Cycloadditions, 47[1]

A Route to Functionalized Cyclic Ethers by Intramolecular Cycloadditions of Unsaturated Nitro Ethers

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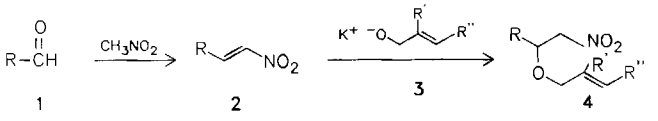
A convenient conversion of aldehydes via nitroolefins **2** into cyclic ethers **6** fused to an isoxazoline ring involves formation of unsaturated nitroalkyl ethers **4** and subsequent intramolecular cycloaddition of an in situ-formed nitrile oxide olefin. The cyclization proceeds with stereoselective formation of *trans* over *cis* isomers in the tetrahydrofuran series and opposite stereoselectivity in the tetrahydropyran and hexahydrooxepine series, depending on the substituent R in the original nitro compound, thus providing access to stereoselectively functionalized cyclic ethers.

Stereoselectively substituted and functionalized tetrahydrofurans and pyrans are of interest as analogs of carbohydrates[2]. We have recently shown[3] that intramolecular nitrile oxide olefin cycloaddition (INOC)[4] represents a useful entry into such cyclic ethers. The starting point for the required unsaturated nitrile oxides **5** has been the reaction of *O*-silyl-β-bromo aldoximes[5] with allyl alcohol which proceeds via nitroso alkenes[6] to produce unsaturated oxime ethers. The latter are transformed by means of NaOCl into nitrile oxides **5**, which spontaneously cyclize to tetrahydrofuro-isoxazolins **6**[3]. Since the α-bromo aldoxime synthons are prepared in a two-step sequence from aldoximes, the application of this method allows aldehydes $R-CH_2CHO$ and allyl alcohols to be converted into functionalized cyclic ethers **6**. A disadvantage is the requirement of a 10-fold excess of the allyl alcohol. Since primary nitro compounds can likewise be converted into nitrile oxides[7], we have felt that the use of stable nitro alkenes may prove more advantageous for these reactions.

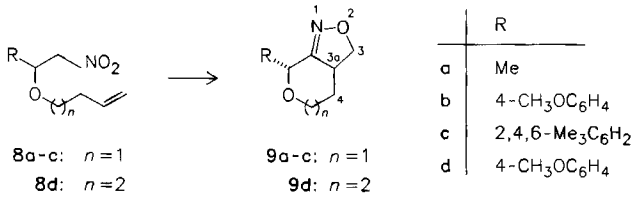


	R	R'=R''
a	Me	H
b	Et	H
c	*i*Pr	H
d	Ph	H

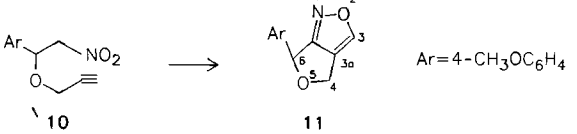
	R	R'	R''
e	4-$CH_3OC_6H_4$	H	H
f	4-$CH_3OC_6H_4$	H	Me
g	4-$CH_3OC_6H_4$	H	Ph
h	4-$CH_3OC_6H_4$	Me	H

Results

We now report on a shorter, more convenient conversion of lower homologous aldehydes R−CHO (**1**) into substituted tetrahydrofurans **6**. The sequence takes advantage of the ready formation of conjugated nitro compounds **2** from **1** followed by Michael addition of the alkoxide of an unsaturated alcohol **3** (2−3 molar equivalents) to produce the unsaturated nitro ethers **4**. Alternatively, the nitro alkenes **2** are generated in situ from the nitro acetates **7**, which prove advantageous for R = aliphatic residue. The nitro ethers **4** are transformed by means of phenyl isocyanate into the nitrile oxides **5**, which spontaneously cyclize.



	R
a	Me
b	4-$CH_3OC_6H_4$
c	2,4,6-$Me_3C_6H_2$
d	4-$CH_3OC_6H_4$



The new sequence is particularly suitable for the synthesis of tetrahydrofurans possessing aryl substituents. Homoallyl alcohol also adds to nitroalkenes **2**, and the resulting nitro ethers **8** are converted via nitrile oxides into cyclic ethers

9a–c in 70–90% yields. The seven-membered ether **9d** is obtained only in 30% yield on high dilution. The reaction of **2** with propargyl alcohol furnishes the acetylenic nitro ether **10** which undergoes the INOC reaction to provide oxazole **11**.

In all cases the basic structure of the products is apparent from ^{1}H- and ^{13}C-correlated NMR and mass spectra as well as elemental analyses (see stereochemical discussion and Experimental).

Stereochemistry

One of the interesting features of INOC reactions is the stereoselectivity during the cyclization process, since this leads to selectively substituted cyclic ethers **6** or **9**. The aliphatically substituted systems **6** (R = Alkyl) are quite sensitive to the steric size of the substituent. While the *trans:cis* ratio in the formation of **6a** or **6b** (R = Me or Et) is 2.5:1, it changes to 6:1 when R is isopropyl.

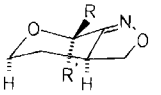
The phenyl and *p*-methoxyphenyl systems **6d** and **6e** are produced in a 4:1 *trans:cis* ratio[8]. No considerable change in the *trans:cis* ratio is observed (3:1 for **6f,g** and 2:1 for **6h**) on additional substitution in the olefinic part of the molecule. The stereochemistry of the olefinic double bond in **4** is maintained in the product **6**. In the cases of **6d–f**, where R = aromatic, separation of the isomers by chromatography has been achieved. The stereochemistry in **6d–f** is confirmed by NOE experiments, in which irradiation of the benzylic singlet causes only a 2.5% enhancement of the bridgehead multiplet in the isolated *cis* isomers.

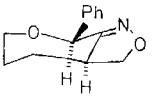
These results are in qualitative agreement with MM2 calculations[3], which predict an energy difference of 0.38 kcal/mol in favor of the *trans* isomer for the cyclization of **5** to **6** when R = Me vs. 0.96 kcal/mol when R = Ph and 0.85 kcal/mol when R = *i*Pr[9].

In the formation of the tetrahydropyrans **9a–c**, the isomer ratio is reversed (1:6 in favor of the *cis* isomer) compared to that in the tetrahydrofurans **6**, as shown before for the phenyl analog of **9b**[3]. MM2 calculations indicate that the *cis* isomer is favored by 1.5 kcal/mol when R = Ph[3]. The identical *trans:cis* ratio of 1:6, when R is Ph or *p*-methoxyphenyl (**9b**), indicates that the *p*-MeO group has no effect on the isomer ratio. Even with the highly hindered mesityl substituent (see **9c**) the *cis* isomer predominates (over 95%).

