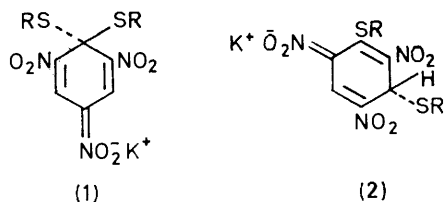


On the Reactions of Alkanedithiols with Picryl Halides

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The reaction of picryl chloride with ethane-1,2-dithiol and base leads to a spiro- σ -adduct *via* the initially formed 2-picrylthioethanethiol. Similar behaviour has been found with propane-1,3-diol and picryl iodide. In contrast, with propane-1,3-dithiol in place of ethane-1,2-dithiol the initially formed 3-picrylthiopropene-1-thiol collapses *via* intramolecular displacement of an *ortho*-nitro-group; no spiro- σ -adduct was detected. With butane-1,4-dithiol or pentane-1,5-dithiol and picryl chloride only polymers were isolated.

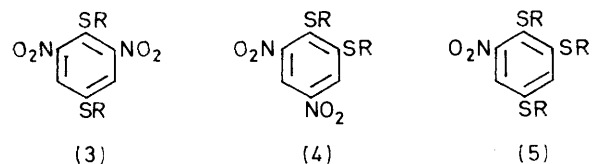
WE have recently reported that thio-analogues [(1) and (2)] of Meisenheimer complexes¹ are produced in the



reactions of thiols with picryl sulphides in dimethyl sulphoxide in the presence of base.² However, the situation was markedly different from that encountered with the original Meisenheimer complexes [*i.e.* (1) and (2) with oxygen in the place of sulphur],^{1b} in that structure (2) was found to be thermodynamically favoured with respect to (1),² which is just the contrary of the position with the corresponding oxygen complexes.^{1b} Moreover, both (1) and (2) rapidly disappeared with either exclusive formation of bis-sulphide (3) (R =

Et)^{2a} or formation of a mixture of sulphides (3)—(5) in which (3) was preponderant (R = *p*-tolyl),^{2b} a phenomenon unknown with the corresponding oxygen complexes, which are stable.^{1b}

In view of these facts we reasoned that a study of a series of compounds of type (6; X = S) (Scheme 1) would be interesting. We considered that treatment of such compounds with an appropriate base would result in cyclization to give either the spiro-compound (7; X = S) (path *a*) or a heterocycle (8; X = S) or (9; X = S)



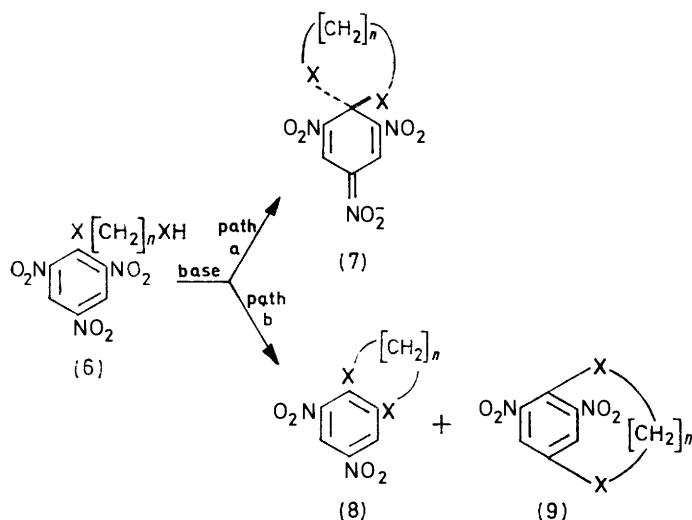
(path *b*) (provided the solution is dilute enough to minimise intermolecular coupling), the outcome depending on the length of the chain joining the sulphur atoms.

¹ (a) J. Meisenheimer, *Annalen*, 1902, **323**, 205; for a review see (b) M. J. Strauss, *Chem. Rev.*, 1970, **70**, 667.

² (a) G. Biggi and F. Pietra, *J.C.S. Chem. Comm.*, 1973, 229; (b) G. Biggi and F. Pietra, *J.C.S. Perkin I*, 1973, 1980.

