

Regioselective and Unusual [3+2] Cycloadditions of α -Nitrostyrenes with 1,3-Diaza-1,3-Butadienes

Arun K. Sharma, Sujit N. Mazumdar and Mohinder P. Mahajan*

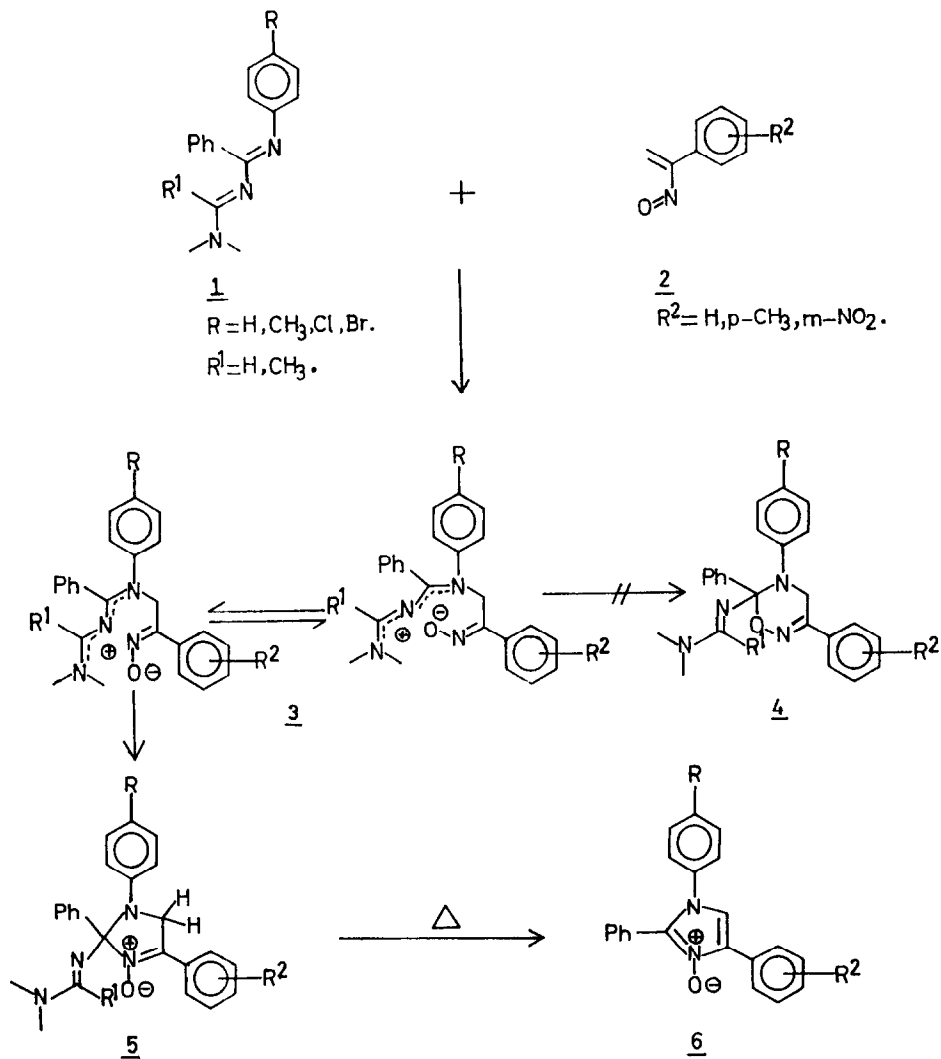
Department of Chemistry, North-Eastern Hill University, Shillong - 793 003, Meghalaya, India

Abstract: α -Nitrostyrenes (**2**), generated *in situ*, underwent unusual regioselective [3+2]cycloadditions with 1,3-diaza-1,3-butadienes (**1**) leading to cyclic nitrones (**5**) in good yields. They also gave cyclic nitrones (**8**) with trisubstituted amidines (**7**).

