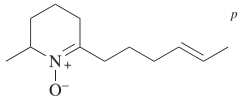
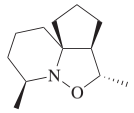
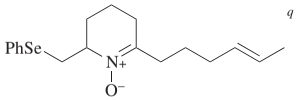
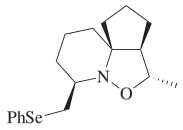
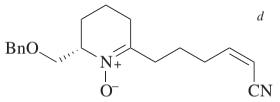
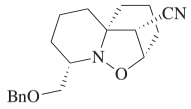
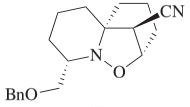
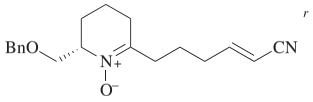
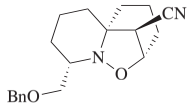
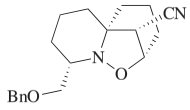
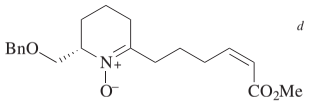
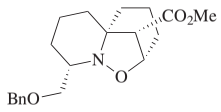
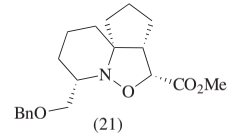
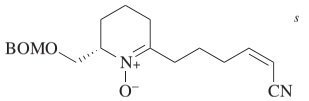
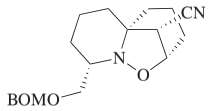
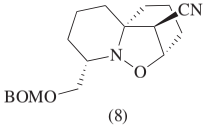
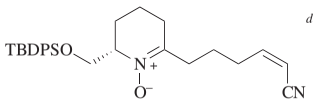
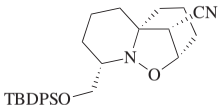
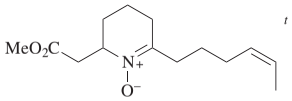
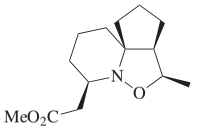
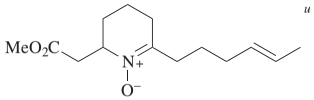
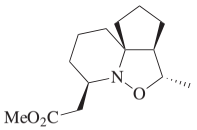
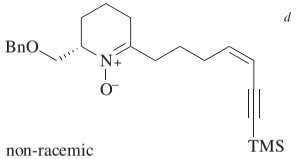
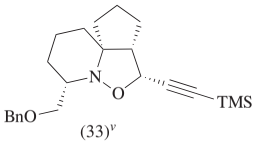
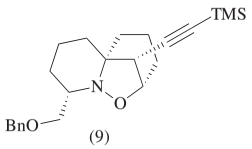
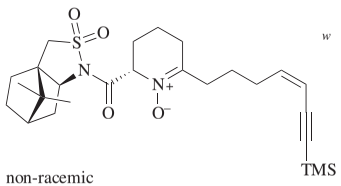
 *p*	Benzene, 80°, 6 h	 (82)		370, 371
 *q*	MeCN, 80°, 5 h	 (47)		201
 *d* non-racemic	Sealed vial, toluene, 190°, 3.5 h	 (82)	+  (7)	174, 218, 431
 *r* non-racemic	Sealed vial, toluene, 190°, 2.5 h	 (35)	+  (15)	431
 *d* non-racemic	Sealed vial, toluene, 190°, 4 h	 (53)	+  (21)	431
 *s* non-racemic	Sealed tube, toluene, 190°, 3.5 h	 (83)	+  (8)	218

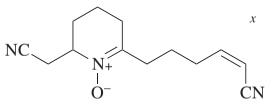
TABLE 8. INTRAMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES (*Continued*)

Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{12}			
 [d] non-racemic	Toluene/EtOH (6:1), MW, 184°	 (78)	430
C_{13}			
 [t]	Xylene/H_2O (10:1), 140°	 (—)	184
 [u]	Xylene/H_2O (10:1), 140°	 (92)	184
 [d] non-racemic	Sealed vial, toluene, 190°, 3 h	 (33)[v] +  (9)	431