We report here the details corresponding to our preliminary communication³ together with some new experiments which show that the adducts (7; X = S) are only produced in the case $n = 2$ whereas with the oxygen analogues (X = O) the adducts (7) could be prepared in both the cases $n = 2$ or 3. Moreover, the heterocycle (8) could only be obtained in the case X = S, $n = 3$, and no evidence for the isomer (9) was found.

From the preparative point of view there is nothing to add to the preliminary data for the X = S, $n = 2$, where the crystalline spiro-adduct (7; X = S, $n = 2$) was isolated.³ More recently this reaction has been investigated quantitatively in another laboratory.⁴



In the case of propane-1,3-dithiol, under a variety of conditions, we were unable to isolate the intermediate (6; $n = 3$). In all such reactions, chromatographic separation led to the product of intramolecular replacement of an *ortho*-nitro-group (8; X = S, $n = 3$) (ca. 8%), along with trimethylene bithiopicrate (ca. 2%) and picric acid (ca. 10%). Much polymeric material was also present. Structure (8; X = S, $n = 3$) was supported by the ¹H n.m.r. spectrum, which showed two non-equivalent aromatic protons besides the expected pattern for the trimethylene chain.

Although in the above reaction compound (6; X = S, $n = 3$) must be an intermediate, the isolation of which was hampered by its rapid hydrolysis to picric acid, it apparently has no tendency to cyclize to the spiro-compound (7; X = S, $n = 3$), as proved by ¹H n.m.r. monitoring. Thus, σ -adducts whose presence was indicated by u.v. spectroscopy during the reaction³

must arise from attack of external base on (6; X = S, $n = 3$).

The readiness of the intermediate (6; X = S, $n = 2$) to cyclize to the spiro-compound (7; X = S, $n = 2$)³ and the reluctance of the compound with one methylene more in the side chain to do so were surprising in view of the fact that better yields of dithioacetals are obtained with propane-1,3-dithiol than with ethane-1,2-dithiol, and that dithioacetals from propane-1,3-dithiol are formed smoothly even in sterically rather congested situations, as in steroids.⁵

These observations were even more surprising when we succeeded in isolating the oxygen analogue (7; X = O, $n = 3$) from treatment of a solution of the intermediate (6; X = O, $n = 3$), prepared from picryl iodide and the monosodium salt of propane-1,3-diol, in tetrahydrofuran with sodium hydride. This adduct was isolated as an amorphous solid containing some propane-1,3-diol which was difficult to remove. Its structure was supported by both the u.v. spectrum [identical with that of (7; X = O, $n = 2$)]⁶ and the ¹H n.m.r. spectrum, which shows a singlet only in the aromatic region, and the expected pattern for the trimethylene chain.

The adduct (7; X = O) is less stable in the case $n = 3$ than in the case $n = 2$.⁶ In fact the adduct (7; X = O, $n = 3$) was rapidly degraded both in water (to give picric acid) and in methanol. Such a decreasing stability with increasing size of the heterocycle parallels our observations with the sulphur analogues (7; X = S, $n = 2$ or 3).

Recent studies by others have shown that the cyclization step to give the spiro-adduct (7) from the conjugate base of (6; $n = 2$) is favoured for X = O with respect to X = S, and that the stability of the adduct (7; X = S, $n = 2$) is due to the relatively high acidity of the precursor (6; X = S, $n = 2$).⁴ Such a sulphur-induced instability in the case of complexes of type (7; $n = 3$) is reinforced by a further instability factor which, from our study of the adduct (7; X = O, $n = 3$) is probably an inhibition of the resonance of the *ortho*-nitro-groups due to interaction with the methylene protons adjacent to the heteroatoms X.

Extension of the above studies to butane-1,4-dithiol and pentane-1,5-dithiol proved fruitless: even under high dilution conditions, treatment with picryl chloride led only to polymeric materials, apart from trivial coupling products.

EXPERIMENTAL

M.p.s were taken with a Kofler hot-stage apparatus. ¹H N.m.r. spectra were obtained with either a Varian A-60 or a JEOL PS 100 spectrometer, with tetramethylsilane as internal standard. U.v. and i.r. spectra were

³ E. Farina, C. A. Veracini, and F. Pietra, *J.C.S. Chem. Comm.*, 1974, 672.

