

**Difurfuralmethylcreatinine.**—The alcoholic extract of the preceding experiment gave 0.7 g. of light gray crystals of m. p. 137°.

*Anal.* Calcd. for  $C_{15}H_{13}O_2N_2$ : N, 14.84. Found: N 15.01.

**Picrate**, m. p. 205° with decomposition.

**5-Salicylcreatinine.**—Five grams of creatinine and an excess of salicylaldehyde were heated at 130° for forty-five minutes. A red transparent mass was obtained which was crystallized from alcohol giving orange-yellow needles of m. p. 232° with decomposition; yield 83%.

*Anal.* Calcd. for  $C_{11}H_{11}O_2N_2$ : N, 19.33. Found: N, 19.41.

**Picrate**, yellow needles of m. p. 269° with decomposition.

**5-Cinnamylcreatinine.**—Eleven grams of creatinine and 13 g. of cinnamic aldehyde were heated in an oil-bath at 135° for eight hours. The gummy solid was extracted twice with boiling acetone, then boiled with water and the residue crystallized from alcohol, giving orange-red crystals of m. p. 280° with decomposition; yield 17%.

*Anal.* Calcd. for  $C_{18}H_{18}ON_2$ : N, 18.48. Found: N, 18.46.

**Picrate**, m. p. 261° with decomposition.

**Dicinnamylcreatinine.**—The acetone extract from 5-cinnamylcreatinine was diluted with ether and a flocculent mass of fine yellow crystals separated. These were boiled with water and recrystallized from acetone, giving a product of m. p. 220° with decomposition; yield, 19%.

*Anal.* Calcd. for  $C_{22}H_{19}ON_2$ : N, 12.32. Found: N, 12.17.

**Picrate**, m. p. 193° with decomposition.

### Summary

1. Furfuraldehyde, cinnamyl aldehyde, salicyl aldehyde and furfuralacrolein have been condensed with creatinine and furfuraldehyde has been condensed with methylcreatinine.

2. The picrates of the above condensation products and the hydrochloride of furfuralcreatinine have been prepared and described.

3. Products formed by the reaction of two molecules of the aldehyde and one of creatinine have been isolated and described.

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[CONTRIBUTION FROM THE RESEARCH LABORATORY OF THE FIRESTONE TIRE AND RUBBER COMPANY]

## A Method for the Preparation of 2-Mercaptobenzothiazole<sup>1</sup>

BY R. F. DUNBROOK AND M. H. ZIMMERMANN

### Introduction

The discovery that 2-mercaptobenzothiazole and its derivatives are useful accelerators for the vulcanization of rubber has in recent years led to extensive searches for new methods of preparing this compound.

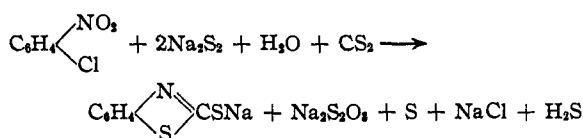
A method for preparing 2-mercaptobenzothiazole distinctly different from processes previously recorded was described by Teppema and Sebrell.<sup>2</sup> The reaction was carried out by heating *o*-nitrochlorobenzene with an aqueous solution of sodium hydrosulfide while passing into the mixture a stream of hydrogen sulfide previously saturated with carbon disulfide. The time of reaction was approximately twenty hours and yields from 87.5–90% were reported.

A modification of this process was mentioned by Sebrell and Teppema by which *o,o'*-dinitrodiphenyl disulfide was first prepared from *o*-nitro-

chlorobenzene and sodium disulfide and was subsequently converted into 2-mercaptobenzothiazole by the action of acid sodium sulfide, hydrogen sulfide and carbon disulfide.

This paper presents a new method<sup>3</sup> for the preparation of 2-mercaptobenzothiazole by the action of sodium polysulfide on *o*-nitrochlorobenzene in the presence of carbon disulfide. This method differs from that of Teppema and Sebrell in dispensing entirely with the use of hydrogen sulfide. The reaction is completed in a shorter time and the optimum yields of 2-mercaptobenzothiazole are somewhat higher than those reported by Teppema and Sebrell.