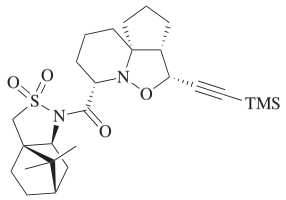
w

non-racemic



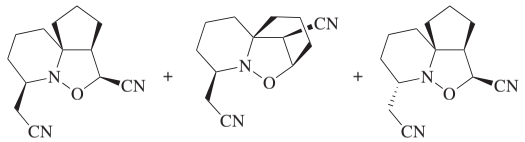
x

Toluene, reflux, 18 h, Ar



(83) 218

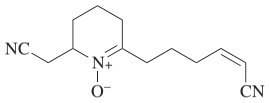
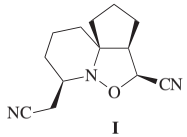
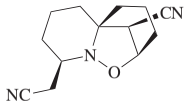
See table.

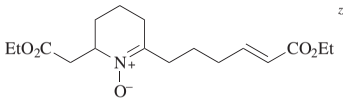
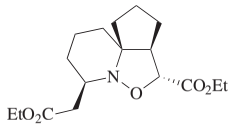


I **II** **III** 373

Reactor	Solvent	Temp (°)	Time (h)	Concn (mM)	**I/II/III**
—	toluene	reflux	3	—	52:30:18
—	chlorobenzene	reflux	3	—	33:18:34
sealed tube	toluene	160	2	7.1	14:25:23
sealed tube	toluene	160	2	9.3	24:17:35
sealed tube	chlorobenzene	180	2	—	10:27:13

TABLE 8. INTRAMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES (*Continued*)

	Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.
C_{13}	*Three-atom tether*			
		See table.	 **I** +  **II**	

Reactor	Solvent	Temp (°)	Time (h)	**I**	**II**	Refs.
—	MeOH	50	7	(90)[x]	(—)	373
—	MeOH/MeCN (10:1)	50	4	(89)[x]	(—)	372
—	MeCN	reflux	7	(54)[x]	(—)	374
—	chlorobenzene	180	2	(—)	(88)[x]	373
flow reactor, 200 mL min^{-1}, 100 psi	MeOH	50	—	(67)[x]	(—)	373a
flow reactor, 200 mL min^{-1}, 250 psi	MeOH	50; then 150	—	(—)	(48)[x]	373a
flow reactor, 350 mL min^{-1}, 100 psi	toluene	180 (MW)	—	(—)	(72)[y]	373a
sealed tube	toluene	160	2	(—)	(47)[x]	432
sealed tube	toluene	180	2.5	(—)	(95)[y]	372
sealed tube	toluene	190	3.5	(—)	(59)[x]	374
	 [z]	See table.		

Solvent	Temp	Time (h)		Refs.
MeCN	reflux	2	(88)	786
MeOH	rt	24	(62)	787
MeOH	reflux	24	(64)	788

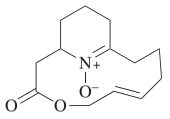
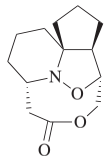
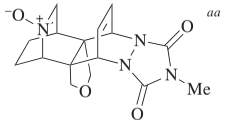
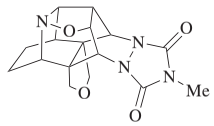
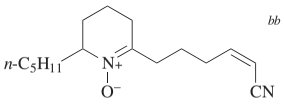
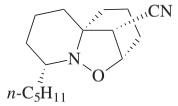
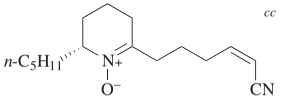
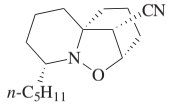
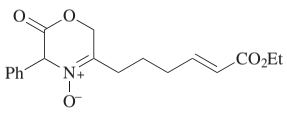
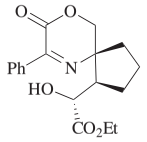
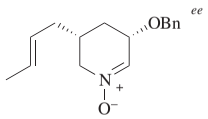
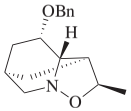
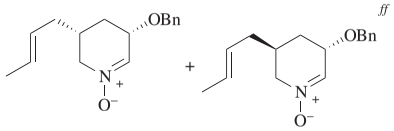
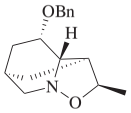
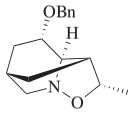
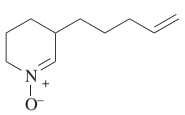
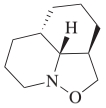
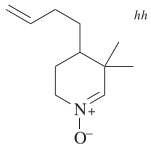
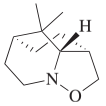
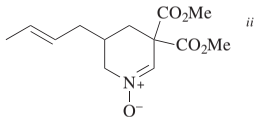
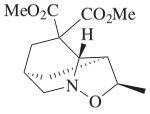
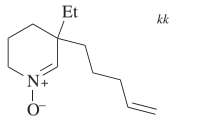
		Toluene, reflux		(64)	154
 *aa*		–70°		(—)	789
C_{16}					
 *bb*		Steel reactor coil, 500 mL min^{-1}, toluene, 190°		(62)	221
 *cc*	non-racemic	Sealed tube, MW, toluene/EtOH, 11 bar, 184°, 50 min		(70)	221
		DCE, rt to 50°, 1.5 h		(74)*dd*	784

