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THE SYNTHESIS AND CHARACTERIZATION OF 2-CHLORO-5-THIOPHENTHIOL

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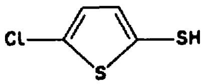
Abstract—Sulphurization of 2-chloro-5-thienyl lithium followed by acidification gives 2-chloro-5-thiophenthiol in 59% yield. A study of the IR and NMR spectra shows that the compound exists solely as the thiol, no isomeric thione forms being detected. Treatment of the thiol with hydrogen peroxide followed by phosphorus pentachloride gives the known 2-chloro-5-thienyl sulphonyl chloride in ca. 38% yield.

Considerable interest has been shown in the preparation of ring substituted thiophenthiols but it is only recently that such compounds have been obtained.[1–3] These compounds are of interest in view of their possible tautomeric nature since theoretically they may exist not only as the thiol but also in an isomeric thione form. Gronowitz *et al.*[3] have synthesized a number of 3-substituted thiophenthiols and undertaken an extensive study of the NMR spectra of these compounds. This has shown that the compounds exist solely in the thiol form. These authors also describe an unsuccessful attempt to synthesize 2-bromo-5-thiophenthiol which apparently decomposed on vacuum distillation with the evolution of hydrogen bromide and hydrogen sulphide.

The present paper deals with the preparation and study of 2-chloro-5-thiophenthiol (I).



I

Simple thiophenthiols have been prepared in good yields either by reduction of the sulphonyl chloride or by sulphurization of a Grignard reagent followed by acidification.[4] Attempts to prepare I by reduction of 2-chloro-5-thienylsulphonyl chloride, prepared by the method of Siedel and Sturm,[5] were unsuccessful. However, as shown in scheme (A), 2-chloro-5-iodothiophen (II) readily forms 2-chloro-5-thienylmagnesium iodide (III) in good yield. Sulphurization of III followed by acidification, however, gave only a 20% yield of the desired thiol (I).

Recently a number of thiophenthiols have been obtained in good yields by sulphurization of the appropriate thienyl-lithium[3,6] and we have now applied this method to the synthesis of I according to reaction scheme (B). 2-Chlorothiophen (IV) reacts readily with n-butyl-lithium to give 2-chloro-5-thienyl-lithium (V) which on

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[1] S. Gronowitz and R. A. Hoffman, *Arkiv Kemi* **15**, 499 (1960).

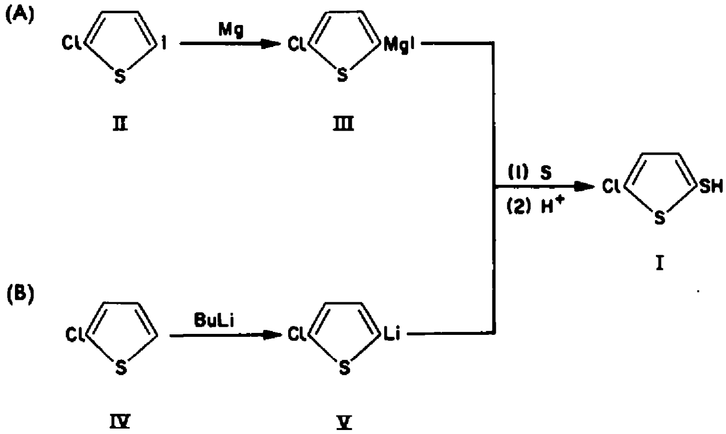
[2] R. J. Fawcett, *Diss. Abs.* **20**, 3510 (1960).

[3] S. Gronowitz, P. Moses, A-B. Hörnfeldt and R. Håkansson, *Arkiv Kemi* **17**, 237 (1961).

[4] W. H. Houff and R. D. Schuetz, *J. Amer. Chem. Soc.* **75**, 6316 (1953).

[5] W. Siedel and K. Sturm, G. P. 1,088,509 (1962).

[6] S. Gronowitz and R. Håkansson, *Arkiv Kemi* **16**, 309 (1960).

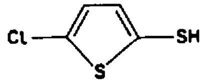


carbonation and acidification yields 2-chloro-5-thiophen carboxylic acid.[7] We have shown that sulphurization of V at -70° followed by acidification gives the desired thiol (I) in 59 % yield.