The stereochemistry in the six-membered ring products **9** has been assigned on the basis of NOE experiments and the γ effect (*gauche* effect) in the ^{13}C-NMR spectra. Thus, irradiation of the benzylic axial proton in **9b** (*cis* isomer) causes an enhancement of 6% for the axial proton at δ = 3.73 (CH_2O) and 2.5% for the axial bridgehead multiplet at 3.50. In both *cis* and *trans* isomers **9b** a diaxial coupling (13 Hz) of the bridgehead hydrogen to the axial proton of the adjacent CH_2 group is observed. These data confirm[3] conformation **12a** for the *cis* isomer of **9b**. For *trans*-**9b** the NMR data suggest conformation **12b** with an axial phenyl substituent rather than a conformation in which Ph is equatorial and the isoxazoline CH is axial.

The axial phenyl group in *trans*-**9b** shields (γ effect) both the CH_2O carbons (δ = 59.58 vs. 66.53 in the *cis* isomer) as well as the bridgehead CH (δ = 43.81 vs. 46.58). The benzylic CH is also shielded in *trans*-**9b** (δ = 72.19 vs. 77.10), as expected. In the mesityl-substituted isoxazoline (*cis* isomer of **9c**), a γ effect of the *o*-methyl groups on the benzylic carbon (δ = 73.67) is observed, while the bridgehead carbon is unaffected.





13

12a: R=Ph, R'=H
b: R=H, R'=Ph

The stereochemistry of the seven-membered ring product **9d** has been tentatively assigned as *cis* (see conformation **13**), due to the low-field absorptions of both the benzylic (δ = 77.35) and the bridgehead carbon (48.43) and a 12-Hz coupling of the axial bridgehead proton to the adjacent axial H[10].

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Experimental

^{1}H (300 MHz) and ^{13}C NMR (75 MHz): Bruker 300 MHz, $CDCl_3$ solutions, internal reference tetramethylsilane. – MS: Finnigan 4021 mass spectrometer, 35 eV. – Chromatographic separations: silica gel (70–230 mesh, Merck) column.

General Procedure for the Synthesis of β-Nitro Ethers **4**, **8**, **10**

2-(Allyloxy)-1-nitropropane (**4a**): A solution of 1.74 g (30 mmol) of allyl alcohol in 20 ml of tetrahydrofuran (THF) was stirred at −10 to −20°C, while 3.36 g (30 mmol) of potassium *tert*-butoxide was added in small portions. After all the base had dissolved, a solution of 0.87 g (10 mmol) of 1-nitro-1-propene (**2a**) in 10 ml of THF was added dropwise over ca. 15 min. Stirring was continued for an additional 15 min, then 2 ml of acetic acid was added, followed by 50 ml of ether. The mixture was filtered, the inorganic salts were washed several times with ether, and the combined filtrates were concentrated. Chromatography of the residue over silica gel with petroleum ether/ether (4:1) gave 1.28 g of **4a** (88%) as a colorless oil. Alternatively, 2-acetoxy-1-nitropropane (**7**, R = Me) was used instead of the nitro alkene without affecting the yield. – ^{1}H NMR: δ = 1.27 (d, *J* = 7 Hz, 3H, CH_3), 3.88 and 4.08 (ddt, *J* = 13/6/1 Hz, 1H, CH_2O), 4.24 (ddq, *J* = 9/7/4 Hz, 1H, CH–O), 4.34 (dd, *J* = 12/4 Hz, 1H, CH_2NO_2), 4.46 (dd, *J* = 12/9 Hz, 1H, CH_2NO_2), 5.18 (dq, *J* = 10/1 Hz, 1H, vinyl), 5.25 (dq, *J* = 17/1 Hz, 1H, vinyl), 5.85 (ddt, *J* = 18/10/6 Hz,1H, vinyl). – ^{13}C NMR: δ = 17.11 (CH_3), 70.26 (CH_2O), 71.62 (CHO), 80.03 (CH_2NO_2), 117.44, 134.12. – MS (*m/z*, relative intensity, EI): 146 [MH^+] (82), 88 [$M^{\cdot+}$ – C_3H_6O] (53), 85 [M^+ – CH_2NO_2H] (100).

$C_6H_{11}NO_3$ (145.2) Calcd. C 49.65 H 7.54
Found C 49.39 H 7.73

2-(Allyloxy)-1-nitrobutane (**4b**) was prepared in the same manner from 2-acetoxy-1-nitrobutane (**7**, R = Et) and allyl alcohol in 66%

yield as a colorless oil. – ^{1}H NMR: δ = 0.98 (t, *J* = 7.5 Hz, 3H, CH_3), 1.63 (m, 2H, CH_2), 3.96–4.13 (m, 3H, CH–O + CH_2O), 4.39 (dd, *J* = 13/4 Hz, 1H, CH_2NO_2), 4.48 (dd, *J* = 13/8 Hz, 1H, CH_2NO_2), 5.19 (dq, *J* = 10/1 Hz, 1H, vinyl), 5.26 (dq, *J* = 17/1 Hz, 1H, vinyl), 5.86 (ddt, *J* = 17/10/6 Hz, 1H, vinyl). – ^{13}C NMR: δ = 9.00 (CH_3), 24.64 (CH_2), 70.98 (CH_2O), 76.82 (CHO), 78.42 (CH_2NO_2), 117.37 and 134.03. – MS (*m/z*, relative intensity, EI): 160 [MH^+] (28), 102 [$M^+ - C_3H_6O$] (41), 99 [$M^+ - CH_2NO_2H$] (100).

$C_7H_{13}NO_3$ (159.2) Calcd. C 52.83 H 8.18
Found C 53.10 H 8.47

2-(Allyloxy)-3-methyl-1-nitrobutane (**4c**) was prepared from 2-acetoxy-3-methyl-1-nitrobutane (**7**, R = *i*Pr) and allyl alcohol in 73% yield as a colorless oil. – ^{1}H NMR: δ = 0.96 and 0.98 (d, *J* = 7 Hz, 3H, *CH*$_3$CH), 1.97 [d sept, *J* = 7/5 Hz, 1H, $(CH_3)_2CH$], 3.92 (dt, *J* = 8/5 Hz, 1H, CH–O), 4.01 and 4.08 (ddt, *J* = 12/6/1 Hz, 1H, CH_2O), 4.40 (dd, *J* = 12/5 Hz, 1H, CH_2NO_2), 4.47 (dd, *J* = 12/8 Hz, 1H, CH_2NO_2), 5.19 (dq, *J* = 10/1 Hz, 1H, vinyl), 5.25 (dq, *J* = 17/1 Hz, 1H, vinyl), 5.85 (ddt, *J* = 17/10/6 Hz, 1H, vinyl). – ^{13}C NMR: δ = 17.68 and 17.86 [$(CH_3)_2CH$], 30.27 [$(CH_3)_2CH$], 72.06 (CH_2O), 77.20 (CH–O), 80.87 (CH_2NO_2), 117.37, 134.15. – MS (*m/z*, relative intensity, EI): 174 [MH^+] (68), 116 [$M^+ - C_3H_6O$] (18), 113 [$M^+ - CH_2NO_2H$] (100).

