Nitrene-like Behaviour of Diazoazoles?

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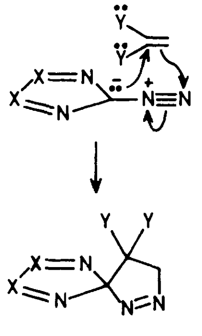
Treatment of 4,5-dicyano-2-diazoimidazole, 2-diazoimidazole, and 3-diazopyrazole with 1,1-dimethoxyethene affords azolo-*as*-triazines (**1c**), (**3c**), and (**8c**), respectively; the involvement as intermediates of either aziridines (**d**), arising from a 'nitrene-like reaction' of diazoazoles, or azoalkenes (**b**) should be questioned at present.

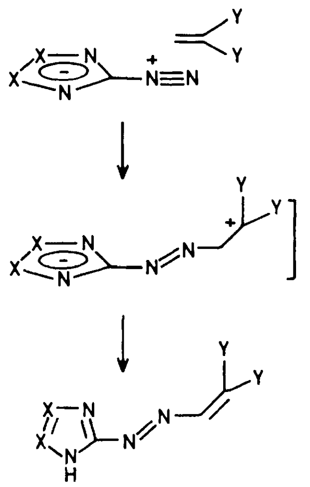
Nitrene-like behaviour has been postulated recently for 4,5-dicyano-2-diazoimidazole (DDI) in its reaction with 1,1-dimethoxyethene and 2,3-dimethylbuta-1,3-diene.[1] Such a suggestion is rather striking, bearing in mind the well-established 1,3-dipolar character[2] of diazo compounds and the participation of diazo groups in typical azo-coupling and related electrocyclic reactions.[3] In fact, these two pathways can also be envisaged for the first step, see (**a**) and (**b**), of the reaction of diazoazoles (*e.g.*, 2-diazoimidazole,[4] 2-DI) with polar alkenes (*e.g.*, 1,1-dimethoxyethene). Moreover, several examples are known of the formation of 1,7-cycloadducts or azolo-*as*-triazine derivatives[5] from diazoazoles and activated double or triple bonds, according to (**c**). 'Formal nitrene-like behaviour,' which could be represented by (**d**), has been demonstrated for some diazoalkenes,[6,7] but it is quite untenable that a diazo group reacts as a standard nitrene. As a matter of fact, all the intermediates shown in (**a**)—(**d**) may be interconverted through one- or two-step reactions. However, what kind of evidence supports pathway (**d**) for DDI and/or other diazoazoles?

We have found that when DDI was treated with 1,1-dimethoxyethene [isolated in 51% yield after distillation from the reaction of bromoacetaldehyde dimethyl acetal and NaH in hexamethylphosphoric triamide (HMPT) at 80—90 °C] in benzene at room temperature[1] a colourless product was obtained in very good yield [m.p. 192 °C (decomp.); δ 7.15 (1H, s) and 3.40 (6H, s) in $(CD_3)_2CO$; δ 6.93 (1H, s) and 3.30 (6H, s) in MeCN], which showed its two equivalent methyl carbons at δ 52.3, a methine carbon at δ 130.0, and six quaternary carbon atoms at δ 144.5, 122.5, 112.1, 108.3, 102.0, and 101.5. Structure (**1c**) rather than (**1b**)[1] must be attributed to the product since among other arguments: (i) the non-equivalence of carbons C-4 and C-5 of the imidazole ring and of the two cyano substituents is only compatible with an N-substituted azole ring; (ii) the expected δ value for the olefinic $C(OMe)_2$ carbon atom of (**1b**) is *ca.* 180 p.p.m.,[8] whereas the carbon at lower field is found at δ 144.5 (and, furthermore, it corresponds to C-2 of the imidazole ring); (iii) the olefinic proton of (**1b**) should appear at δ 5.4, taking into account the shift of 2.4 p.p.m. induced by a phenylazo substituent on geminal olefinic protons[9] (note that the olefinic protons of 1,1-dimethoxyethene appear at δ 3.00 in $CDCl_3$), perhaps even in the δ 5.5—6.0 range, but never at δ 6.5—7.0. Heating of (**1c**) either in refluxing xylene, in a sealed tube with benzene at 150 °C,[1] or without solvent to 170 °C gave, as the major product, 6,7-dicyano-1-methylimidazo[2,1-*c*]-*as*-triazin-4-one, (**2**), m.p. 218—219 °C, ν(C=O) 1710 cm^{-1}, δ 7.84 (1H, s) and 4.15 (3H, s) in $(CD_3)_2CO$.