The ultimate reaction may be represented by the equation



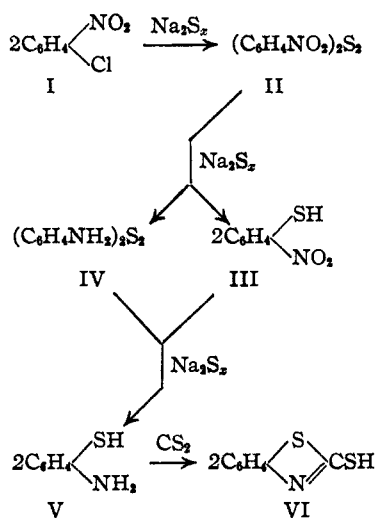
In just what steps it proceeds is not definitely

(3) Dunbrook, U. S. Patent 1,960,205, March 22, 1934.

(1) Presented at the Cleveland Meeting of the American Chemical Society, September, 1934.

(2) Teppema and Sebrell, *THIS JOURNAL*, **49**, 1748 (1927); Sebrell and Teppema, U. S. Patent 1,662,015, March 6, 1928; U. S. Patent 1,785,656, December 16, 1930; U. S. Patent 1,669,630, May 15, 1928.

known, but it is probable that it follows one or the other of the courses shown



The formation of *o,o'*-dinitrodiphenyl disulfide (II) from *o*-nitrochlorobenzene (I) and sodium disulfide is well known. The reduction of this compound (II) to *o*-nitrothiophenol (III) was accomplished by Brand,<sup>4</sup> who stated that either sodium hydrogen sulfide, sodium sulfide, sodium disulfide or sodium polysulfide is capable of reducing *o,o'*-dinitrodiphenyl disulfide to *o*-nitrothiophenol. Brand stated that if larger quantities of sodium polysulfide were used, the nitro group was also reduced (V).

The authors believe that with an excess of sodium polysulfide present the *o,o'*-dinitrodiphenyl disulfide (II) may first be reduced to *o,o'*-diaminodiphenyl disulfide (IV). Zincke and Siebert<sup>5</sup> have shown that *o,o'*-diaminodiphenyl disulfide (IV) is easily reduced to *o*-aminothiophenol (V) by sodium sulfide.

The action of carbon disulfide on *o*-aminothiophenol (V) to form 2-mercaptobenzothiazole (VI) was first studied by Hofmann. Teppema and Sebrell<sup>2</sup> have shown that an alkaline medium is essential in order to obtain high yields.

#### Procedure

In a typical experiment 228 g. of crystallized sodium sulfide ( $\text{Na}_2\text{S} \cdot 9\text{H}_2\text{O}$ ) was mixed with 60.6 g. of sulfur in a 600-cc. beaker. Two hundred cubic centimeters of water was added to the mixture of sulfur and sodium sulfide and the whole heated until all of the sulfur had dissolved. The sodium polysulfide solution was transferred to a 2-liter, 3-necked round-bottomed flask, the central opening of which was provided with an efficient agitator and mer-

cury seal. The other two openings were provided with a reflux condenser and a thermometer, respectively. Fifty grams of *o*-nitrochlorobenzene was added to the flask, the stirrer started, and 40 cc. of carbon disulfide added through the condenser. The mixture was heated on the steam-bath for three hours. At the end of the refluxing period, the contents of the flask were subjected to steam distillation. The residual liquid was diluted to 1000 cc., cooled to 20° in an ice-bath, and the 2-mercaptobenzothiazole was precipitated by the addition of dilute hydrochloric acid (1:1). The precipitate, consisting of a mixture of the thiazole and sulfur, was collected on a Buchner funnel and washed with water to remove sodium chloride. The thiazole was separated from the sulfur by solution in sodium hydroxide (800 cc. of water, 20 g. of sodium hydroxide). After removing the sulfur by filtration, the free mercaptobenzothiazole was precipitated from the solution containing the sodium salt by means of dilute hydrochloric acid at 20°. The product was filtered, washed and dried on a steam-plate.