$C_8H_{15}NO_3$ (173.2) Calcd. C 55.49 H 8.67
Found C 55.79 H 8.91

1-(Allyloxy)-2-nitro-1-phenylethane (**4d**) was prepared from β-nitrostyrene (**2d**) and allyl alcohol in 87% yield as a light yellow oil. – ^{1}H NMR: δ = 3.82 (ddt, *J* = 13/6/1 Hz, 1H, CH_2O), 3.98 (ddt, *J* = 13/5/1 Hz, 1H, CH_2O), 4.40 (dd, *J* = 13/3 Hz, 1H, CH_2NO_2), 4.64 (dd, *J* = 13/10 Hz, 1H, CH_2NO_2), 5.14 (dd, *J* = 10/3 Hz, 1H, CH–O), 5.17 (dq, *J* = 10/1 Hz, 1H, vinyl), 5.21 (dq, *J* = 17/1 Hz, 1H, vinyl), 5.83 (dddd, *J* = 17/10/6/5 Hz, 1H, vinyl), 7.32–7.43 (m, 5H, Ph). – ^{13}C NMR: δ = 70.00 (CH_2O), 77.47 (CH–O), 80.40 (CH_2NO_2), 117.59, 126.82, 129.02, 133.71, 136.39. – MS [*m/z*, relative intensity, CI(NH_3)]: 225 [MNH_4^+] (100), 207 [MH^+] (1), 147 [$M^+ - CH_2NO_2$] (16).

$C_{11}H_{13}NO_3$ (207.2) Calcd. C 63.77 H 6.28
Found C 63.93 H 6.29

1-(Allyloxy)-1-(4-methoxyphenyl)-2-nitroethane (**4e**) was obtained from 4-methoxy-β-nitrostyrenc (**2e**) and allyl alcohol in 69% yield as a light yellow oil. – ^{1}H NMR: δ = 3.78 (ddt, *J* = 13/6/1 Hz, 1H, CH_2O), 3.80 (s, 3H, CH_3O), 3.97 (ddt, *J* = 13/5/1 Hz, 1H, CH_2O), 4.37 (dd, *J* = 13/4 Hz, 1H, CH_2NO_2), 4.64 (dd, *J* = 13/10 Hz, 1H, CH_2NO_2), 5.09 (dd, *J* = 10/4 Hz, 1H, CH–O), 5.15 (dq, *J* = 10/1 Hz, 1H, vinyl), 5.18 (dq, *J* = 17/1 Hz, 1H, vinyl), 5.84 (dddd, *J* = 17/10/6/5 Hz, 1H, vinyl), 6.94 and 7.28 (dt, *J* = 9/2 Hz, 2H, Ar). – ^{13}C NMR: δ = 55.29 (CH_3O), 69.59 (CH_2O), 76.90 (CH–O), 80.39 (CH_2NO_2), 114.39, 117.59,. 128.04, 128.14, 133.74, 160.13. – MS (*m/z*, relative intensity, EI): 237 [M^+] (33), 177 [$M^+ - CH_2NO_2$] (100), 144 [177 – C_2H_4] (21), 135 [277 – C_3H_6] (71), 134 [$M^+ - HNO_2 - C_3H_6OH$] (58), 121 [177 – C_3H_6O] (41).

$C_{12}H_{15}NO_4$ (237.3) Calcd. C 60.74 H 6.33
Found C 60.58 H 6.46

1-(trans-2-Butenyloxy)-1-(4-methoxyphenyl)-2-nitroethane (**4f**) was prepared from 4-methoxy-β-nitrostyrene (**2e**) and crotyl alcohol in 82% yield as a light yellow oil. – ^{1}H NMR: δ = 1.69 (dq, *J* = 6/1 Hz, 3H, CH_3), 3.72 (ddm, *J* = 12/7 Hz, 1H, CH_2O), 3.82 (s, 3H, CH_3O), 3.89 (ddm, *J* = 12/6 Hz, 1H, CH_2O), 4.36 (dd, *J* = 13/4 Hz, 1H, CH_2NO_2), 4.62 (dd, *J* = 13/10 Hz, 1H, CH_2NO_2), 5.05 (dd, *J* = 10/4 Hz, 1H, CH–O), 5.45–5.70 (m, 2H, vinyl), 6.92 and 7.28 (dt, *J* = 9/2 Hz, 2H, Ar). – ^{13}C NMR: δ = 17.63 (CH_3), 55.23 (CH_3O), 69.35 (CH_2O), 76.57 (CH–O), 80.38 (CH_2NO_2), 114.31, 126.55, 128.12, 128.26, 130.13, 160.02 – MS (*m/z*, relative intensity, EI): 251 [M^+] (1), 191 [$M^+ - CH_2NO_2$] (39), 180 [$M^+ - C_4H_7O$] (23), 137 [191–C_4H_6] (100), 135 [191 – C_4H_8] (32), 134 [$M^+ - HNO_2 - C_4H_7OH$] (58).

$C_{13}H_{17}NO_4$ (251.3) Calcd. C 62.15 H 6.77
Found C 61.93 H 7.05

1-(4-Methoxyphenyl)-2-nitro-1-(trans-3-phenyl-2-propenyloxy)-ethane (**4g**) was prepared from 4-methoxy-β-nitrostyrene (**2e**) and cinnamyl alcohol in 66% yield as a light yellow oil. – ^{1}H NMR: δ = 3.82 (s, 3H, CH_3O), 3.96 (ddd, *J* = 13/6/1 Hz, 1H, CH_2O), 4.13 (ddd, *J* = 13/5/1 Hz, 1H, CH_2O), 4.39 (dd, *J* = 13/4 Hz, 1H, CH_2NO_2), 4.68 (dd, *J* = 13/10 Hz, 1H, CH_2NO_2), 5.14 (dd, *J* = 10/4 Hz, 1H, CH_2NO_2), 6.18 (ddd, *J* = 16/6/5 Hz, 1H, vinyl), 6.49 (dt, *J* = 16/1 Hz, 1H, vinyl), 7.20–7.38 (m, 5H, Ph). – ^{13}C NMR: δ = 55.53 (CH_3O), 69.28 (CH_2O), 76.82 (CH–O), 80.40 (CH_2NO_2), 114.47, 125.06, 126.54, 127.81, 128.07, 128.25, 128.55, 132.89, 136.46, 160.19. – MS (*m/z*, relative intensity, EI): 313 [M^+] (1), 180 [M^+ – PhCH=CHCH$_2$O] (26), 134 [180 – NO_2] (100), 117 [PhCH=CHCH$_2^+$] (44).

$C_{18}H_{19}NO_4$ (313.4) Calcd. C 69.01 H 6.07
Found C 69.08 H 5.81

1-(4-Methoxyphenyl)-1-(2-methyl-2-propenyloxy)-2-nitroethane (**4h**) was prepared from 4-methoxy-β-nitrostyrene (**2e**) and methallyl alcohol in 77% yield as a light yellow oil. – ^{1}H NMR: δ = 1.68 (s, 3H, Me), 3.68 (br d, *J* = 12 Hz, 1H, CH_2O), 3.82 (s, 3H, CH_3O), 3.85 (br d, *J* = 12 Hz, 1H, CH_2O), 4.37 (dd, *J* = 12.5/3.5 Hz, 1H, CH_2NO_2), 4.65 (dd, *J* = 12.5/10 Hz, 1H, CH_2NO_2), 4.86 and 4.88 (m, 1H, vinyl), 5.05 (dd, *J* = 10/3.5 Hz, 1H, CH–O), 6.92 and 7.28 (dt, *J* = 9/2 Hz, 2H, Ar). – ^{13}C NMR: δ = 19.39 (CH_3), 55.31 (CH_3O), 72.63 (CH_2O), 76.89 (CH–O), 80.48 (CH_2NO_2), 113.10, 114.41, 128.03, 128.21, 141.28, 160.15. – MS [*m/z*, relative intensity, CI (NH_3)]: 269 [MNH_4^+] (100), 251 [M^+] (12), 197 [$M^+ - C_4H_6$], (55), 191 [$M^+ - CH_2NO_2H$] (49), 180 [$M^+ - C_4H_7O$] (75).

