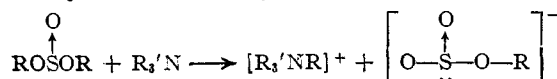
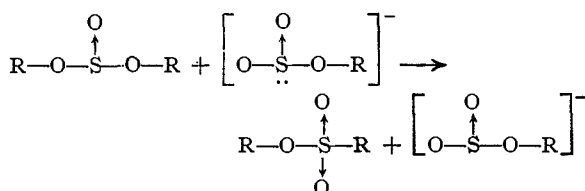


ethanesulfonic acid, depending on the reaction conditions. Butanesulfonic acid or its ester could not be isolated from a similar reaction with *n*-butyl sulfite, the only products formed being *n*-butyl alcohol, di-*n*-butyl ether and probably *n*-butene. Efforts to rearrange 2-chloroethyl sulfite were also unsuccessful.

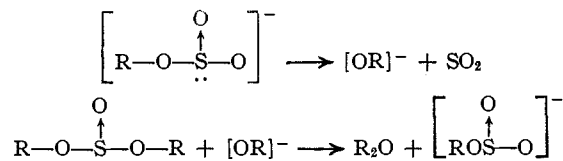
A possible mechanism<sup>5</sup> for this rearrangement involves, as the first step, the formation of a quaternary ammonium alkyl sulfite.



This negative ion then reacts with a second alkyl sulfite molecule to form the ester of an alkanesulfonic acid with the propagation of another alkyl sulfite ion, which may continue the reaction.



The formation of sulfur dioxide and an ether in the reaction can result from the decomposition of the alkyl sulfite ion,  $\text{ROSO}_2^-$ , to an alkoxide ion and sulfur dioxide. The alkoxide ion then reacts with a neutral alkyl sulfite molecule to produce an ether.



Thus, by this mechanism, the amine serves essentially as an initiator of the reaction, although its presence in the mixture is probably soon lost, through formation of the quaternary salt.

#### Experimental

**Methyl Methanesulfonate.**—Fifty-five grams (0.5 mole) of dimethyl sulfite,<sup>6</sup> b. p. 125–126° (735 mm.), was refluxed with 1.9 g. (0.01 mole) of tri-*n*-butylamine (Eastman Kodak Co.) for nineteen hours. The reflux temperature increased from 126 to 207°. During this time, 20.8 g. of volatile products were collected in a Dry Ice trap connected to the reflux condenser.

Distillation of the reaction product through a Vigreux column gave 26.8 g. (49% yield) of methyl methanesulfonate, b. p. 100.5–101.5° (25 mm.), 198–198.6° (732 mm.),  $n_D^{20}$  1.4140.

*Anal.* Calcd. for  $\text{C}_2\text{H}_6\text{SO}_3$ : S, 29.1. Found: S, 29.8.

A viscous residue of 3.8 g. remained. No dimethyl sulfite was recovered.

The material in the Dry Ice trap was vaporized and repeatedly passed over a hot sodium hydroxide solution to remove sulfur dioxide; analysis of this solution iodometrically showed the presence of 9.8 g. (30% yield) of sulfur dioxide. The effluent gases, free of sulfur dioxide, were

(5) This was suggested by Dr. P. D. Bartlett.

(6) A commercial product of this Division, used without further purification.

condensed in a second Dry Ice trap. This liquid, 5.7 g. (26% yield), boiled at –23 to –20° and was dimethyl ether.

When the above reaction was repeated, using 500 g. of dimethyl sulfite, 17.1 g. of amine, and a reflux period of twenty-six hours, a 56% yield of methyl methanesulfonate was obtained.

**Ethyl Ethanesulfonate.**—A mixture of 69 g. (0.50 mole) of diethyl sulfite<sup>6</sup> and 1.9 g. (0.01 mole) of tri-*n*-butylamine was heated under reflux for twenty-five and one-half hours, during which time the reflux temperature decreased from 150 to 109°. Collected in the Dry Ice trap was 3.0 g. of liquid, of which 1.9 g. was identified as sulfur dioxide.

Distillation of the reaction product through a 1.0 × 30-cm. Fenske column gave 49.0 g. of diethyl sulfite (71% recovery) and 4.2 g. (0.03 mole) of ethyl ethanesulfonate, b. p. 101.5–102.5° (18 mm.),  $n_D^{20}$  1.4212.

*Anal.* Calcd. for  $\text{C}_4\text{H}_{10}\text{SO}_3$ : S, 23.2. Found: S, 23.7.

This represented a 21% yield of ethyl ethanesulfonate, based on the ethyl sulfite not recovered.

**Ethanesulfonic Acid.**—Using the same quantities of reactants as above, the diethyl sulfite and tri-*n*-butylamine were heated in a flask attached to a short Vigreux column so as to remove the low boiling reaction products. The mixture was then heated at 150–160° for twenty-one hours during which time a non-condensable gas passed through the attached Dry Ice trap. It decolorized bromine water and probably was ethylene.