Diels-Alder cycloaddition reactions in which a nitroso (-N=O) group participates as 2π component have been extensively exploited in cycloaddition reactions¹. The α -nitrosoalkenes usually generated *in situ* by reactions of α -haloketoximes with bases², form another group of extremely reactive synthetic intermediates which have been successfully trapped as 4π component in a variety of Diels-Alder cycloaddition reactions². Almost in all reactions of α -nitrosoalkenes with polarised⁴ and unpolarised alkenes², allenes³ and all carbon dienes⁴, the major isolable product is an oxazine derivative. In cycloaddition reactions of 2,5-dimethylfuran and cyclopentadiene with α -nitrostyrene, the formal 1,4-additions were believed to arise from the initial addition of α -nitrostyrene as the 2π component at its alkene group followed by a [3,3]sigmatropic shift⁵. Even though there are a number of reports concerning the cycloaddition reactions of α -nitrosoalkenes with carbon-carbon double bonds, corresponding reports concerning cycloadditions with carbon-nitrogen double bonds are very rare⁵. Mackay *et al.*⁵, while investigating the reactions of α -nitrostyrenes with 2,5-dimethylfuran have isolated, in addition to oxazine derivatives, a second product, a nitrone, arising from [3+2] cycloaddition. These nitrones were isolated either by carrying out the reactions of 2,5-dimethylfuran with two equivalent of α -nitrostyrenes or by the reactions of one equivalent of α -nitrostyrenes with oxazine derivatives. A number of unsuccessful attempts were also made to improve the yields of nitrone derivatives by carrying out the reactions under different reaction conditions. The authors failed to observe the reactions of α -nitrostyrenes with various cyclic and acyclic models bearing carbon-nitrogen double bonds and hence could not generalise such cycloaddition modes. Thus, they⁵ concluded that the [3+2] cycloaddition of α -nitrostyrenes to C-N double bonds occurs only for 1,2-oxazines fused to a five-membered ring and having a double bond allylic to the oxazine oxygen. The formation of cyclic nitrones resulting from the [3+2] cycloaddition of α -nitrostyrenes is of great synthetic utility as the methods of preparing such nitrones is limited to a relatively few routes⁶. Keeping these observations in view and to compare their dienic properties, we have investigated the reactions of highly polarised 1,3-diaza-1,3-butadienes (**1**)⁷ having two carbon-nitrogen double bonds with α -nitrostyrenes (**2**).

Treatment of 1-aryl-4-dimethylamino-1,3-diaza-1,3-butadienes (**1**) with α -nitrostyrenes (**2**), generated from α -halooximes and sodium carbonate, resulted in very good yields (76-90%) of previously unreported nitrones (**5**). The nitrones (**5**) arise from regioselective [3+2] cycloadditions of α -nitrostyrenes with the 1,2-C=N of 1,3-diazabutadienes. The products were characterised as

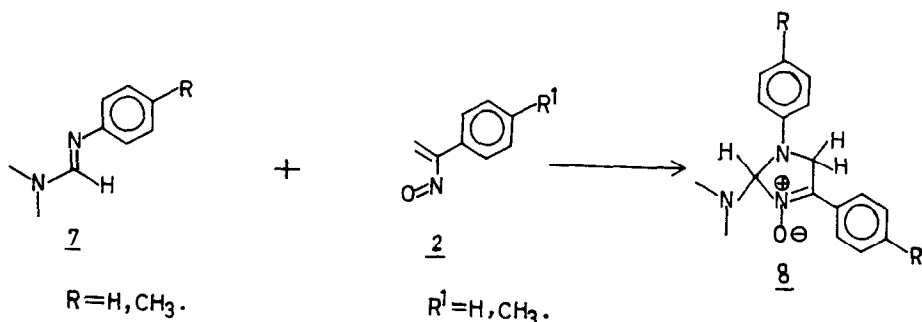
1,4-diaryl-2-*N'*-(*N,N*-dimethylformamidino/acetamidino)-2-phenyl- Δ^3 -imidazoline-3-oxides (**5**) on the basis of analytical and spectral evidence⁸. Their IR spectra (KBr) showed strong absorptions around 1630 cm^{-1} and 1590 cm^{-1} due to C=N, and 1220 cm^{-1} for N-O of a nitron. The nitron (**5**), as apposed to the oxadiazine (**4**), structures for the products were supported by the ^1H NMR signals for the methylene and *ortho* phenyl protons of the nitron ring. The former gave an AB quartet (unresolved at 90 MHz but resolved at 200 MHz) at δ ca. 4.95 ($J=14.4\text{Hz}$) (in CDCl_3) downfield from the position, δ ca. 3.50, typical of an oxadiazine⁵. Similarly, the *ortho* protons of phenyl group attached to nitron ring resonated at δ ca. 8.40 downfield from the corresponding signals, δ ca. 7.70, of typical oxazines² and the appearance of a distinct singlet around δ 7.5 for a formamidino proton comparable with its