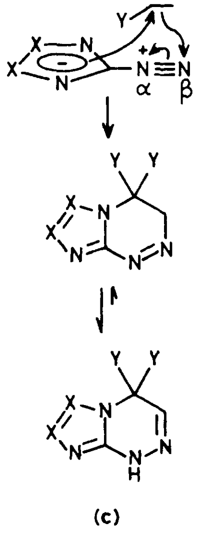
In a similar way, when 2-DI was treated, in benzene at room temperature, with 3 equiv. of 1,1-dimethoxyethene, the solution turned reddish† but a colourless product, m.p. 137—140 °C, *m/z* 182 (M^+), was obtained in 70—81% yields



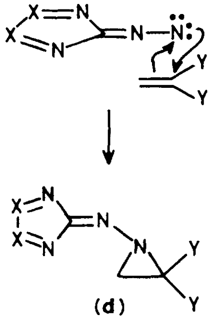
(**a**)



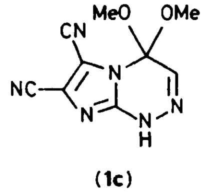
(**b**)



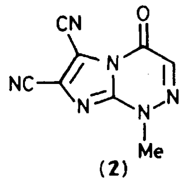
(**c**)



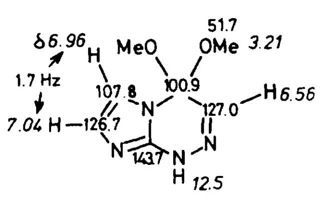
(**d**)



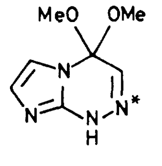
(**1c**)



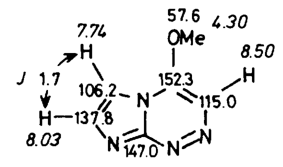
(**2**)



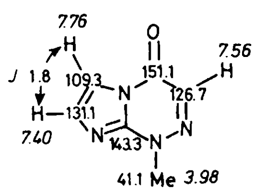
(**3c**)‡ §



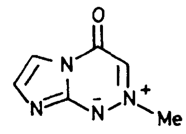
(**3c***)



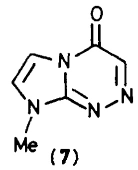
(**4**) § ¶



(**5**)



(**6**)



(**7**)

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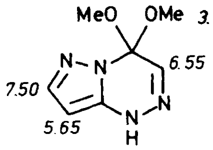
† T.l.c. indicates that the brown-red colour is due to minor amounts of very polar compounds; the ^1H n.m.r. spectrum of the crude (94% yield) is practically identical to that of the recrystallised, colourless product. In the experiments performed in benzene, 2-phenylimidazole appears to be the only significant by-product.

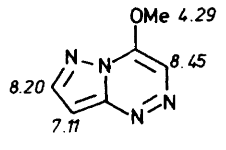
‡ In $(CD_3)_2SO$ the methoxy groups appear at δ 3.10, the singlet at δ 6.67, and the doublets at δ 6.86 and 7.02.

§ δ_H Values are shown in italics, δ_C in roman.

¶ Spectra recorded in $CDCl_3$. In $(CD_3)_2SO$ the methoxy group appears at δ 4.28, the singlet at δ 8.81, and the two imidazole protons become almost equivalent (δ 8.04 and 8.01, *J* 1.5 Hz).



(8c)



(9)

after two recrystallisations of the reaction residue from CH_2Cl_2–pentane; its 200 MHz ^1H n.m.r. and 50.3 MHz ^{13}C n.m.r. spectra in $CDCl_3$ (having two equivalent methoxy groups, three methines, and two quarternary carbons) showed clearly that the product was (**3c**) and ruled out (**3a**), (**3b**), and (**3d**).

To confirm structure (**3c**), 2-DI labelled with 25% of ^{15}N at N_β (starting from 2-aminoimidazole sulphate[4] and commercial $Na^{15}NO_2$) was allowed to react with an excess of 1,1-dimethoxyethene as above, affording a major compound to which structure (**3c/3c***) was assigned in view of its ^1H, ^{13}C, and ^{15}N n.m.r. spectra: (i) the proton signal at δ 6.56 shows a lateral doublet due to the ^1H–^{15}N splitting with $|J|$ 14.2 Hz; (ii) the carbon signal at δ 127.0 is also split ($|J|$ 2.3 Hz); (iii) the proton-undecoupled ^{15}N signal appears as a doublet, $|J|$ 14.2 Hz, at δ −42.4 (*i.e.* 42.4 p.p.m. to higher field than 10 M $H^{15}NO_3$, the external reference). These *J* values agree perfectly with those found for pyridine and other azine and imine derivatives.[10] Moreover, the ^{15}N chemical shift of the labelled nitrogen lies in the expected zone for (**3c***), whereas that expected for (**3b***) is 145—215 p.p.m., at lower field than $H^{15}NO_3$.[10]

The reaction of 2-DI with 1,1-dimethoxyethene was also monitored by ^1H n.m.r. spectroscopy in C_6D_6 at 0—5 °C. The proton signals of the reagents disappeared in several minutes, but only the signals corresponding to (**3c**), which increased throughout the experiment, could be detected in the aromatic and olefinic regions of the spectrum. Intermediates (**3a**), (**3b**), and/or (**3d**) might be involved, but their half-lives seem to be too short under these conditions to allow their detection.