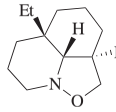
TABLE 8. INTRAMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES (*Continued*)

Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.
Four-atom tether			
C_9  *ee* non-racemic	47°, 8.5 h	 (67)	383
 *ff* non-racemic	H_2SO_4 (1.5 M), 1,4-dioxane, 60°, 24 h	 **I** +  **II** **I** + **II** (58) **I/II** = 59:41	382
C_{10}  *gg*	Toluene, 110°, 1.5 h	 (77)	378
C_{11}  *hh*	Toluene, 110°, 2 h	 (87)	380
 *ii*	Toluene, reflux, 1 h *jj*	 (27)	381

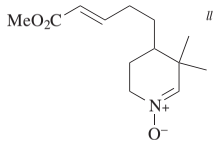
C_{12}



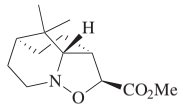
Toluene, reflux, 1 h



(64) 377

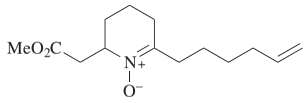


Toluene, 110°, 2 h

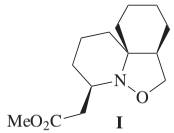


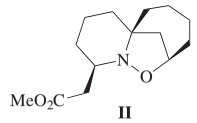
(95) 380

C_{13}



DMF, 110°, 2 d

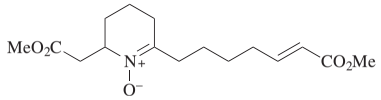


I + 

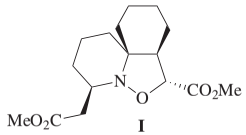
II 350

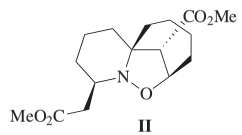
I + **II** (60), **I/II** = 1:1

C_{14}

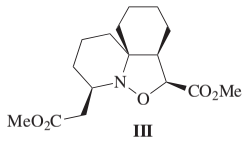


MeCN, 80°, 16 h



I + 

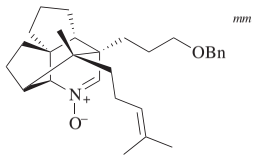
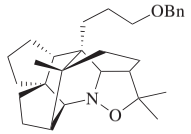
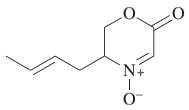
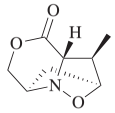
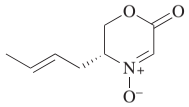
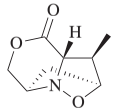
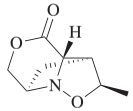
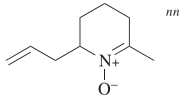
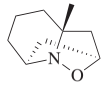
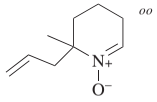
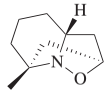
II 350

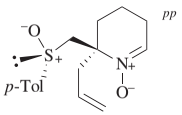
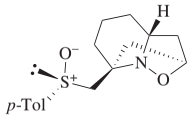
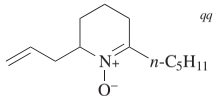
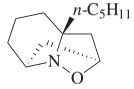
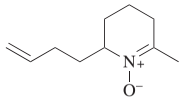
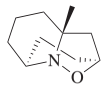
+ 

