Nitrile Sulphides

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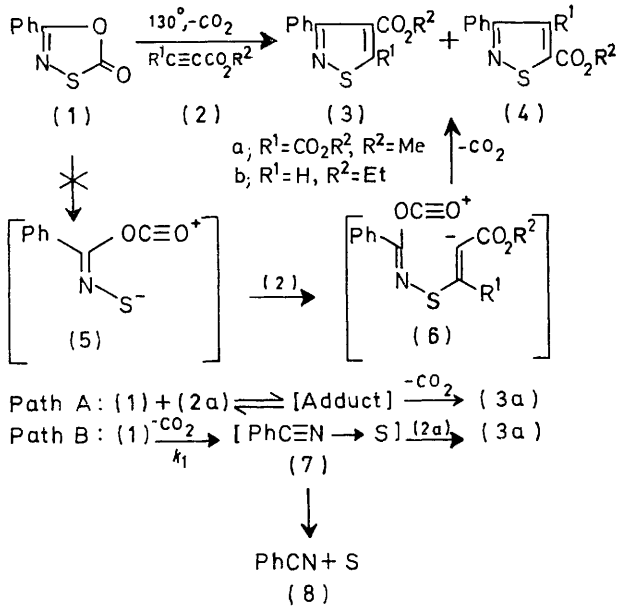
Summary Kinetic studies provide support for benzonitrile sulphide as an intermediate produced in the decarboxylation of 5-phenyl-1,3,4-oxathiazol-2-one; thermolysis of 5-methyl-1,3,4-oxathiazol-2-one in the presence of dimethyl acetylenedicarboxylate produced dimethyl 3-methylisothiazole-4,5-dicarboxylate, presumably *via* acetonitrile sulphide.

RECENTLY, we reported that thermolysis of 5-phenyl-1,3,4-oxathiazol-2-one (**1**) in the presence of dimethyl acetylenedicarboxylate (**2a**) produced dimethyl 3-phenylisothiazole-4,5-dicarboxylate, (**3a**) ≡(**4a**), in >90% yield, possibly *via* benzonitrile sulphide.[1] Thermolysis of (**1**) in the presence of 2 equiv. of ethyl propiolate (**2b**) at 130° gave (**3b**) and (**4b**), each in 35% yield.[1] Formation of both (**3b**) and (**4b**) is contrary to strictly ionic or radical-addition reactions. This excludes, for example, heterolysis of one bond of (**1**) to give the intermediate (**5**), subsequent Michael addition of (**5**) to the acetylenic bond, and then loss of carbon dioxide from (**6**) and ring closure to give the product; this process, as well as

a similar homolytic route, would produce (**3b**) exclusively from (**2b**). Rather, the reactions of (**1**) with (**2**) to produce (**3**) and (**4**) appear consistent only with two possible mechanisms: formation of an intermediate adduct [such as a



π-complex[2] or cycloadduct(s) similar to those obtained from sydnones[3] and from 4-aryl-1,3,2-oxathiazolium-5-olates[4]] between (**1**) and (**2**) which then loses carbon dioxide to form the product, as illustrated for (**3a**) in Path A, or decarboxylation of (**1**) to form benzonitrile sulphide (**7**) which then undergoes 1,3-dipolar cycloaddition to the acetylene (Path B).

We have performed kinetic experiments that exclude Path A as a possible mechanism and thus provide support for Path B and the intermediacy of benzonitrile sulphide.[5,6] These experiments consisted of g.c. determination of the rates of disappearance of (**1**) (0·1 M) and of (**2a**) (0—0·5 M) and of appearance of (**3a**) and (**8**) in chlorobenzene solution at 125·0°. The rate of disapppearance of (**1**) is cleanly unimolecular ($k_1 = 2{\cdot}6 \times 10^{-5}$ s^{-1} at 125°) and is invariant with concentration of (**2a**). In the absence of (**2a**), (**1**) produces benzonitrile (100% yield) and sulphur; reaction of 0·1 M-(**1**) and 0·1 M-(**2a**) produces (**3a**) in 90·5% yield. Furthermore, the rate constants for formation of (**3a**) and (**8**) and for disappearance of (**2a**) (1—5 equiv.) are first order and are all equal to the rate constant for disappearance of (**1**). These results are consistent with Path B with decarboxylation of (**1**) as the rate-determining step,† and are inconsistent with Path A.

Aliphatic nitrile sulphides also may be generated and trapped in synthetically useful reactions. Thus, thermolysis of 5-methyl-1,3,4-oxathiazol-2-one[7] in the presence of 2 equiv. of (**2a**) produced dimethyl 3-methylisothiazole-4,5-dicarboxylate,‡ m.p. 34·5—35·5°, in 58% yield. This latter material was hydrolysed to the known 3-methylisothiazole-4,5-dicarboxylic acid, m.p. 163° (decomp.) [lit.[8] m.p. 160° (decomp.)], in 90% yield. Decarboxylation of the diacid in *o*-dichlorobenzene at reflux for 5 min gave 3-methylisothiazole-4-carboxylic acid, m.p. 235·5—237·5° (lit.[9] m.p. 236—238°), in nearly quantitative yield.

Isothiazoles have been of considerable interest since the synthesis of the parent ring system in 1956.[10] Our new synthesis of isothiazoles provides one of the best routes to 3-aryl- and 3-alkyl-isothiazolecarboxylic acids.

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† A referee suggests that our kinetic results do not exclude the possibility of the antiaromatic 3-phenylthiazirine (**9**) as an intermediate. Since (**9**) should give cycloaddition products different than (**3**) and (**4**), since (**9**) appears[5,6] to be unstable relative to (**7**), and since decarboxylation of (**1**) can lead directly to (**7**), it seems unnecessary to postulate (**9**) as an intermediate in our reaction.

‡ This new compound gave satisfactory C,H,N, and S analyses and spectral data.

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[5] An u.v. spectrum of an unstable intermediate from photolysis of 4-phenyl-1,3,2-oxathiazolium-5-olate at 85K has been tentatively ascribed to benzonitrile sulphide: A. Holm, N. Harrit, K. Bechgaard, O. Buchardt, and S. E. Harnung, *J.C.S. Chem. Comm.*, 1972, 1125.
[6] Subsequent to our initial report,[1] Gotthardt also used (**2a**) to trap benzonitrile sulphide produced in photolysis of 4-phenyl-1,3,2-oxathiazolium-5-olate: H. Gotthardt, *Tetrahedron Letters*, 1971, 1277; H. Gotthardt, *Chem. Ber.*, 1972, **105**, 188.
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