$C_{13}H_{17}NO_4$ (251.3) Calcd. C 62.15 H 6.77
Found C 62.01 H 6.90

2-(3-Butenyloxy)-1-nitropropane (**8a**) was prepared from 2-acetoxy-1-nitropropane (**7**, R = Me) and 3-buten-1-ol in 79% yield as a colorless oil. – ^{1}H NMR: δ = 1.25 (d, *J* = 6.5 Hz, 3H, CH_3), 2.30 (qt, *J* = 6.5/1 Hz, 2H, *CH*$_2$CH$_2$O), 3.41 and 3.61 (dt, *J* = 9/6.5 Hz, 1H, CH_2O), 4.18 (m, 1H, CH–O), 4.32 (dd, *J* = 13/4 Hz, 1H, CH_2NO_2), 4.44 (dd, *J* = 13/9 Hz, 1H, CH_2NO_2), 5.04 (dq, *J* = 10/1 Hz, 1H, vinyl), 5.08 (dq, *J* = 17/1 Hz, 1H, vinyl), 5.78 (ddt, *J* = 17/10/1 Hz, 1H, vinyl). – ^{13}C NMR: δ = 17.14 (CH_3), 34.22 (CH_2CH_2O), 68.91 (CH_2O), 72.44 (CH–O), 80.06 (CH_2NO_2), 116.62 and 134.78. – MS (*m/z*, relative intensity, CI, CH_4): 160 [MH^+] (5), 118 [$MH^+ - CH_2$=C=O) (34), 99 [$M^+ - CH_2NO_2$] (100).

$C_7H_{13}NO_3$ (159.2) Calcd. C 52.83 H 8.18
Found C 53.11 H 8.46

1-(3-Butenyloxy)-1-(4-methoxyphenyl)-2-nitroethane (**8b**) was prepared from 4-methoxy-β-nitrostyrene (**2e**) and 3-buten-1-ol in 83% yield as a light yellow oil. – ^{1}H NMR: δ = 2.28 (qt, *J* = 7/1 Hz, 2H, *CH*$_2$CH$_2$O), 3.35 and 3.42 (dt, *J* = 9/7 Hz, 1H, CH_2O), 3.81 (s, 3H, CH_3O), 4.46 (dd, *J* = 13/4 Hz, 1H, CH_2NO_2), 4.60 (dd, *J* = 13/10 Hz, 1H, CH_2NO_2), 5.01 (m, 2H, CH–O + vinyl), 5.03 (dq, *J* = 10/1 Hz, 1H, vinyl), 5.73 (ddt, *J* = 17/10/7 Hz, 1H, vinyl), 6.92 and 7.28 (dt, *J* = 9/2 Hz, 2H, Ar). – ^{13}C NMR: δ = 33.85 (*CH*$_2$CH$_2$O), 55.26 (CH_3O), 68.46 (CH_2O), 77.97 (CH–O), 80.40 (CH_2NO_2), 114.33, 116.47, 127.98, 128.34, 134.65, 160.04. – MS

(*m/z*, relative intensity, EI): 251 [M^+] (19), 191 [$M^+ - CH_2NO_2$] (100), 134 [$M^+ - NO_2 - C_4H_9O$] (89).

$C_{13}H_{17}NO_4$ (251.3) Calcd. C 62.15 H 6.77
Found C 61.92 H 6.89

1-(3-Butenyloxy)-2-nitro-1-(2,4,6-trimethylphenyl)ethane (**8c**) was prepared from 2,4,6-trimethyl-β-nitrostyrene (**2**, R = mesityl) and 3-buten-1-ol in 81% yield as a light yellow oil. – ^{1}H NMR: δ = 2.27 (s, 3H, 4-Me), 2.29 (m, 2H, CH_2CH_2O), 2.43 (br s, 6H, 2,6-Me), 3.33 and 3.39 (dt, *J* = 9/6.5 Hz, 1H, CH_2O), 4.30 (dd, *J* = 13/3 Hz, 1H, CH_2NO_2), 4.88 (dd, *J* = 13/10 Hz, 1H, CH_2NO_2), 5.00 (dq, *J* = 1 Hz, 1H, vinyl), 5.03 (dq, *J* = 17/1 Hz, 1H, vinyl), 5.54 (dd, *J* = 10/3 Hz, 1H, CH–O), 5.74 (ddt, *J* = 17/10/6.5 Hz, 1H, vinyl), 6.85 (s, 2H, Mesityl). – ^{13}C NMR: δ = 20.29 (2,6-Me), 20.77 (4-Me), 34.04 (CH_2CH_2O), 68.69 (CH_2O), 75.63 (CH–O), 77.94 (CH_2NO_2), 116.55, 128.77, 130.46 (br), 134.81, 137.11 (br), 138.21. – MS (*m/z*, relative intensity, EI): 263 [M^+] (2), 203 [$M^+ - CH_2NO_2$] (100), 192 [$M^+ - C_4H_7O$] (23), 146 [192 – NO_2] (86), 132 [192 – CH_2NO_2] (42).

$C_{15}H_{21}NO_3$ (263.3) Calcd. C 68.44 H 7.98
Found C 68.53 H 8.20

1-(4-Methoxyphenyl)-2-nitro-1-(4-pentenyloxy)ethane (**8d**) was prepared from 4-methoxy-β-nitrostyrene (**2e**) and 4-penten-1-ol in 87% yield. – ^{1}H NMR: δ = 1.61 (quint, *J* = 6.5 Hz, 2H, $OCH_2CH_2CH_2$), 2.10 (m, 2H, $OCH_2CH_2CH_2$), 3.30 and 3.38 (dt, *J* = 9/6.5 Hz, 1H, CH_2O), 3.82 (s, 3H, CH_3O), 4.36 (dd, *J* = 13/4 Hz, 1H, CH_2NO_2), 4.60 (dd, *J* = 13/10 Hz, 1H, CH_2NO_2), 4.93 (dq, *J* = 10/1 Hz, 1H, vinyl), 4.98 (dq, *J* = 17/1 Hz, 1H, vinyl), 5.74 (ddt, *J* = 17/10/7 Hz, 1H, vinyl). 6.92 and 7.28 (dt, *J* = 9/2 Hz, 2H, Ar). – ^{13}C NMR: δ = 28.66 (CH_2CH_2O), 30.07 ($CH_2CH_2CH_2O$), 55.31 (CH_3O), 68.43 (CH_2O), 77.98 (CH–O), 80.52 (CH_2NO_2), 114.36, 114.89, 128.00, 128.49, 137.99, 160.08. – MS (*m/z*, relative intensity, EI): 265 [M^+] (5), 205 [$M^+ - CH_2NO_2$] (100), 180 [$M^{\cdot+} - C_5H_9O$] (42), 134 [180 – NO_2] (30).