III

I + **II** + **III** (72)
I/II/III = 10:2:1

TABLE 8. INTRAMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES (*Continued*)

	Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.
	Four-atom tether			
C_{22}	 *mm*	Benzene, 80°, 20 h	 (83)	379
	Five-atom tether			
C_8		Sealed tube, toluene, 200°	 (78)	68, 387
	 non-racemic	Sealed tube, toluene, 200°, 2.5 h	 +  **I** **II** **I** + **II** (78), **I/II** = 10:1	68, 386, 387, 388
C_9	 *nn*	Toluene, reflux, 9 h	 (71)	171
	 *oo* non-racemic	Toluene, reflux, 40 h	 (56)	790

 *pp* non-racemic	—		(54)	428
C_{13}					
 *qq*	Toluene, reflux, 9 h		(76)	171
Six-atom tether					
C_{10}					
	Dean-Stark head, dry toluene, reflux, 20 h		(74)	389

[a] The nitrone was generated in situ by reaction of 2-(3-chloropropyl)-hex-5-enal with $NH_2OH{\bullet}HCl$ in the presence of DIPEA.

[b] The nitrone was generated in situ by oxidation of the corresponding hydroxylamine with NMO/TPAP (cat.).

[c] The nitrone was generated in situ by TBAT-mediated desilylative cyclization of (*S*,*E*)-5-(*tert*-butyldiphenylsilyloxyimino)-4-((*E*)-*N*-(4-methoxybenzyl)but-2-enamido)pentyl methanesulfonate.

[d] The nitrone was generated in situ by cycloreversion of its cycloadduct with styrene.

[e] The nitrone was generated in situ by cyclization of 1,10-undecadien-6-one oxime catalysed by $PdCl_2(MeCN)_2$.

[f] The nitrone was generated in situ by cyclization of 1,2-epoxy-10-undecen-6-one oxime.

[g] The nitrone was generated in situ by addition of PhSeBr to undeca-1,10-dien-6-one oxime followed by treatment with K_2CO_3.

[h] The nitrone was generated in situ by reaction of undeca-1,10-dien-6-one oxime with I_2 (1 eq) in CH_2Cl_2 at rt for 16 h in the presence of K_2CO_3 followed by treatment with $Na_2S_2O_3$.

TABLE 8. INTRAMOLECULAR CYCLOADDITIONS OF 6-MEMBERED CYCLIC NITRONES (*Continued*)

[i] The nitrone was generated in situ by reaction of 2-(3-chloropropyl)-2-ethylhex-5-enal with NH_2OH•HCl in the presence of DIPEA.

[j] The nitrone was generated in situ by cyclization of 11-hydroxyaminoundec-2-en-6-ynenitrile.

[k] The nitrone was generated in situ by cycloreversion of a 9:1 (*Z*)/(*E*) mixture of the adduct with styrene, (6*R**,8*R**)-6-(5'-cyanopent-4'-en-1'-yl)-8-phenyl-1-aza-9-oxabicyclo[4.3.0]nonane.

[l] The nitrone was generated in situ by reaction of 7-oxododeca-2,11-dienoate methyl ester with NH_2OH•HCl/NaOAc followed by intramolecular Michael addition of the formed oxime.

[m] The nitrone was generated in situ by reaction of 7-oxododeca-2,11-dienoate ethyl ester with NH_2OH•HCl/NaOAc followed by intramolecular Michael addition of the formed oxime.

[n] The nitrone was generated in situ by addition of PhSeBr to dodeca-1,10-dien-6-one oxime followed by treatment with K_2CO_3.

[o] The nitrone was generated in situ via intramolecular addition of 2-but-3-enyl-2-(2-methyl-[1,3]dioxolan-2-yl)-hex-5-enal oxime.

[p] The nitrone was formed in situ by cyclization of 1,11-dodecadien-6-one oxime catalyzed by $PdCl_2(MeCN)_2$.

[q] The nitrone was generated in situ by addition of PhSeBr to dodeca-1,10-dien-6-one oxime followed by treatment with K_2CO_3.

