Addition of 3-Nitrosobut-3-en-2-one to Olefins and to Electron-rich Heterocycles

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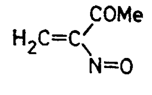
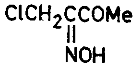
Summary 3-Nitrosobut-3-en-2-one (**1**) adds to olefins to give 1,2-oxazine derivatives (**3**); furan and indole give the oximes (**5**) and (**7**) in good yields.

α-NITROSOSTYRENE adds efficiently to dienes and to enamines, giving 5,6-dihydro-4*H*-1,2-oxazines.[1] We have also observed addition, in lower yields, to conjugated olefins such as indene,[2] but simple alkenes react in very low yields or not at all. Such reactions should be facilitated by an increase in the electrophilic character of the nitrosoalkene. This can be achieved by introducing an additional electron-withdrawing group at the 1-position. Thus, we find that



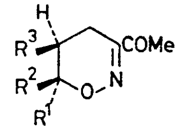
$H_2C{=}C(COMe)N{=}O$

(1)



$ClCH_2C({=}NOH)COMe$

(2)



(3)

a; R^1 = Ph, R^2 = Me, R^3 = H
b; R^1 = Ph, R^2 = H, R^3 = Me
c; R^1 = Me, R^2 = H, R^3 = Ph
d; R^1 = H, R^2 = Ph, R^3 = Me
e; R^1 = R^3 = Ph, R^2 = H
f; R^1 = C_6H_{13}, R^2 = R^3 = H
g; R^1 = H, R^2, R^3 = $-[CH_2]_4-$

3-nitrosobut-3-en-2-one (**1**) gives adducts with a variety of olefins, including simple alkenes, and with electron-rich heterocyclic compounds. Typical examples are shown in the Table.

TABLE

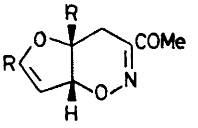
Products of addition of 3-nitrosobut-3-en-2-one.[a]

Substrate	Products	% Yield[b]	M.p./°C
α-Methylstyrene	(**3a**)	44	217—218[c]
trans-Propenylbenzene	(**3b**), (**3c**) (87 : 13)	37	55—56 (**3b**)
cis-Propenylbenzene	(**3d**), (**3b**) (81 : 19)	14	198—200[c] (**3d**)
trans-Stilbene	(**3e**)	46	108—111
Oct-1-ene	(**3f**)	32	125—126[c]
Cyclohexene	(**3g**)	22	146—148[c]
Furan	(**4a**)	75	180—182[c] (**5**)
2,5-Dimethylfuran	(**4b**)	58	32—35
Indole	(**7**)	73	120—121
3-Methylindole	(**6**)	86	84—86

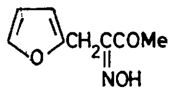
[a] 1-Chlorobutane-2,3-dione 2-oxime (2 mmol) in dichloromethane (50 cm^3) was stirred at room temperature for 24 h with anhydrous sodium carbonate (10 mmol) and the substrate (20 mmol). [b] Yields are for isolated, pure products. All gave satisfactory analytical and spectral data. [c] 2-4-Dinitrophenylhydrazone.

1-Chlorobutane-2,3-dione 2-oxime (**2**) is readily prepared in high yield by the addition of nitrosyl chloride to but-3-en-2-one.[3] When the chloro-oxime is stirred in dichloromethane with anhydrous sodium carbonate, the nitrosoalkene (**1**) is probably formed as a transient intermediate. It has not been detected directly, but in the presence of suitable olefins, 1 : 1 adducts are formed. The structures of the adducts are assigned mainly on the basis of their n.m.r. spectra. The adducts formed with olefins are all 5,6-dihydro-4*H*-1,2-oxazines (**3**), which show characteristic chemical shifts and couplings in the ^{1}H n.m.r. spectrum.[1] These reactions show a high degree of regioselectivity: only one regioisomer can be detected in the additions to α-methylstyrene and to oct-1-ene, and with *trans*-propenylbenzene there is a strong preference (87 : 13) for the 6-phenyl isomer (**3b**) over the 6-methyl isomer (**3c**). Addition to *trans*-stilbene and to *trans*-propenylbenzene is also highly stereoselective, only the *trans* adducts being detected.† In the addition to *cis*-propenylbenzene,‡ however, the *trans*-adduct (**3b**) is formed as well as the *cis*-adduct (**3d**), the latter being the major product. This indicates that the addition goes, at least in part, by a stepwise mechanism,§ possibly involving an intermediate zwitterion. In the case of 2 + 2 cycloadditions it has been shown that highly stereoselective addition can take place even when zwitterionic intermediates are involved.[4]

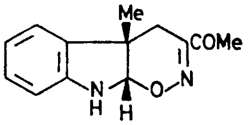
Addition to furan and to 2,5-dimethylfuran also gives the corresponding cycloadducts (**4**), in good yields, but the furan adduct (**4a**) is unstable and completely isomerises to the oxime (**5**) within a few hours at room temperature. 3-Methylindole gives a good yield of the cycloadduct (**6**), which contains the same ring system as is present in the alkaloid geneserine.[5] With indole, the open-chain oxime (**7**) is the only product detected. This last reaction provides a very mild method for the introduction of a highly functionalised side chain into the 3-position of indole.



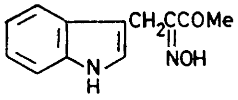
(4)
a; R = H
b; R = Me



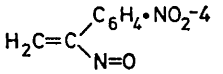
(5)



(6)



(7)



$H_2C{=}C(C_6H_4\cdot NO_2\text{-}4)N{=}O$

(8)

We have observed a similar series of reactions with 4-nitro-α-nitrosostyrene (**8**); the yields of adducts tend to be higher than with 3-nitrosobut-3-en-2-one but the addition is less regioselective.

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† The isomers are readily distinguishable by means of the H-5 to H-6 coupling constants, which are about 2 Hz for the *cis* adducts and about 10 Hz for the *trans* adducts.

‡ This olefin was prepared by the stereoselective reduction of propynylbenzene, as described by C. A. Brown and V. K. Ahuja, *J.C.S. Chem. Comm.*, 1973, 553. No *trans*-propenylbenzene could be detected in the olefin by n.m.r. spectroscopy.

§ Compounds (**3b**) and (**3d**) are not interconverted under the reaction conditions.

5,6-Dihydro-1,2-oxazines undergo a variety of potentially useful ring-opening reactions when they are heated or treated with electrophiles.[2,6] The addition of electrophilic nitrosoalkenes to olefins provides a simple route to a wide range of these compounds.

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[1] R. Faragher and T. L. Gilchrist, *J.C.S. Chem. Comm.*, 1976, 581; *J.C.S. Perkin I*, in the press.

[2] R. Faragher and T. L. Gilchrist, *J.C.S. Chem. Comm.*, 1977, 252; *J.C.S. Perkin I*, in the press.

[3] K. A. Ogloblin and A. A. Potekhin, *J. Gen. Chem. U.S.S.R.*, 1964, **34**, 2710.

[4] R. Huisgen, *Accounts Chem. Res.*, 1977, **10**, 117.

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