Scheme-1

literature value⁹. Their ¹³C NMR spectra showed peaks around δ 140 and δ 160 assigned to the nitrone carbon and amidino carbon, respectively. Their mass spectra exhibited intense M-16 or M-17 peaks, diagnostic of nitrones⁵, in addition to strong M-amidino and imidazole ion peaks. The oxadiazine structure (4) was clearly ruled out by the above spectral data. The formation of the cyclic nitrones (5) was further confirmed by their thermal degradation. Heating of these compounds (5) in dry benzene in sealed tubes at 140-150°C for six to seven hours resulted in compounds, which were characterised as 1,4-diaryl-2-phenylimidazole-3-oxides (6)⁸. The compounds (6) showed strong IR bands at around 1210 cm⁻¹ typical for the N-O bonds of nitrones¹⁰. The ¹H NMR spectra of (6) showed the absence of the dimethylformamidino unit and the presence of two downfield protons around δ 7.86 assigned to two *ortho* protons of the phenyl group attached to the carbon of the nitrone. Their ¹³C NMR spectra also attest to the imidazole N-oxide structure. Their mass spectra exhibited intense M-16 peaks characteristic of heterocyclic N-oxides, in addition to the molecular ion peak.

It was felt that all polarised carbon-nitrogen double bonds may also add to α -nitrosoalkenes in a [3+2] manner. Hence, in order to generalise the versatility of the reaction, we have further investigated the cycloaddition reactions of α -nitrostyrenes with *N,N,N'*-trisubstituted amidines (7). These reactions have also been shown to follow [3+2] cycloaddition pathway leading to nitrones (8) (Scheme-2). ¹H NMR signatures attest to the assigned structure, which in addition to other signals, showed characteristic downfield shift for two *ortho* phenyl protons of nitrones and an ABq (*J* = 14.5 Hz, unresolved in a few cases) for the methylene protons around δ 4.70. Nakanishi *et al.*¹¹ have reported the formation of imidazole derivatives, probably *via* oxadiazines, in the reactions of α -halooximes with *N*-phenyl-*N*-methylbenzamidines by using iron carbonyls. The formation of oxadiazines in this case may be due to the presence of a phenyl group on the nitrogen of disubstituted amidines.



Scheme-2

The mechanism leading to the formation of nitrones (5) is outlined in Scheme-1. It is presumed that the nitrosoalkenes (2) add to 1,3-diazabutadienes (1) to give interconvertible cisoid and transoid zwitterionic intermediate (3) and that for steric reasons the transoid forms of (3) yield the nitrones (5). A detailed study concerning these nitrones and cycloadditions of α -nitrostyrene with various types of C=N is underway and the results of these investigations will be reported shortly.

Acknowledgement: We thank the Council of Scientific and Industrial Research, New Delhi, for financial support.

