glass crucibles clog easily and are not too useful in these determinations.

As a check on our analytical procedures, samples of the tris-(triphenylsilyl)vanadate(V) and tetrakis(triphenylsiloxy)vanadium(IV) were analyzed by a commercial laboratory. The results were:

| Sample | Calcd. | Commercial lab | This lab |
|---|---|---|---|
| $[(C_6H_5)_3SiO]_3VO$ | V 5.71 | 5.64 | 5.62 |
| | Si 9.42 | 9.23 | 9.46 |
| $[(C_6H_5)_3SiO]_4V$ | V 4.42 | 4.7 | 4.33 |
| | Si 9.75 | 10.00 | 9.56 |

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# Synthesis of 2-Anilinoethanethiol by Hydride Reduction

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Since the discovery that several classes of compounds protected organisms from otherwise lethal doses of ionizing radiation,[1] a great deal of effort has been directed toward the synthesis of homologs of the protective compounds. Among the functional groups in protective molecules are the amino and mercapto groups. Our investigation concerning mercaptoethylation of amines has led to novel syntheses of 2-anilinoethanethiol and to an unexpected reaction of 3-phenylrhodanine.

By reducing 2-mercaptoacetanilide with lithium aluminum hydride, 2-anilinoethanethiol was prepared. By treating 2,2''-dithiobisacetanilide in the same manner, the same aminothiol was prepared.

Incidental to this work, we had occasion to attempt the reduction of 3-phenylrhodanine with the thought that a substituted 2-aminoethanethiol might be produced in such a reaction. However, there were produced *N*-methylaniline and a number of products which could not be separated by fractional distillation. The formation of *N*-methylaniline undoubtedly involves a complete removal of sulfur from C-2 and a cleavage of the nitrogen-to-carbonyl amide bond. Examples of hydrogenolysis of sulfur during reduction by metal hydrides have been found by others,[2] as have examples of amide cleavage.[3] While there is no way of knowing which bonds are broken first, a pertinent comparison might be made with the reductive cleavage of *N*-methylanilides.[4]

## Experimental

**Materials.**—2-Mercaptoacetic acid (trademark "Thiovanic Acid") was a gift of Evans Chemetics, Inc. Dithiodiacetic acid (dithiodiglycolic acid) was purchased from Aldrich Chemical Co. and recrystallized from ethyl acetate–benzene. 2-Mercaptoacetanilide was prepared by a modification of the method of VanAllan[5] in which water was removed with a Dean-Stark water separator instead of being removed by distillation through an esterification column.

**2,2''-Dithiobisacetanilide.**—A mixture of 54.6 g. (0.3 mole) of dithiodiacetic acid, 55.8 g. (0.6 mole) of aniline, and 600 ml. of benzene was heated in a 1-l. flask equipped with a Dean-Stark water separator surmounted by a reflux condenser carrying a calcium chloride drying tube. After 4 days, 9.6 ml. of water had collected. The contents of the flask were poured into an equal volume of hexane. The resulting suspension was filtered. The precipitated 2,2''-dithiobisacetanilide, after recrystallization from acetone, weighed 42.8 g. (43%) and had m.p. 161–163° (reported,[6] 165–166°).

**2-Anilinoethanethiol.**—To a dry 1-l. flask, flushed with nitrogen, carrying a calcium chloride drying tube, and equipped for stirring magnetically, were added 500 ml. of tetrahydrofuran, 19 g. (0.5 mole) of lithium aluminum hydride, and 50.2 g. (0.3 mole) of 2-mercaptoacetanilide. After stirring for 3 days at room temperature, the reaction mixture was treated with 50 ml. of water and filtered. The filtrate consisted of tetrahydrofuran and water. To a suspension of the precipitate and 1 l. of water was added 43 ml. (0.5 mole) of concentrated hydrochloric acid. This suspension was extracted with ether. After evaporation of ether from the dried extract, there was obtained 16.8 g. (37%) of 2-anilinoethanethiol, b.p. 110–112°/3 mm., $n^{20}_{D}$ 1.6041 (reported,[7,8] b.p. 95–97°/2.5 mm., $n^{20}_{D}$ 1.6040, $n^{25}_{D}$ 1.6022). The product was further characterized by the *N*-acetyl derivative with m.p. 64.5–65.5° (reported,[7] 65–66°).

When 39.8 g. (0.12 mole) of 2,2''-dithiobisacetanilide was treated with lithium aluminum hydride in the same way, 22.3 g. (61%) of 2-anilinoethanethiol was produced.