Attempts to purify (**3c**) by column chromatography on silica gel, instead of by recrystallisation, with CH_2Cl_2–MeOH (99 : 1) as the eluant, caused its partial transformation into a product showing three aromatic protons and only one methoxy group, to which structure (**4**) must be assigned, as well as into minor amounts of 1-methylimidazo[2,1-*c*]-*as*-triazin-4-one, (**5**) and its isomers (**6**) and (**7**), as deduced by comparison (t.l.c. and ^1H n.m.r.) with authentic samples of (**5**)—(**7**) obtained by other routes.[11] Moreover, a mixture of (**5**)—(**7**) was produced by heating (**3c**) in refluxing benzene for several hours. Compound (**4**) was also converted into the above-mentioned mixture by heating.[12] Thus, the sequence (**3c**) → (**4**) → (**5**) + (**6**) + (**7**) appears to be sound.

Similarly, when 3-diazopyrazole (3-DP) and an excess of 1,1-dimethoxyethene were allowed to react in CH_2Cl_2 or benzene at room temperature for 45 min, (**8c**) was obtained. Upon standing, even in the n.m.r. tube in $CDCl_3$, (**8c**) lost MeOH and was (partially) converted into (**9**).

In conclusion, there is no evidence for the formation of species (**b**) or (**d**). The involvement of aziridines (**d**) as intermediates,‖ which would suggest a nitrene-like behaviour of diazoazoles, has also to be proved yet.

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References

1 A. Padwa and M. Tohidi, *J. Chem. Soc., Chem. Commun.*, 1984, 295.

2 R. Huisgen, *Angew. Chem., Int. Ed. Engl.*, 1963, **2**, 565, 633; D. S. Wulfman, G. Linstrumelle, and C. F. Cooper, in 'The Chemistry of Diazonium and Diazo Groups,' ed. S. Patai, Wiley, Chichester, 1978.

3 M. P. Sammes and A. R. Katritzky, *Adv. Heterocycl. Chem.*, 1983, **34**, 2; I. Arenal, M. Bernabé, O. Cuevas, and E. Fernández, *Tetrahedron*, 1983, **39**, 1387; M. Tisler and B. Stanovnik, *Heterocycles*, 1976, **4**, 1115; J. St. Pyrek and O. Achmatowicz, *Tetrahedron Lett.*, 1970, 2651; O. W. Webster, *J. Am. Chem. Soc.*, 1966, **88**, 4055.

4 J. Vilarrasa and R. Granados, *J. Heterocycl. Chem.*, 1974, **11**, 867, and references therein.

5 A. Padwa, T. Kumagai, and A. D. Woolhouse, *J. Org. Chem.*, 1983, **48**, 2336, and references therein.

6 Y. Nishizawa, T. Miyashi, and T. Mukai, *J. Am. Chem. Soc.*, 1980, **102**, 1176.

7 A. Padwa and H. Ku, *Tetrahedron Lett.*, 1980, **21**, 1009; A. Padwa and A. Rodriguez, *ibid.*, 1981, **22**, 187; T. Miyashi, Y. Fujii, Y. Nishizawa, and T. Mukai, *J. Am. Chem. Soc.*, 1981, **103**, 725; A. Padwa, A. Rodriguez, M. Tohidi, and T. Kukunaga, *ibid.*, 1983, **105**, 933; A. Padwa, T. Kumagi, and M. Tohidi, *J. Org. Chem.*, 1983, **48**, 1834.

8 E. Beitmaier and W. Voelter, '^{13}C NMR Spectroscopy,' Verlag Chemie, Weinheim and New York, 1978.

9 J. Schantl, *Org. Magn. Reson.*, 1979, **12**, 652.

10 G. C. Levy and R. L. Lichter, '^{15}N Nuclear Magnetic Resonance,' Wiley, New York, 1979; G. J. Martin, M. L. Martin, and J. P. Gouesnard, '^{15}N-NMR Spectroscopy,' Springer-Verlag, Berlin, 1981.

11 J. Farràs, E.Fos, R. Ramos, and J. Vilarrasa, unpublished work; R. Ramos, Graduation Thesis, Universitat de Barcelona, 1983.

12 See M. W. Winkley, G. F. Judd, and R. K. Robins, *J. Heterocycl. Chem.*, 1971, **8**, 237, and references therein for similar methyl rearrangements (from O to N).

13 M. J. S. Dewar and W. Thiel, *J. Am. Chem. Soc.*, 1977, **99**, 4899.

14 E. Fos, J. Vilarrasa, and J. Fernández, *J. Org. Chem.*, 1985, **50**, 4894.

‖ According to MNDO SCF-MO calculations (refs. 13 and 14), species (**d**) are predicted to lie *ca.* 160 kJ mol^{-1} above (**c**). Thus, such aziridine intermediates are unlikely.