References

- (a) Kirby, G.W. *Chem. Soc. Rev.*, **1977**, *6*, 1; (b) Kirby, G.W.; Sweeny, J.G. *J. Chem. Soc. Perkin Trans. I*, **1981**, 3250; (c) Kirby, G.W.; McGuigan, H.; Mclean, D. *J. Chem. Soc., Perkin Trans. I*, **1985**, 1961; (d) Christie, C.C.; Kirby, G.W.; McGuigan, H.; Mackinnon, J.W.M.J. *J. Chem. Soc., Perkin Trans. I*, **1985**, 2469; (e) Kirby, G.W.; Nazeer, M. *Tetrahedron*, **1988**, *29*, 6173.
- (a) Gilchrist, T.L. *Chem. Soc. Rev.*, **1983**, *12*, 53; (b) Crystal, E.J.T.; Gilchrist, T.L.; Stretch, W. *J. Chem. Res. (S)*, **1987**, 180; *J. Chem. Res. (M)*, **1987**, 1563 and references therein.
- Zimmer, R.; Reissig, H.U. *Angew. Chem. Int. Ed., Engl.*, **1988**, *27*, 1518.
- Faragher, R.; Gilchrist, T.L. *J. Chem. Soc., Chem. Commun.*, **1976**, 581.
- (a) Mackay, D.; Watson, K. *J. Chem. Soc., Chem. Commun.*, **1982**, 775; 777. (b) Lai, E.C.K.; Mackay, D.; Taylor, N.J.; Watson, K.N. *J. Chem. Soc., Perkin Trans. I*, **1990**, 1497.
- Lathbury, D.C.; Shaw, R.W.; Bates, P.A.; Hursthouse, M.B.; Gallagher, T. *J. Chem. Soc., Perkin Trans. I*, **1989**, 2415 and references therein.
- Mazumdar, S.N.; Mahajan, M.P. *Synthesis*, **1990**, 417.
- Spectroscopic data:
5a (R=R¹=R²=H) ¹H NMR(CDCl₃): δ 2.81-2.93 (bd, 6H, -N(CH₃)₂); 4.93-4.97 (ABq, 2H, -CH₂-, J=14.4Hz); 6.72-6.80 (m, 2H, arom.); 7.01-7.43 (m, 9H, arom.), 7.48 (s, 1H, N=C-H), 7.60-7.74 (m, 2H, arom.) and 8.30-8.43 (d, 2H, arom.). ¹³C NMR (CDCl₃): δ_C 160.72 (formamidino carbon). ν/cm⁻¹(KBr): 1590, 1630 (C=N) and 1220 (N-O). m/z 384 (M⁺, 11%), 368 (M⁺-16, 8.6%), 367 (M⁺-17, 30%), 312 (5%), 296 (40%) and 180 (5%).
6a (R=R²=H): ¹H NMR (CDCl₃): δ 7.26-7.46 (m, 13H, arom.) and 7.86-7.95 (m, 2H, arom.). ¹³C NMR (CDCl₃): δ_C 118.35, 124.83, 125.57, 126.77, 127.98, 128.22, 128.39, 128.56, 129.24, 130.10, 133.67, 138.18, 141.44 and 146.68. ν/cm⁻¹(KBr): 1205 (N-O). m/z 313 (M⁺ + 1, 2.3%), 312 (M⁺, 2.9%), 297 (15.2%) and 296 (M⁺ -16, 65.8%).
8a (R=R¹=H): ¹H NMR: δ 2.67 (s, 6H, -N(CH₃)₂), 4.58-4.79 (ABq, 2H, -CH₂-, J=14.5 Hz), 5.83 (s, 1H, -CH), 6.73-6.98 (d, 2H, arom.), 7.20-7.60 (m, 6H, arom.) and 8.28-8.50 (d, 2H, arom.). ν/cm⁻¹(KBr): 1615 (C=N) and 1230 (N-O). Satisfactory microanalyses were obtained for these compounds.
- Mazumdar, S.N.; Mahajan, M.P. *Tetrahedron*. **1991**, *47*, 1473.
- Delpierre, G.R.; Lamchen, M. *Q. Rev.*, **1965**, *19*, 329.
- Nakanishi, S.; Nantaku, J.; Otsuji, Y. *Chemistry Letters*, **1983**, 341.

(Received in UK 27 April 1993; accepted 8 October 1993)