

Nitrile Sulphides

By ROBERT K. HOWE* and JOHN E. FRANZ

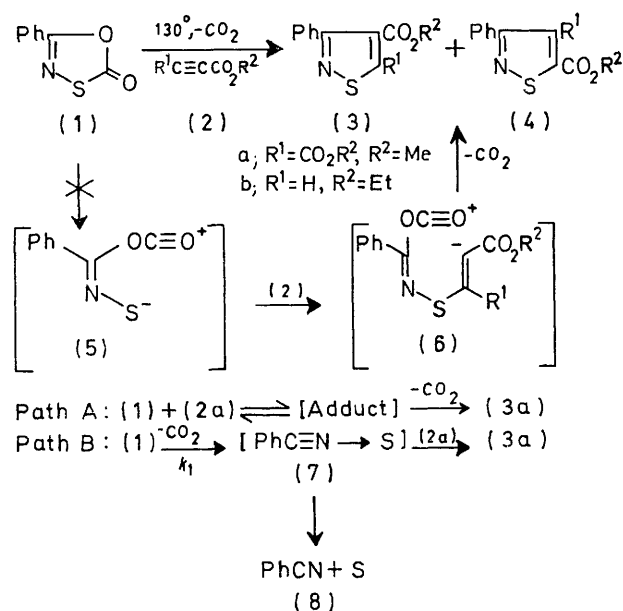
(Research Department, Agricultural Division, Monsanto Company, St. Louis, Missouri 63166)

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 acetylene-

dicarboxylate (**2a**) produced dimethyl 3-phenylisothiazole-4,5-dicarboxylate, (**3a**) \equiv (**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 -complex² or cycloadduct(s) similar to those obtained from sydnone³ and from 4-aryl-1,3,2-oxathiazolium-5-olates⁴] 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)

† 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.

¹ J. E. Franz and L. L. Black, *Tetrahedron Letters*, 1970, 1381.

² A. Senning and P. Kelly, *Acta Chem. Scand.*, 1967, **21**, 1871.

³ R. Huisgen, H. Gotthardt, and R. Gashey, *Angew. Chem. Internat. Edn.*, 1962, **1**, 48.

⁴ H. Gotthardt, *Tetrahedron Letters*, 1971, 1281; H. Gotthardt, *Chem. Ber.*, 1972, **105**, 196.

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.

⁷ B.P. 1,079,348/1967.

⁸ M. P. L. Caton, D. H. Jones, R. Slack, and K. R. H. Wooldridge, *J. Chem. Soc.*, 1964, 446.

⁹ D. Buttmore, D. H. Jones, R. Slack, and K. R. H. Wooldridge, *J. Chem. Soc.*, 1963, 2032.

¹⁰ K. R. H. Wooldridge, *Adv. Heterocyclic Chem.*, 1972, **14**, 1.

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°C. The rate of disappearance of (1) is cleanly unimolecular ($k_1 = 2.6 \times 10^{-5} \text{ s}^{-1}$ at 125°C) 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-one⁷ 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.

(Received, 16th February 1973; Com. 216.)