**Reduction of 3-Phenylrhodanine.**—In a manner similar to that described above, 20.9 g. (0.1 mole) of 3-phenylrhodanine[9] was treated with 11.4 g. (0.3 mole) of lithium aluminum hydride in tetrahydrofuran. After hydrolysis, the mixture was filtered. After removing water and tetrahydrofuran from the filtrate, there remained 4.62 g. of a yellow liquid. This liquid was distilled through a spinning band column. There was obtained 3.12 g. (30%) of *N*-methylaniline, b.p. 187–191°/752 mm., whose infrared spectrum was identical with that of authentic *N*-methylaniline and whose *p*-toluenesulfonamide was identical with the derivative prepared from the authentic amine.

After adding hydrochloric acid to the precipitate–water suspension, the mixture was extracted with ether. The extract was dried and the ether was removed by distillation. The residual red liquid, 3.2 g., distilled over the range 54–90°/10 mm. Infrared spectra of various fractions indicated the presence of amino, hydroxyl, mercapto, and monosubstituted benzene groups, but none was superimposable upon the spectrum of 2-anilinoethanethiol.

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(1) Summarized by A. Pihl and L. Eldjarn, *Pharmacol. Rev.*, **10**, 437 (1958).

(2) R. C. Arnold, A. P. Lien, and R. M. Alm, *J. Am. Chem. Soc.*, **72**, 731 (1950); H. Barrera and R. E. Lyle, *J. Org. Chem.*, **27**, 641 (1962); M. W. Cronyn and J. E. Goodrich, *J. Am. Chem. Soc.*, **74**, 3936 (1952); T. L. Cairns, G. L. Evans, A. W. Larchar, and B. C. McKusick, *ibid.*, **74**, 3982 (1952); W. Carpenter, M. S. Grant, and H. R. Snyder, *ibid.*, **82**, 2739 (1960); N. G. Gaylord and D. J. Kay, *ibid.*, **78**, 2167 (1956); O. Hromatka, G. Stehlek, and F. Sauter, *Monatsh. Chem.*, **91**, 107 (1960); A. Mustafa and M. K. Hilmy, *J. Chem. Soc.*, 1343 (1952); W. Ried and F. Müller, *Chem. Ber.*, **85**, 470 (1952).

(3) Summarized by N. G. Gaylord, "Reduction with Complex Metal Hydrides," Interscience Publishers, Inc., New York, 1956, pp. 575–590.

(4) F. Weygand and G. Eberhardt, *Angew. Chem.*, **64**, 458 (1952).

(5) J. A. VanAllan, *J. Am. Chem. Soc.*, **69**, 2914 (1947).

(6) B. Holmberg, *J. prakt. Chem.*, [2] **84**, 634 (1911).

(7) H. R. Snyder, J. M. Stewart, and J. B. Ziegler, *J. Am. Chem. Soc.*, **69**, 2672 (1947).

(8) D. D. Reynolds, D. L. Fields, and D. L. Johnson, *J. Org. Chem.*, **26**, 5125 (1961).

(9) B. Holmberg, *J. prakt. Chem.*, [2] **79**, 253 (1909).

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# The Magnetic Anisotropy of the Aromatic Ring, Aryl Thioethers and Sulfones

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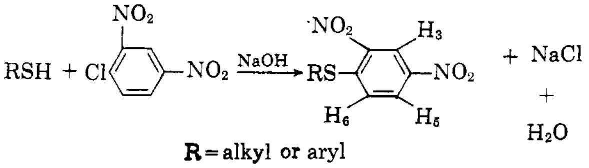
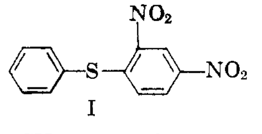
During a study[1] of thioethers prepared[2,3] by the reaction of 2,4-dinitrochlorobenzene and the desired thiol, the n.m.r. spectra of those derivatives which

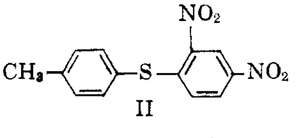


R = alkyl or aryl

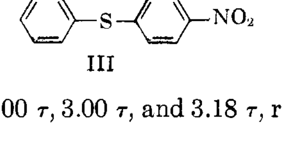
were synthesized from the aromatic thiols exhibited an apparent anomaly—the position of the proton ($H_6$) *ortho* to the thioether group was displaced to high field. Examination of the aromatic protons in the spectra of the 2,4-dinitrophenyl alkyl thioethers showed the chemical shifts and the coupling constants were consistent with what might be expected, and the $\tau$ values[4] for the aromatic protons of similar trisubstituted aromatics are shown in Table I as well as the typical thioethers. The spectra of the alkyl thioethers in the aromatic region are simple first order and the proton *ortho* to thioether group ($H_6$) has its resonance of 2.41 $\tau$ (*ortho* coupled). However, the ($H_6$) resonance of the aryl thioethers (I, II, III, and IV) were 3.00 $\tau$,