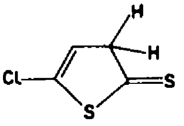
I proved to be more unstable than the simple 2-thiophenthiol, decomposing after ca. 24 hr at room temperature with the formation of a black tar and evolution of hydrogen chloride. No hydrogen sulphide, however, was detected.

Attempts were made, using the Grignard method (scheme A), to prepare the analogous 2-bromo- and 2-iodo-5-thiophenthiols. These compounds decomposed on vacuum distillation with the evolution of the appropriate hydrogen halide and hydrogen sulphide confirming earlier reported findings.[8]

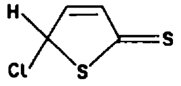
The structure of I is of interest since the compound can theoretically exist not only in the thiol form but also in two possible isomeric thione forms. Decisive information



I



Ia



Ib

as to the correct structure has been obtained from the IR and NMR spectra where no bands ascribable to the thione forms (Ia or Ib) were detected.

The IR spectrum of I, Fig. 1, shows the SH—stretching band at 2520 cm^{-1} (3·97 μ). The characteristic ring stretching frequencies of the thiophen nucleus are shown in the region 1520–970 cm^{-1} (6·6–10·3 μ)[8] and the 2,5-disubstituted thiophen pattern by the strong absorption at 792 cm^{-1} (12·6 μ).

The evidence obtained from an examination of the NMR spectrum of I finally confirms that the compound exists as the simple thiol and not in one of its thione forms (Ia or Ib). Analysis of the spectrum shows peaks in two distinct regions. The first of these consists of a quadruplet and a doublet (at 3·12 τ and 3·28 τ) due to protons 4 and 3 respectively in the thiophen nucleus ($J_{34} = 4{\cdot}2$ c/s). A doublet occurs in the second region of the spectrum at 6·5τ and is assigned to the SH group (J_{SH-4} 1·8 c/s). This is illustrated in Fig. 2. It is assumed that the thiol proton spin is coupled with

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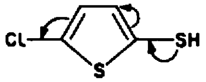
[7] G. B. Bachman and L. V. Heisey, *J. Amer. Chem. Soc.* **70**, 2378 (1948).

[8] A. R. Katritzky and A. J. Bolton, *J. Chem. Soc.* 3500 (1959).

position 4 rather than position 3 since the former is one of the positions activated by the mesomeric effect of the thiol on the thiophen nucleus. These results are in good



agreement with those obtained by Hoffman and Gronowitz[9] for other substituted thiophenthiols.

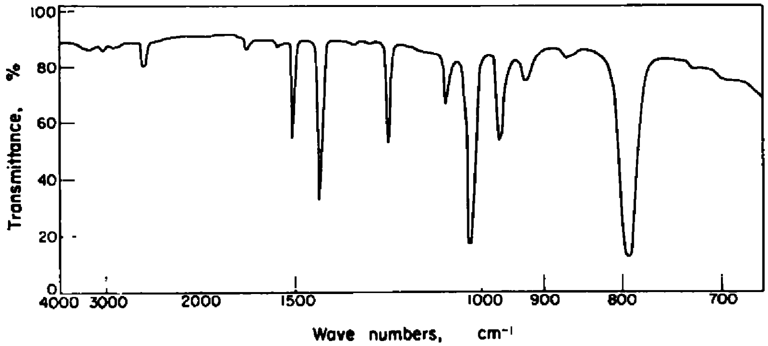
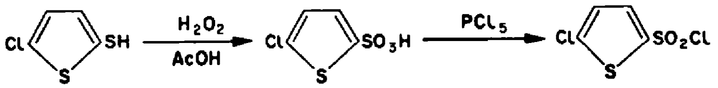


FIG. 1. IR spectrum of 2-chloro-5-thiophenthiol.

The thiol (I) was characterized by conversion to the known 2-chloro-5-thienylsulphonyl chloride. The method used was based on the known oxidation of thiols with hydrogen peroxide to sulphonic acids[10] which in turn are readily converted by phosphorus pentachloride to the corresponding sulphonyl chlorides.[11]



A further derivative, 2,4-dinitrophenyl-2^1-chloro-5′-thienylsulphide, was prepared by reaction of I with 2,4-dinitrochlorobenzene, a known reagent for the characterization of thiols.[12]