Distillation of the product remaining in the reaction flask gave 9.0 g. (16% yield) of ethanesulfonic acid, b. p. 136–140° (2 mm.),  $n_D^{20}$  1.4335.

*Anal.* Calcd. for  $\text{C}_2\text{H}_6\text{SO}_3$ : S, 29.1; neut. equiv., 110. Found: S, 29.7; neut. equiv., 116.

No diethyl sulfite was recovered.

The volatile products liberated during the reaction, and condensed in the receiver and Dry Ice trap, consisted of 0.29 mole (58% yield) of sulfur dioxide, and 0.24 mole (48% yield) of diethyl ether.

**Attempted Rearrangement of Dibutyl Sulfite.**—A mixture of 87 g. (0.5 mole) of di-*n*-butyl sulfite<sup>6</sup> and 1.9 g. (0.01 mole) of tri-*n*-butylamine was heated for sixty-five hours at 150–160° in a flask attached to a short Vigreux column. A total of 10.6 g. of volatile products was evolved, of which 7.6 g. (0.12 mole) was identified as sulfur dioxide; the remaining material may have been *n*-butene, although this was not conclusively established.

Distillation of the reaction product gave 19.9 g. of material, b. p. 43–47° (30 mm.),  $n_D^{20}$  1.4000, which was a mixture of *n*-butyl alcohol and probably di-*n*-butyl ether.

*Anal.* Calcd. for  $\text{C}_4\text{H}_9\text{OH}$ : OH, 23.0. Found: OH, 5.7.

The *n*-butyl alcohol in this fraction was identified as its  $\alpha$ -naphthylurethan, m. p. 68°. On continued distillation, 49.2 g. (0.28 mole) of unreacted dibutyl sulfite was recovered, and a residue of 3.9 g. remained.

COLUMBIA CHEMICAL DIVISION  
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#### Halogen-Lithium Interconversion with Iodothiophenes

BY E. CAMPAIGNE AND WILLIAM O. FOYE

In connection with the preparation of 2,5-diphenylthiophene, the reaction of 2,5-diiodothiophene with phenyllithium was observed. Lithium-halogen interchange was found to occur, which conforms with previous results in which lithium has been introduced into heterocyclic nuclei without further reaction with the halogen compound

produced.<sup>1</sup> While Bachman has observed that *n*-butyllithium causes the replacement of at least one  $\alpha$ -chlorine atom by lithium in 2,5-dichloro and 2,3,4,5-chlorothiophenes,<sup>2</sup> the present work provides a convenient method of preparing thio-phenedilithium.

Proof of the interconversion consisted in carbonating the dilithiothiophene to the 2,5-dicarboxylic acid and the iodobenzene formed to benzoic acid. No evidence of mono-metalation in this reaction could be found. Direct reaction of lithium with 2,5-diiodothiophene in ether solution at room temperature was found not to take place.

An analogous result was obtained in the reaction with phenyllithium and 2-iodothiophene.

#### Experimental

**Thiophene-2,5-dicarboxylic Acid.**—A solution of phenyllithium was prepared from 7.5 g. (0.05 mole) of dry bromobenzene according to the procedure of Evans and Allen.<sup>3</sup> To the stirred solution, kept under a slight pressure of nitrogen, was added 3.5 g. (0.01 mole) of 2,5-diiodothiophene (prepared by modifying the directions of Minnis<sup>4</sup> for 2-iodothiophene by using twice the quantities of yellow mercuric oxide and iodine) in 20 cc. of anhydrous ether during a period of ten minutes. The diiodothiophene solution lost its color immediately on reaching the phenyllithium, and a solid formed at once.

After the preceding mixture had been stirred for ten minutes, it was poured into a beaker containing 40 g. of Dry Ice, and the acid worked up in the usual manner. The white product was collected and combined with a second crop obtained by extracting the filtrate with ether; the yield was 0.9 g. (53% based on diiodothiophene) of thiophene-2,5-dicarboxylic acid, which sublimed at 150–300°. The dimethyl ester was prepared by the Fischer-Speier method; m. p. 145–146°. These values agree with those recorded.<sup>5</sup>

**Characterization of the Iodobenzene.**—The ether solution remaining after extraction of the acid yielded, after removal of the ether, 4.4 g. of colorless liquid from which 1.1 g. of an oil boiling at 165–185° was obtained. The high boiling fraction was allowed to react with magnesium, and the product was carbonated in the usual manner to give 66% of benzoic acid, m. p. 120–121°, which showed no depression when mixed with an authentic sample. An authentic sample of 2-iodothiophene was found to boil at 186–187°, giving a red vapor and red distillate (the b. p. at atm. press. has not been reported), so it is apparent that none of this compound was present.