$C_{14}H_{19}NO_4$ (265.3) Calcd. C 63.40 H 7.17
Found C 63.36 H 7.43

1-(4-Methoxyphenyl)-2-nitro-1-propargyloxyethane (**10**) was prepared from 4-methoxy-β-nitrostyrene (**2e**) and propargyl alcohol in 85% yield after crystallization from chloroform/petroleum ether, m.p. 53–54°C. – ^{1}H NMR: δ = 2.45 (t, *J* = 3 Hz, 1H, C≡CH), 3.82 (s, 3H, CH_3O), 3.90 and 4.15 (dd, *J* = 16/3 Hz, 1H, CH_2O), 4.41 (dd, *J* = 13/4 Hz, 1H, CH_2NO_2), 4.69 (dd, *J* = 13/10 Hz, 1H, CH_2NO_2), 5.29 (dd, *J* = 10/4 Hz, 1H, CH–O), 6.92 and 7.30 (dt, *J* = 9/2 Hz, 1H, Ar). – ^{13}C NMR: δ = 55.33 (CH_3O), 55.72 (CH_2O), 75.19 (C≡*C*–H), 76.32 (CH–O), 78.39 (*C*≡CH), 79.98 (CH_2NO_2), 114.50, 126.85, 128.47, 160.40. – MS (*m/z*, relative intensity, EI): 235 [M^+] (39), 175 [$M^+ - CH_2NO_2$] (100), 135 [175 – C_3H_4] (67), 134 [Ar=$CHCH_2^+$] (38).

$C_{12}H_{13}NO_4$ (235.2) Calcd. C 61.28 H 5.53
Found C 60.99 H 5.63

General Procedure for the Cycloaddition

3a,4-Dihydro-6-methyl-3H,6H-furo[3,4-c]isoxazole (**6a**): To a solution of 0.725 g (5.0 mmol) of **4a** in 30 ml of dry benzene, containing a few drops of trimethylamine, was added 1.775 g (15 mmol) of phenyl isocyanate. The solution was allowed to stand at room temp. for 2 d, diphenylurea was filtered, benzene removed in vacuo and the residue chromatographed over silica with chloroform as the eluent to yield 0.572 g (90%) of a 2.5:1 *trans:cis* mixture of **6a** as a colorless oil. The spectral data were in agreement with those reported[3].

6-Ethyl-3a,4-dihydro-3H,6H-furo[3,4-c]isoxazole (**6b**) was prepared from **4b** as a 2.5:1 *trans:cis* mixture in 83% yield (colorless oil). – *trans*-**6b**: ^{1}H NMR: δ = 1.01 (t, *J* = 7.5 Hz, 3H, CH_3), 1.62–1.90 (m, 2H, CH_2), 3.64 (dd, *J* = 9/8 Hz, 1H, 4-H), 3.98 (dd, *J* = 12/8 Hz, 1H, 3-H), 4.10–4.30 (m, 1H, 3a-H), 4.27 (t, *J* = 8 Hz, 1H, 4-H), 4.47 (br t, *J* = 7 Hz, 1H, 6-H), 4.54 (t, *J* = 9 Hz, 1H, 3-H). – ^{13}C NMR: δ = 9.00 (CH_3), 26.63 (CH_2), 55.42 (C-3a), 69.62 (C-4), 72.96 (C-6), 73.18 (C-3), 121.49 (C=N). – *cis*-**6b**: ^{1}H NMR: δ = 1.08 (t, *J* = 7.5 Hz, 3H, CH_3), 1.62–1.90 (m, 2H, CH_2), 3.68 (m, 1H, 4-H), 3.98 (m, 1H, 3-H), 4.10–4.30 (m, 2H, CH_2O 3a, 4-H), 4.47 (br t, *J* = 7 Hz, 1H, 6-H), 4.55 (m, 1H, 3-H). – ^{13}C NMR: δ = 9.42 (CH_3), 26.10 (CH_2), 56.10 (C-3a), 68.39 (C-4), 72.82 (C-6), 73.41 (C-3), 170.96 (C=N). – MS (*m/z*, relative intensity, EI, mixture of isomers): 142 [MH^+] (100), 141 [M^+] (38), 111 [$M^+ - CH_2O$] (60).

$C_7H_{11}NO_2$ (mixture of isomers) (141.2)
Calcd. C 59.57 H 7.80 Found C 59.80 H 8.04

3a,4-Dihydro-6-isopropyl-3H,6H-furo[3,4-c]isoxazole (**6c**) was prepared from **4c** as a 6:1 *trans:cis* mixture in 85% yield (colorless oil). – *trans*-**6c** in mixture: ^{1}H NMR: δ = 0.99 and 1.04 [d, *J* = 7 Hz, 3H, $(CH_3)_2CH$], 2.04 [oct, *J* = 7 Hz, 1H, $(CH_3)_2CH$], 3.64 (dd, *J* = 9,8 Hz, 1H, 4-H), 3.98 (dd, *J* = 13/7.5 Hz, 1H,3-H), 4.0–4.35 (m, 3H, 3a-, 4-, 6-H), 4.55 (dd, *J* = 8.5, 7.5 Hz, 1H, 3-H). – ^{13}C NMR: δ = 17.60 and 17.97 [$(CH_3)_2CH$], 31.52 [$(CH_3)_2CH$], 56.11 (C-3a), 69.64 (C-4), 72.96 (C-3), 27.43 (C-6), 171.23 (C=N). – *cis*-**6c** in the mixture: ^{1}H NMR: δ = 1.06 and 1.10 [d, *J* = 7 Hz, 3H, $(CH_3)_2CH$], 1.94 [octet, *J* = 7 Hz, 1H, $(CH_3)_2CH$], 3.66 (m, 1H, 4-H), 3.96 (m, 1H, 3-H), 4.0–4.35 (m, 3H, 3a-, 4-, 6-H), 4.56 (m, 1H, 3-H). – ^{13}C NMR: δ = 17.83 and 18.15 [$(CH_3)_2CH$], 31.72 [$(CH_3)_2CH$], 56.38 (C-3a), 68.88 (C-4), 73.04 (C-3), 76.62 (C-6), 169.90 (C=N). – MS (*m/z*, relative intensity, mixture of isomers, EI): 156 [MH^+] (100), 155 [M^+] (29), 125 [$M^+ - CH_2O$] (33), 112 [$M^+ - C_3H_8$] (34).