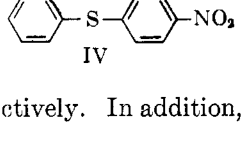
I



II



III

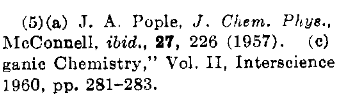


IV

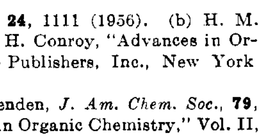
3.00 $\tau$, 3.00 $\tau$, and 3.18 $\tau$, respectively. In addition, it is not surprising that the spectrum of 2,4-dinitrophenyl benzyl thioether exhibited no anisotropic effect on the protons—*i.e.*, similar to an aliphatic derivative. The magnetic anisotropy of the benzene ring has been discussed[5] and its effect on the chemical shift of protons has been reported[6]—*i.e.*, a high or low field displacement of a proton in the vicinity of the aromatic ring, depending on the relative geometry of the system. Diphenyl ether has been discussed[7] and the possibility of calculation of the shielding of each individual proton of the diphenyl ether may be established in this manner. However, with the use of non-equivalent rings, gross changes can be observed as long as one of the rings has its electron current altered by withdrawing groups and as a result, the spectral analysis is limited to first order treatment. The aromatic protons of the thiols exhibited little or no effect due to the anisotropy of the ring containing the nitro groups.

In addition, the evaluation of the relative roles of resonance effects and inductive effect have also been discussed,[8] and it appears unlikely the high field shift is caused by either of these. A steric interaction might alter the coplanarity[9] of the nitro group with the aromatic ring. Since the resonance position of proton ($H_3$) is essentially unchanged, a steric effect appears to make little or no contribution. Therefore, the anisotropic effect of the phenyl ring must cause the observed displacement. Many examples of this shielding effect[10] exist in the literature, but the aryl thioethers and sulfones have not been studied.

The oxidation of the thioether to the sulfone[2] would introduce a group which would yield a system that tended toward coplanarity. The n.m.r. spectrum of the sulfone (V), in addition to a multiplet centered at 1.45 $\tau$ ($H_3$, $H_5$, and $H_6$), contained a typical AB-type spectrum at higher field (2.11 $\tau$ and 2.60 $\tau$).[11]



V



VI

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[1] R. Rittner, G. Tilley, A. Mayer, Jr., and S. Siggia, *Anal. Chem.*, **34**, 237 (1962).

[2] N. D. Cheronis and J. B. Entrikin, "Semimicro Qualitative Organic Analysis," Crowell Co., New York, 1947, p. 321.

[3] R. W. Bost, J. O. Turner, and R. D. Norton, *J. Am. Chem. Soc.*, **54**, 1985 (1932).

[4] G. V. D. Tiers, *J. Phys. Chem.*, **62**, 1151 (1958).

[5] (a) J. A. Pople, *J. Chem. Phys.*, **24**, 1111 (1956). (b) H. M. McConnell, *ibid.*, **27**, 226 (1957). (c) H. Conroy, "Advances in Organic Chemistry," Vol. II, Interscience Publishers, Inc., New York 1960, pp. 281–283.

[6] (a) J. S. Waugh and R. W. Fessenden, *J. Am. Chem. Soc.*, **79**, 846 (1957). (b) H. Conroy, "Advances in Organic Chemistry," Vol. II, Interscience Publishers, Inc., New York, 1960, pp. 284–285. (c) J. A. Pople, W. G. Schneider, and H. J. Bernstein, "High Resolution Nuclear Magnetic Resonance," McGraw-Hill, New York (1959), pp. 180–183. (d) S. Brownstein, *J. Am. Chem. Soc.*, **83**, 2300 (1958). (e) C. E. Johnson and F. A. Bovey, *J. Chem. Phys.*, **29**, 1012 (1958).

[7] H. Shimizu, S. Fujiwara, and Y. Morino, *J. Chem. Phys.*, **34**, 1467 (1961).

[8] P. L. Corio and B. P. Dailey, *J. Am. Chem. Soc.*, **78**, 3043 (1956).

[9] E. R. Alexander, "Principles of Ionic Organic Reactions," John Wiley & Sons, Inc., New York, 1950, p. 20.

[10] D. Y. Curtin, H. Gruen and B. A. Shoulders, *Chem. Ind.* (London), 1205 (1958).