[r] The nitrone was generated in situ by cycloreversion of a 2:1 (*E*)/(*Z*) mixture of the adduct with styrene, (2*S*,6*R*,8*R*)-2-(benzyloxymethyl)-6-(5'-cyanopent-4'-en-1'-yl)-8-phenyl-1-aza-9-oxabicyclo[4.3.0]nonane.

[s] The nitrone was generated in situ by cycloreversion of a 9:1 (*Z*)/(*E*) mixture of the adduct with styrene (2*S*,6*R*,8*R*)-2-(benzyloxymethyloxymethyl))-6-(5'-cyanopent-4'-en-1'-yl)-8-phenyl-1-aza-9-oxabicyclo[4.3.0]nonane.

[t] The nitrone was generated in situ by intramolecular cyclization of the oxime obtained from methyl (2*E*,11*Z*)-7-oxotrideca-2,11-dienoate with NH_2OH•HCl in the presence of NaOAc.

[u] The nitrone was generated in situ by intramolecular cyclization of the oxime obtained from methyl (*E*,*E*)-7-oxotrideca-2,11-dienoate with NH_2OH•HCl in the presence of NaOAc.

[v] Unreacted (*Z*)-(2*S*,6*R*,8*R*)-2-(benzyloxymethyl)-6-[7'-(trimethylsilyl)-hept-4'-en-6'-yn-1'-yl]-8-phenyl-1-aza-9-oxabicyclo[4.3.0]nonane was recovered in 43% yield.

[w] The nitrone was generated in situ starting from (*Z*)-(2*S*,2'*S*)-*N*-(2'-hydroxyamino-13'-trimethylsilyltridec-6',12'-diyn-10'-enoyl)bornane-10,2-sultam.

[x] The nitrone was generated in situ starting from (2*Z*,11*Z*)-7-oxotrideca-2,11-dienedinitrile and NH_2OH.

[y] The nitrone was generated in situ by cycloreversion of the kinetic adduct **I**.

[z] The nitrone was generated in situ by reaction of diethyl (2*E*,11*E*)-7-oxotrideca-2,11-dienedioate with NH_2OH•HCl in the presence of NaOAc.

[aa] The nitrone was produced in situ from the corresponding imine by Na_2WO_4/H_2O_2 oxidation.

[bb] The nitrone was generated in situ by cycloreversion of a 9:1 (*Z*)/(*E*) mixture of (2*R**,6*S**,8*R**)-6-(5'-cyanopent-4'-en-1'-yl)-2-pentyl-8-phenyl-1-aza-9-oxabicyclo[4,3,0]-nonane.

[cc] The nitrone was generated in situ by cycloreversion of a 95:5 (*Z*)/(*E*) mixture of (2*R*,6*S*,8*R*)-6-(5'-cyanopent-4'-en-1'-yl)-2-pentyl-8-phenyl-1-aza-9-oxabicyclo[4,3,0]-nonanes.

[dd] The primary cycloadduct was not isolated.

[ee] The nitrone was generated in situ from 2-*O*-benzyl-4[(2*E*)-but-2-en-1-yl]-3,4,5-trideoxy-5(hydroxyamino)-l-erythropentose dimethyl acetal by acidic hydrolysis.

[ff] The nitrones were generated in situ from an epimeric mixture of *N*-[2-(2-benzyloxy-3,3-dimethoxy-propyl)-hex-4-enyl]-hydroxylamine.

[gg] The nitrone was generated in situ by reaction of 2-(3-chloropropyl)-hept-6-enal with $NH_2OH{\bullet}HCl$ in the presence of DIPEA.

[hh] The nitrone was generated in situ by cyclization of 3-(2-bromoethyl)-2,2-dimethyl-hept-6-enal oxime.

[ii] The unstable nitrone was produced by oxidation of the piperidine precursor by Na_2WO_4/H_2O_2 and used directly by replacing of the solvent. The regioisomeric nitrone that was also formed is unable to give a stable cycloadduct and likely equilibrates to the reactive regioisomeric nitrone.

[jj] A catalytic amount of (bis)[5-*tert*-butyl)-4-hydroxy-2-methylphenyl] sulfide is added.

[kk] The nitrone was generated in situ starting from 2-(4-chlorobutyl)-2-ethylhex-5-enal.