$C_8H_{13}NO_2$ (mixture of isomers) (155.2)
Calcd. C 61.93 H 8.39 Found C 61.63 H 8.46

3a,4-Dihydro-6-phenyl-3H,6H-furo[3,4-c]isoxazole (**6d**) was prepared from **4d** as a 4:1 *trans:cis* mixture[8] in 87% yield (oil). By chromatography with dichloromethane over silica gel the two isomers were separated. *trans*-**6d** was identical with the earlier described compound[3]. – *cis*-**6d**: crystals from methanol, m.p. 93°C. – ^{1}H NMR: δ = 3.91 (m, 1H, 4-H), 4.06 (m, 1H, 3-H), 4.40 (m, 2H, 3a, 4-H), 4.62 (m, 1H, 3-H), 5.61 (s, 1H, 6-H). Irradiation with this frequency increases the intensity of the signal at δ = 4.40 by 2.5% (NOE), 7.30–7.43 (m, 5H, Ph). – ^{13}C NMR: δ = 56.08 (C-3a), 69.31 (C-4), 73.11 (C-6), 73.98 (C-3), 126.40, 128.45, 128.74, 137.31 (Ph), 170.64 (C=N). – MS (*m/z*, relative intensity, EI): 189 [M^+] (46), 159 [$M^+ - CH_2O$] (19), 130 [159 – CHO] (30).

$C_{11}H_{11}NO_2$ (189.2) Calcd. C 69.84 H 5.82
Found C 69.72 H 5.94

3a,4-Dihydro-6-(4-methoxyphenyl)-3H,6H-furo[3,4-c]isoxazole (**6e**) was prepared from **4e** as a 4:1 *trans:cis* mixture in 87% yield. The two isomers were separated by chromatography over SiO_2 with dichloromethane. – *trans*-**6e**: crystals from methanol, m.p. 112–113°C. – ^{1}H NMR: δ = 3.77 (dd, *J* = 9/8 Hz, 1H, 4-H), 3.79 (s, 3H, CH_3O), 4.03 (dd, *J* = 12/8 Hz, 1H, 3-H), 4.18–4.32 (m, 1H, 3a-H), 4.38 (t, *J* = 8 Hz, 1H, 4-H), 4.56 (dd, *J* = 9/8 Hz, 1H, 3-H), 5.53 (br s, 1H, 6-H), 6.90 and 7.31 (dt, *J* = 9/2 Hz, 2H, Ar). – ^{13}C NMR: δ = 54.68 (C-3a), 55.17 (CH_3O), 69.69 (C-4), 72.64 (C-6), 73.48 (C-3), 114.00, 127.07, 129.34, 159.63 (Ar), 170.51 (C=N). – MS (*m/z*, relative intensity, EI): 219 [M^+] (52), 189 [$M^+ - CH_2O$] (84), 135 [ArC≡O^+] (100).

$C_{12}H_{13}NO_3$ (219.2) Calcd. C 65.75 H 5.94
Found C 65.74 H 6.17

cis-**6e**: ^{1}H NMR: δ = 3.79 (s, 3H, CH_3O), 3.86 (m, 1H, 4-H), 4.08 (m, 1H, 3-H), 4.28–4.40 (m, 2H, 3a,4-H), 4.61 (m, 1H, 3-H), 5.52 (br s, 1H, 6-H), 6.90 and 7.35 (dt, *J* = 9,2 Hz, 2H, Ar). – ^{13}C NMR: δ = 55.17 (CH_3O), 55.77 (C-3a), 68.91 (C-4), 72.78 (C-6), 74.03 (C-3), 113.89, 127.94, 129.15, 159.63 (Ar), 170.51 (C=N). – MS (*m/z*, relative intensity, EI): 219 [M^+] (58), 189 [$M^+ - CH_2O$] (27), 160 [189 – CHO] (28), 135 [$ArC{\equiv}O^+$] (100).

3a,4-Dihydro-6-(4-methoxyphenyl)-3-methyl-3H,6H-furo[3,4-c]isoxazole (**6f**) was prepared from **4f** as a 3:1 *trans:cis* mixture in 79% yield. The two isomers were separated by chromatography over SiO_2 with dichloromethane. – *trans*-**6f**: crystals from methanol, m.p. 94°C. – ^{1}H NMR: δ = 1.51 (d, *J* = 7 Hz, 3H, CH_3), 3.80 (s, 3H, CH_3O), 3.78–4.00 (m, 2H, 3a-, 4-H), 4.22–4.42 (m, 1H, 4-H), 4.60–4.70 (m, 1H, 3-H), 5.50 (br s, 1H, 6-H), 6.88 and 7.32 (dt, *J* = 9/2 Hz, 2H, Ar). – ^{13}C NMR: δ = 18.22 (CH_3), 55.32 (CH_3O), 59.69 (C-3a), 69.13 (C-4), 73.09 (C-6), 83.97 (C-3), 114.13, 127.15, 129.60, 159.76 (Ar), 171.80 (C=N). – MS (*m/z*, relative intensity, EI): 233 [M^+] (19), 189 [$M^+ - CH_3CHO$] (100), 135 [$ArC{\equiv}O^+$] (73).

$C_{13}H_{15}NO_3$ (233.3) Calcd. C 66.95 H 6.43
Found C 66.75 H 6.70

cis-**6f**: oil. – ^{1}H NMR: δ = 1.54 (d, *J* = 7 Hz, 3H, CH_3), 3.80 (s, 3H, CH_3O), 3.78–4.00 (m, 2H, 3a-, 4-H), 4.12–4.32 (m, 1H, 4-H), 4.59–4.69 (m, 1H, 3-H), 5.48 (br s, 1H, 6-H), 6.88 and 7.36 (dt, *J* = 9,2 Hz, Ar). – ^{13}C NMR: δ = 18.22 (CH_3), 55.32 (CH_3O), 60.93 (C-3a), 68.32 (C-4), 73.24 (C-6), 84.41 (C-3), 114.04, 128.16, 129.23, 159.76 (Ar), 171.80 (C=N). – MS (*m/z*, relative intensity EI): 233 [M^+] (19), 188 [$M^+ - C_2H_5O$] (7), 135 [$ArC{\equiv}O^+$] (100).

3a,4-Dihydro-6-(4-methoxyphenyl)-3-phenyl-3H,6H-furo[3,4-c]isoxazole (**6g**) was prepared from **4g** as a 3:1 *trans:cis* mixture in 78% yield (oil). – *trans*-**6g**: ^{1}H NMR: δ = 3.80 (s, 3H, CH_3O), 3.97 (dd, *J* = 9/8 Hz, 1H, 4-H), 4.19–4.30 (dddd; *J* = 12/9/8/1 Hz, 3a-H), 4.41 (t, *J* = 8 Hz, 1H, 4-H), 5.52 (d, *J* = 12 Hz, 1H, 3-H), 5.59 (s, 1H, 6-H), 6.91 and 7.32 (dt, *J* = 9/2 Hz, 2H, Ar), 7.32–7.42 (m. 5H, Ph). – ^{13}C NMR: δ = 55.33 (CH_3O), 60.65 (C-3a), 69.35 (C-4), 73.19 (C-6), 89.09 (C-3), 114.20, 126.66, 127.07, 128.80, 129.40, 136.88, 159.84 (Ar+Ph), 171.21 (C=N). – *cis*-**6g**: ^{1}H NMR: δ = 3.81 (s, 3H, CH_3O), 4.05 (m, 1H, 4-H), 4.30–4.45 (m, 2H, 3a-, 4-H), 5.50 (d, *J* = 12 Hz, 1H, 3-H), 5.56 (br s, 1H, 6-H), 6.93 (dt, *J* = 9, 2 Hz, 2H, Ar), 7.30–7.42 (m, 7H, Ar+Ph). – ^{13}C NMR: δ = 55.33 (CH_3O), 61.85 (C-3a), 68.52 (C-4), 73.28 (C-6), 89.57 (C-3), 114.10, 126.77, 127.07, 128.80, 129.05, 136.73, 159.84 (Ph+Ar), 171.53 (C=N). – MS (*m/z*, relative intensity, mixture of isomers, EI): 296 [MH^+] (32), 189 [M^+ – Ar] (100), 135 [$ArC{\equiv}O^+$] (61).