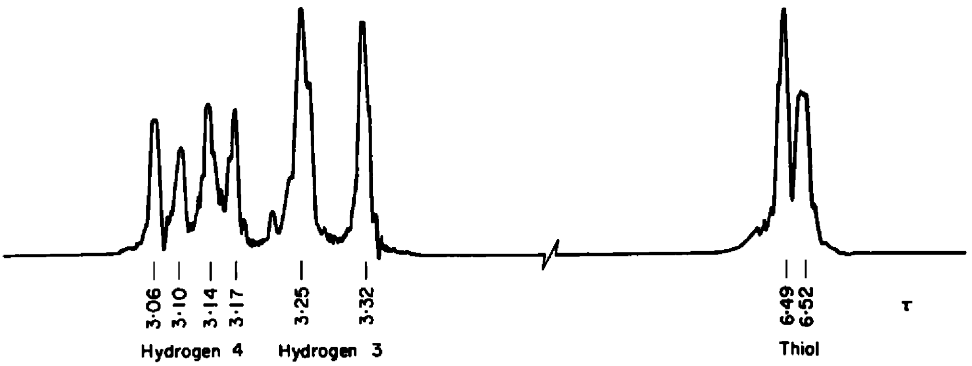


FIG. 2. NMR spectrum of 2-chloro-5-thiophenthiol.

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[9] R. A. Hoffman and S. Gronowitz, *Arkiv Kemi*, **16**, 563 (1961).

[10] H. J. Backer, *Rec. Trav. Chim.* **54**, 205 (1935).

[11] R. B. Wagner and H. D. Zook, *Synthetic Organic Chemistry* p. 821. J. Wiley, New York (1956).

[12] H. D. Hartough, *Thiophene and Its Derivatives* p. 435. Interscience, New York (1952).

EXPERIMENTAL

IR spectra were measured on a Perkin–Elmer Infracord 137. The NMR spectrum was run at 60 M c/s with tetramethylsilane as internal standard on a Perkin–Elmer R10 spectrometer.

2-Chloro-5-thiophenthiol (I). 2-Chlorothiophen (53·5 g; 0·45 g mole) cooled to 0° was added dropwise to a stirred solution of *n*-butyl-lithium[13] (0·46 g mole) in 900 ml ether at 0° under N_2. After addition the stirred mixture was heated under reflux for 5 hr to complete reaction, cooled to −40° and treated with S (14.4 g; 0·45 g mole). The mixture was left at 0° for 16 hr and poured into excess iced water: the aqueous phase was acidified with 4 N H_2SO_4 and extracted with ether. The organic phases were combined, washed with water and dried (Na_2SO_4). On distillation this yielded I as a pale yellow oil, b.p. 54°/2mms Hg (40·0 g; 59% yield), n_D^{25} 1·6131; λ_{max} (in hexane) 204, 250 and 260 mμ (ε, 3,972, 6,400 and 6,400 respectively).

The thiol (I) was treated with KOHaq and 2,4-dinitrochlorobenzene in hot MeOH for 0·5 hr according to a standard procedure.[14] Recrystallization of the reaction product from MeOH gave an orange crystalline solid, 2,4–dinitrophenyl-2¹-chloro-5-thienylsulphide. (Found; C, 37·7; H, 1·8; Cl, 11·3; N, 8·9; O, 20·3; S, 20·1. $C_{10}H_5ClO_4N_2S_2$ requires: C, 37·9; H, 1·6; Cl, 11·2; N, 8·9; O, 20·2; S, 20·3%).

Oxidation of I *to 2-chloro-5-thienylsulphonyl chloride*. 2-Chloro-5-thiophenthiol (8·2 g; 0·055 g mole) in 10 ml glacial acetic acid was added slowly to a mixture of 30% H_2O_2 (33 ml) and glacial acetic acid (50 ml) at 55°. After addition the mixture was heated to 70° for 1·5 hr and then allowed to cool. Removal of acetic acid gave a yellow oil which was treated at room temp. with PCl_5 (10 g). This was poured into excess cold water and extracted with chloroform. The organic layer yielded 2-chloro-5-thienylsulphonyl chloride (4·6 g; 38% yield) as a colourless oil, b.p. 74–76°/0·06 mms Hg. (lit.[5] b.p. 64–66°/0·05 mm Hg).

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[13] H. Gilman, J. A. Beel, C. G. Brannen, M. W. Bullock, G. E. Dunn and L. S. Miller, *J. Amer. Chem. Soc.* **71**, 1499 (1949).

[14] A. I. Vogel, *Textbook of Practical Organic Chemistry* (3rd Edition) p. 500, Longmans Green, London (1956).