**Reaction of 2-Iodothiophene with Phenyllithium.**—To a solution of phenyllithium prepared from the same quantities of reagents as mentioned above was added a solution of 4.2 g. (0.02 mole) of 2-iodothiophene<sup>4</sup> in 20 cc. of anhydrous ether over a ten-minute period. The mixture was carbonated and extracted in the usual manner to give 1.5 g. (58% based on 2-iodothiophene) of crude acid, m. p. 110–111°. Since recrystallization from water did not raise the m. p., probably due to the presence of benzoic acid, the amide was prepared. This melted at 171–174° which agrees with the reported value.<sup>6</sup> The ether solution remaining was shaken with sulfuric acid to remove thiophenes, and was fractionated to give 2.0 g. of a colorless oil

boiling at 165–180°. The presence of iodine was confirmed in the high boiling fraction.

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### Preparation and Properties of Gallium Lactate<sup>1</sup>

BY H. C. DUDLEY AND RAY F. GARZOLI

A study of the toxic properties of gallium compounds has shown that the quantity of injected material needed to produce marked systemic effects is quite large. For this reason a water-soluble gallium compound was needed which had as its acidic constituent some non-toxic yet easily metabolized group. A search of the literature yielded little information. A mention of gallium lactate is made by Neogi and Naudi<sup>2</sup> but those authors give few details of the preparation and little information about the properties.

#### Preparation

Fifty grams of metallic gallium (Eagle Pitcher 98.6%) was dissolved in 200 ml. of concentrated hydrochloric acid by warming on the steam-bath and adding in small portions a total of 15 ml. of concentrated nitric acid. The solution was evaporated to 200 ml., diluted to 700 ml. with water and the gallium hydroxide precipitated by the addition of a slight excess of ammonium hydroxide. The mixture was gently warmed to expel excess ammonia, and the semi-gelatinous precipitate was collected by centrifugation and washed twice with cold water.

Portions of about 20 g. each of washed freshly precipitated<sup>3</sup> gallium hydroxide were mixed with 100 ml. of concentrated lactic acid (reagent grade, assay 85–90%). The mixture was diluted with water to a total volume of about 3.5 liters and heated on a steam-bath and stirred at frequent intervals until the volume was reduced by evaporation to 1 liter. The excess gallium hydroxide was filtered off and the clear filtrate evaporated on a steam-bath to a viscous liquid at which point the gallium lactate partially crystallized in white plates or sheets. Anhydrous acetone was added to the sirupy mixture to dissolve the excess lactic acid and precipitate the dissolved salt. The gallium lactate was washed once with 200 ml. of acetone, dried, ground to a fine powder and again extracted with desiccated acetone. The final product after vacuum desiccation was an amorphous white powder. The yield was about 85 g. gallium lactate (88%), and without further purification this product assayed 20.60% Ga (20.70% theoretical) and 1.47% moisture, was completely water soluble and was suitable for physiological studies.

A highly purified product has been obtained by dissolving 100 g. of the gallium lactate prepared as described above in 600 ml. of distilled water, evaporating on a steam-bath and taking the first 25 g. of the white floc which separated. This product was again purified by the same means: the purified material so obtained was a white amorphous powder which gave the following analysis:

*Anal.* Calcd. for Ga(CH<sub>3</sub>CHOHCOO)<sub>2</sub>: Ga, 20.70; C, 32.08; H, 4.49. Found: Ga, 20.71; C, 31.92; H, 4.69.

(1) The opinions or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or the endorsement of the Navy Department.

(2) P. Neogi and S. K. Naudi, *Jour. Indian Chem. Society*, **13**, 399 (1936).

(3) Gallium hydroxide is an unstable hydrate of gallium oxide. The most reactive form, Ga<sub>2</sub>O<sub>3</sub>·2H<sub>2</sub>O, loses one molecule of water on standing to form Ga<sub>2</sub>O<sub>3</sub>·H<sub>2</sub>O, which in turn on gentle heating forms in part the relatively inert Ga<sub>2</sub>O<sub>3</sub>.

(1) Gilman, "Organic Chemistry," Vol. I, John Wiley and Sons, Inc., New York, N. Y., 1943, p. 538.

(2) G. Bryant Bachman, unpublished data.

(3) Evans and Allen, "Organic Syntheses," Coll. Vol. II, John Wiley and Sons, Inc., New York, N. Y., 1943, p. 517.

(4) Minnis, "Organic Syntheses," Coll. Vol. II, John Wiley and Sons, Inc., New York, N. Y., 1943, p. 357.

(5) Steinkopf, "Die Chemie des Thiophens," lithographed by Edwards Brothers, Inc., Ann Arbor, Michigan, 1944, p. 93.

(6) Hantzsch, *Ber.*, **24**, 48 (1891).