$C_{18}H_{17}NO_3$ Calcd. 295.129 Found 295.128 (MS)

3a,4-Dihydro-6-(4-methoxyphenyl)-3a-methyl-3H,6H-furo[3,4-c]isoxazole (**6h**) was prepared from **4h** as a 2:1 *trans:cis* mixture in 84% yield (oil). – *trans*-**6h**: ^{1}H NMR: δ = 1.37 (s, 3H, CH_3), 3.81 (s, 3H, CH_3O), 3.94 and 4.04 (d, *J* = 8 Hz, 1H, 4-H), 4.19 and 4.22 (d, *J* = 8/1 H, 3-H), 5.56 (br s, 1H, 6-H), 6.91 and 7.37 (dt, *J* = 9/2 Hz, 2H, Ar). – ^{13}C NMR: δ = 20.32 (CH_3), 55.26 (CH_3O), 61.43 (C-3a), 72.99 (C-6), 75.91 (C-4), 80.19 (C-3), 114.02, 126.91, 129.44, 159.44 (Ar), 174.20 (C=N). – *cis*-**6h**: ^{13}C NMR: δ = 20.43 (CH_3), 55.26 (CH_3O), 61.93 (C-3a), 72.21 (C-6), 75.24 (C-4), 80.19 (C-3), 114.02, 127.97, 128.98, 159.47 (Ar), 174.06 (C=N). – MS (*m/z*, relative intensity, mixture of isomers, EI): 234 [MH^+] (37), 233 [M^+] (31), 232 [M^+ – H] (69), 203 [$M^+ - CH_2O$] (45), 135 [$ArC{\equiv}O^+$] (100).

$C_{13}H_{15}NO_3$ Calcd. 233.119 Found 233.119 (MS)

cis-3,3a,4,5-Tetrahydro-7-methyl-7H-pyrano[3,4-c]isoxazole (**9a**) was prepared in 72% yield from **8a** as a colorless oil. The spectral data were identical with those of the earlier reported compound[3].

3,3a,4,5-Tetrahydro-7-(4-methoxyphenyl)-7H-pyrano[3,4-c]-isoxazole (**9b**) was prepared in 95% yield from **8b** as a 6:1 *cis:trans* mixture (oil). – *cis*-**9b**: ^{1}H NMR: δ = 1.92 (qd, *J* = 13/5 Hz, 1H, H_{ax}), 2.22 (ddt, *J* = 13/7.5, 1 Hz, 1H, H_{eq}), 3.30–3.64 (m, 1H, 3a-H), 3.73 (td, *J* = 13/2 Hz, 1H) 3.80 (s, 3H, CH_3O), 3.86 (dd, *J* = 12/8 Hz, 1H, 3-H), 4.21 (ddd, *J* = 13/5/2 Hz, 1H, 5-H_{eq}), 4.67 (dd, *J* = 10/8 Hz, 1H, 3-H), 5.07 (br s, 1H, 7-H), 6.90 and 7.38 (dt, *J* = 9/2 Hz, 2H, Ar). – ^{13}C NMR: δ = 32.92 (C-4), 46.58 (C-3a), 55.24 (CH_3O), 66.53 (C-5), 73.96 (C-3), 77.10 (C-7), 113.78, 128.59, 129.00, 158.68 (Ar), 159.81 (C=N). – *trans*-**9b**: ^{1}H NMR: δ = 1.86 (qd, *J* = 13/5 Hz, 1H, H_{ax}), 2.08 (ddt, *J* = 13/7/2 Hz, 1H, H_{eq}), 3.38 (br qd, *J* = 12/6 Hz, 1H, 3a-H), 3.58 (td, *J* = 11/2 Hz, 1H, 5-H_{ax}), 3.80 (ddd, *J* = 11/5/2 Hz, 1H, 5-H_{eq}), 3.82 (s+dd, *J* = 12/8 Hz, 4H, CH_3O + 3-H), 4.64 (dd, *J* = 10/8 Hz, 1H, 3-H), 5.81 (br s, 1H, 7-H), 6.92 and 7.28 (dt, *J* = 9/2 Hz, 2H, Ar). – ^{13}C NMR: δ = 33.15 (C-4), 43.81 (C-3a), 55.24 (CH_3O), 59.58 (C-5), 72.19 (C-7), 73.69 (C-3), 114.24, 127.58, 127.96, 159.81 (Ar), 156.78 (C=N). – MS (*m/z*, relative intensity, mixture of isomers, EI): 233 [M^+] (100), 203 [$M^+ - CH_2O$] (52), 202 [$M^+ - CH_2OH$] (53), 172 [202 – CH_2O] (35), 135 [$ArC{\equiv}O^+$] (86).

$C_{13}H_{15}NO_3$ (mixture of isomers) (233.3)
Calcd. C 66.95 H 6.43 Found C 66.69 H 6.69

3,3a,4,5-Tetrahydro-7-(2,4,6-trimethylphenyl)-7H-pyrano[3,4-c]isoxazole (**9c**) was obtained from **8c** in 80% yield as an oil, containing >95% of *cis*-**9c** and a trace of the *trans*-isomer. Crystallization from chloroform/hexane (60%) gave pure *cis*-**13c**, m.p. 135–136°C. – ^{1}H NMR: δ = 1.91 (qd, *J* = 12/5 Hz, 1H, H_{ax}), 2.20 (ddt, *J* = 12/6/2 Hz, 1H, H_{eq}), 2.24 (s, 3H, 4-CH_3), 2.34 (br s, 6H, 2,6-CH_3), 3.50 (m, 1H, 3a-H), 3.66 (td, *J* = 12/2 Hz, 1H, 5-H_{ax}), 3.82 (dd, *J* = 13/8 Hz, 1H, 3-H), 4.21 (dddd, *J* = 12/5/2 Hz, 1H, 5-H_{eq}), 4.69 (dd, *J* = 10/8 Hz, 1H, 3-H), 5.48 (br s, 1H, 7-H). Irradiation at this frequency increases the intensity of the signal at δ = 3.66 by 6% and the signal at δ = 3.50 by 2.5% (NOE), 6.84 (br s, 2H, Ar). – ^{13}C NMR: δ = 20.85 (br, CH_3), 31.80 (C-4), 46.76 (C-3a), 66.41 (C-5), 73.67 (C-3, -7), 128.13, 129.99, 137.82 (Ar), 156.60 (C=N). – MS (*m/z*, relative intensity, EI): 245 [M^+] (42), 214 [$M^+ - CH_2O$] (12), 200 [$M^+ - CH_2O - CH_3$] (94), 184 [$M^+ - CH_2CH_3O$] (73), 147 [$ArC{\equiv}O^+$] (100).