⁴ M. R. Crampton and M. J. Willison, *J.C.S. Perkin II*, 1976, 901.

⁵ L. F. Fieser and M. Fieser, 'Reagents for Organic Synthesis,' vol. I, Wiley, New York, 1967, p. 956.

⁶ R. Foster, C. A. Fyfe, and J. W. Morris, *Rec. Trav. chim.*, 1965, **84**, 516.

obtained with, respectively, a Unicam SP 800 and a Perkin-Elmer 337 grating spectrophotometer.

Reaction of Picryl Chloride with Propane-1,3-dithiolate.—A typical experiment was as follows. To a solution of sodium methoxide (2.24 mmol) in methanol (4 ml) was added neat propane-1,3-dithiol (1.12 mmol) under nitrogen. The mixture was warmed at 40 °C for 10 min and then, after cooling to room temperature, picryl chloride (1.12 mmol), dissolved in 1:1 benzene-methanol (10 ml) was added with stirring under nitrogen. After 48 h the mixture was neutralized, most of the solvent was evaporated off, and the residue was chromatographed on a 2 mm thick silica gel layer (eluant chloroform). From the yellow band at R_F 0.65, 2,3-dihydro-6,8-dinitro-1,5-benzodithiepin (8; X = S, $n = 3$) (0.019 g, 20%) was obtained; m.p. 175° (from benzene-light petroleum) (Found: C, 40.2; H, 3.1; N, 9.8. $C_8H_6N_2O_4S_2$ requires C, 39.7; H, 2.9; N, 10.3%); δ (C_6D_6) 7.92 (1 H, d, J 3 Hz), 7.78 (1 H, d, J 3 Hz), 2.4 (4 H, m), and 1.4 (2 H, m) (the multiplet at δ 2.4 changed into two singlets on irradiation at δ 1.4); m/e 272 (100%). From the yellow band at R_F 0.2 an impure solid was obtained which, after re-elution with 96:4 chloroform-diethyl ether, gave trimethylene bistiopicrate (0.012 g, 2%), m.p. 167–169° (from chloroform) (Found: C, 33.0; H, 1.8; N, 14.9. $C_{15}H_{10}N_6O_{12}S_2$ requires C, 33.9; H, 1.9; N, 15.8%); δ (C_6D_6) 7.72 (4 H, s), 2.5 (4 H, t), and 1.3 (2 H, quintet). Elution of the residue with 7:3 chloroform-methanol led to picric acid (yellow band at R_F 0.5) in 5% yield.

Reaction of Picryl Iodide with Sodium 3-Hydroxypropoxide.—To a vigorously stirred suspension of sodium 3-hydroxypropoxide (1.7 mmol) in dried tetrahydrofuran (8 ml) (sodium took 1 day to react with tetrahydrofuran under these conditions at 55 °C) was added a solution of picryl iodide (probably picryl chloride would also be suitable, but it was not available at the time) (1.5 mmol) in tetrahydrofuran (2 ml) at room temperature under nitrogen. After 15 min, part of this mixture (6 ml) was added to neat sodium hydride (1 mmol) with stirring under nitrogen at room temperature. After 40 h the red amorphous precipitate of the adduct (7; X = O, $n = 3$), decomp. $>120^\circ$, was filtered off under nitrogen, washed with tetrahydrofuran and diethyl ether, and dried under vacuum; yield 0.140 g; λ_{max} (Me_2CO) 493, 465, and 415 nm; δ (D_2O) 8.8 (2 H, s), 3.2 (4 H, t), and 1.1 (2 H, quintet) [besides strong propane-1,3-diol signals at 3.6 (t) and 1.7 (quintet)]. Attempts to isolate the intermediate (6; X = O, $n = 3$) from the remaining 4 ml of reaction mixture failed: only picric acid and tarry materials were obtained. The preparation of the adduct (7; X = O, $n = 3$) could not be carried out in propane-1,3-diol, which could not be then removed, or in non-polar solvents (other than tetrahydrofuran) which did not dissolve the glycol.

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