[ll] The nitrone was generated in situ by cyclization of (*E*)-methyl 6-(2-bromoethyl)-7-formyl-7-methyloct-2-enoate oxime.

[mm] The nitrone was generated by oxidation of the amine precursor with Na_2WO_4/H_2O_2.

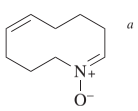
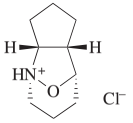
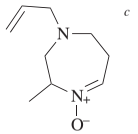
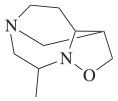
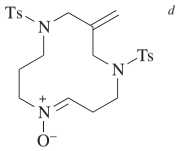
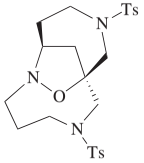
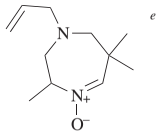
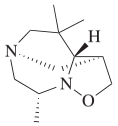
[nn] The nitrone was generated in situ by cyclization of *N*-(1-allyl-hex-5-ynyl)hydroxylamine.

[oo] The nitrone was generated in situ by oxidation of the corresponding hydroxylamine with Pd black.

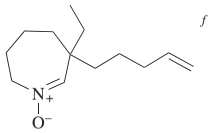
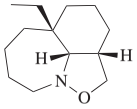
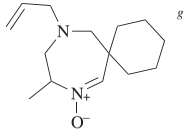
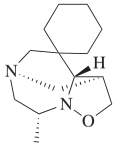
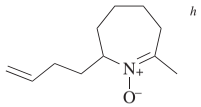
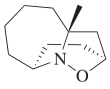
[pp] The nitrone was generated in situ by oxidation of the corresponding hydroxylamine with Ni_2O_3.

[qq] The nitrone was generated in situ by cyclization of *N*-(1-allyl-dec-5-ynyl)hydroxylamine.

TABLE 9. INTRAMOLECULAR CYCLOADDITIONS OF *n*-MEMBERED CYCLIC NITRONES ($n > 6$)

Nitrone	Conditions	Product(s) and Yield(s) (%)	Refs.
Three-atom tether			
C_9  *a*	1. THF, reflux, 24 h 2. HCl	 (84)[b]	229
Four-atom tether			
 *c*	Sealed tube, 180°	 (—)	183, 444
C_{10}  *d*	CH_2Cl_2, rt, 65 h	 (20)	485
C_{11}  *e*	Solvent, reflux		188

Solvent	Time (h)	
BuOH	12	(tr)
1,4-dioxane	144	(24)
MeCN	110	(tr)
toluene	48	(49)

C_{13}	 [f]	Toluene, heat		(22)	791
C_{14}	 [g]	Solvent, reflux		Solvent / Time (h): BuOH 12 (tr); toluene 36 (23)	188
Seven-atom tether					
C_{11}	 [h]	Sealed tube, degassed toluene, 140°, 23 h		(60)	172

[a] The nitrone was generated in situ by reaction of 1-hydroxy-*cis*,*cis*-5-[(*p*-tolylsulfonyl)oxy]decahydroquinoline with *t*-BuOK (1.05 eq).

[b] The primary cycloadduct was not isolated.

[c] The nitrone was generated in situ starting from 1-(*E*)-3-(diallylamino)propanal oxime.

[d] The nitrone was generated in situ by oxidation of 3-methylene-1,5-bis(4-methylbenzenesulfonyl)-1,5,9-triazacyclododecane with *m*-CPBA.

[e] The nitrone was generated in situ, together with its isomeric acyclic *N*-unsubstituted nitrone, by cyclization of 3-(*N*,*N*-diallylamino)-2,2-dimethylpropionaldehyde oxime.

[f] The nitrone was generated in situ starting from 2-ethyl-2-(4-iodobutyl)hept-6-enal and NH_2OH.

[g] The nitrone was generated in situ, together with its isomeric acyclic *N*-unsubstituted nitrone, by cyclization of 1-(*N*,*N*-diallylaminomethyl)cyclohexanecarboxaldehyde oxime.

[h] The nitrone was generated in situ by rearrangement of (2*S**,5*R**)-1-hydroxy-2-methyl-5-(6-trimethylsilyl-5-hexynyl)pyrrolidine.

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