$C_{15}H_{19}NO_2$ (245.3) Calcd. C 73.47 H 7.76
Found C 73.19 H 7.62

3a,4,5,6-Tetrahydro-8-(4-methoxyphenyl)-3H,8H-oxepino[3,4-c]isoxazole (**9d**): To a solution of 265 mg (1.0 mmol) of **8d** in 100 ml of benzene, containing a few drops of triethylamine, was added 0.36 g (3.0 mmol) of phenyl isocyanate, and the mixture was refluxed for ca. 12 h. The usual workup yielded 75 mg (30%) of **9d** after crystallization from methanol, m.p. 68–69°C. – ^{1}H NMR: δ = 1.55–1.93 (m, 4H, 4-,5-H), 3.28 (dtd, *J* = 12/6/4 Hz, 1H, 3a-H), 3.48 (ddd, *J* = 13/10/3 Hz, 1H, 6-H_{ax}), 3.79 (s, 3H, CH_3O), 4.12 (d, *J* = 6 Hz, 2H, 3-H), 4.23 (dm, *J* = 13 Hz, 1H, 6-H_{eq}), 5.55 (br s, 1H, 8-H), 6.89 and 7.38 (dt, *J* = 9/2 Hz, 2H, Ar). Irradiation at δ = 4.12 collapsed the dtd at δ = 3.28 to a dd (*J* = 12/4 Hz). Irradiation at δ = 4.23 collapsed the ddd at δ = 3.48 to a dd (*J* = 10/3 Hz). – ^{13}C NMR: δ = 29.98 and 32.41 (C-4, -5), 48.43 (C-3a), 55.27 (CH_3O), 70.51 (C-6), 75.41 (C-3), 77.35 (C-8), 113.92, 127.36, 131.81, 159.40 (Ar), 165.50 (C=N). – MS (*m/z*, relative intensity, CI, CH_4): 248 [MH^+] (100), 140 [M^+ – Ar] (26).

$C_{14}H_{17}NO_3$ (247.3) Calcd. C 68.02 H 6.88
Found C 67.75 H 6.69

6-(Methoxyphenyl)-4H,6H-furo[3,4-c]isoxazole (**11**) was prepared from **10** in 85% yield after crystallization from methanol, m.p. 58°C. – ^{1}H NMR: δ = 3.80 (s, 3H, CH_3O), 4.94 (ddd, *J* = 12/1/0.5 Hz, 1H, 4-H), 5.03 (dt, *J* = 12/1 Hz, 1H, 4-H), 6.06 (br s,

1H, 6-H), 6.91 and 7.35 (dt, J = 9/2 Hz, 2H, Ar), 8.07 (t, J = 1 Hz, 1H, 3-H). – ^{13}C NMR: δ = 55.26 (CH_3O), 63.67 (C-4), 76.19 (C-6), 114.07 (Ar), 123.06 (C-3), 127.86, 129.89 (Ar), 148.04 (C-3a), 159.78 (Ar), 172.43 (C=N). – MS (*m/z*, relative intensity, EI): 217 [M^+] (25), 135 [$ArC{\equiv}O^+$] (100).

$C_{12}H_{11}NO_3$ (217.2) Calcd. C 66.36 H 5.07
Found C 66.08 H 4.86

CAS Registry Numbers

2 (R = mesityl): 128869-45-4 / **2a**: 3156-70-5 / **2d**: 102-96-5 / **2e**: 3199-10-0 / **3f**: 6117-91-5 / **3g**: 104-54-1 / **3h**: 513-42-8 / **4a**: 127865-31-0 / **4b**: 132439-78-2 / **4c**: 132439-79-3 / **4d**: 132439-80-6 / **4e**: 132439-81-7 / **4f**: 132439-82-8 / **4g**: 132439-83-9 / **4h**: 132439-84-0 / **6a** (*cis* isomer): 120783-51-9 / **6a** (*trans* isomer): 120783-52-0 / **6b** (*cis* isomer): 132439-85-1 / **6b** (*trans* isomer): 132439-86-2 / **6c** (*cis* isomer): 132439-87-3 / **6c** (*trans* isomer): 132439-88-4 / **6d** (*cis* isomer): 120783-50-8 / **6d** (*trans* isomer): 132439-89-5 / **6e** (*cis* isomer): 132439-90-8 / **6e** (*trans* isomer): 132439-91-9 / **6f**: 132439-92-0 / **6g**: 132439-93-1 / **6h** (*cis* isomer): 132439-94-2 / **6h** (*trans* isomer): 132439-95-3 / **7** (R = Me): 3156-76-1 / **7b**: 3156-75-0 / **7c**: 41367-90-2 / **8a**: 127865-35-4 / **8b**: 132439-96-4 / **8c**: 132439-97-5 / **8d**: 132439-98-6 / **9a** (*cis* isomer): 127865-36-5 / **9b** (*cis* isomer): 132439-99-7 / **9b** (*trans* isomer): 132440-00-7 / **9c** (*cis* isomer): 132440-01-8 / **9c** (*trans* isomer): 132440-02-9 / **9d** (*cis* isomer): 132440-03-0 / **10**: 132440-04-1 / **11**: 132440-05-2 / allyl alcohol: 107-18-6 / 3-buten-1-ol: 627-27-0 / 4-penten-1-ol: 821-09-0 / propargyl alcohol: 107-19-7

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[1] Part 46: A. Hassner, R. Maurya, A. Padwa, W. H. Bullock, *J. Org. Chem.*, in press.
[2] For instance, J. Yoshimura, *Adv. Carbohydr. Chem.* **42** (1984) 69; M. Bourgeois, *Helv. Chim. Acta.* **56** (1973) 2879; **58** (1975) 363.
[3] A. Hassner, K. S. K. Murthy, A. Padwa, U. Chiacchio, D. C. Dean, A. M. Schoffstall, *J. Org. Chem.* **54** (1989) 5277.
[4] A. P. Kozikowski, *Acc. Chem. Res.* **17** (1984) 410, and references cited.
[5] A. Hassner, K. S. K. Murthy, *Tetrahedron Lett.* **28** (1987) 683.
[6] T. L. Gilchrist, *Chem. Soc. Rev.* **12** (1983) 53.
[7] T. Mukaiyama, T. Hoshino, *J. Am. Chem. Soc.* **82** (1960) 5339.
[8] Previously (ref.[3]) it has been thought that **6d** had formed as the *trans* isomer exclusively. We now have shown that an 80:20 *trans*:*cis* mixture is formed.
[9] We are indebted to Prof. *A. Padwa* for the MM2 calculations.
[10] No NOE can be measured between the benzylic and bridgehead protons. An alternative *trans* configuration for **9d** with an equatorial phenyl group and axial bridgehead hydrogen cannot, however, be excluded.

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