The experimental results are shown by curves A, B, C and D.

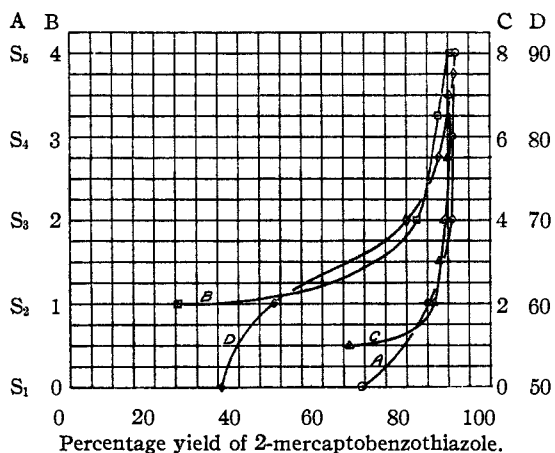


Fig. 1.—Curve A, effect of varying the amount of sulfur in sodium polysulfide ( $\text{S}_x$  in  $\text{Na}_2\text{S}_x$ ); Curve B, effect of varying the ratio of  $\text{Na}_2\text{S}_x$  to *o*-nitrochlorobenzene (molar ratio); Curve C, effect of time of refluxing (hrs.); Curve D, effect of temperature (°C.).

Curve A shows the results of a series of experiments to determine the effect of increasing amounts of sulfur in sodium polysulfide. It will be noted that the yield was low when sodium sulfide only was used, but that the yield of 2-mercaptobenzothiazole rapidly approached a maximum with increasing amounts of sulfur. Further, it may be seen that the yield was only slightly increased when using a polysulfide containing more sulfur than sodium trisulfide. When sodium monosulfide was used, considerable *o*-chloroaniline was produced by the reduction of *o*-nitrochlorobenzene. When using 2.63 moles of polysulfide per mole of *o*-nitrochlorobenzene, a

(4) Brand, *Ber.*, **42**, 3464 (1909).

(5) Zincke and Siebert, *ibid.*, **48**, 1242 (1915).

practical optimum was reached with a proportion of Na to S corresponding to  $\text{Na}_2\text{S}_3$ .

Curve B shows the results obtained when the ratio of  $\text{Na}_2\text{S}_3$  to *o*-nitrochlorobenzene was varied. The yield of 2-mercaptobenzothiazole increased very rapidly up to a ratio of 2 moles of  $\text{Na}_2\text{S}_3$  to one of *o*-nitrochlorobenzene.

The effect of time of refluxing is shown by Curve C. It will be seen that the yield was only very slightly increased after three hours of refluxing. At a temperature of 70 to 80° the yield gradually increased with the time of refluxing up to seven hours. At higher temperatures, between 85 and 90°, the maximum yield was obtained in three hours.

Curve D shows the effect of temperature. Below 70° the yields of 2-mercaptobenzothiazole were very low. The maximum yield was ob-

tained at a temperature of 85 to 90°, using a ratio of three moles of  $\text{Na}_2\text{S}_3$  to one mole of *o*-nitrochlorobenzene.

**Acknowledgment.**—The authors wish to acknowledge the helpful assistance given by Dr. N. A. Shepard during this investigation.

#### Summary

A new method for the direct preparation of 2-mercaptobenzothiazole in one step from *o*-nitrochlorobenzene is described.

The optimum yields are obtained when *o*-nitrochlorobenzene is heated with an aqueous solution of sodium polysulfide ( $\text{Na}_2\text{S}_3$ ) and carbon disulfide at 85–90° for three hours using three moles of  $\text{Na}_2\text{S}_3$  to one mole of *o*-nitrochlorobenzene.

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[CONTRIBUTION FROM THE HALL LABORATORY OF CHEMISTRY, WESLEYAN UNIVERSITY]

## The Toxic Principle of the Poison Ivy

BY G. ALBERT HILL, VINCENT MATTACOTTI AND W. D. GRAHAM

Within the past forty years, three notable attempts have been made to isolate and to identify the toxic principle of that member of the Rhus group known as poison ivy. In 1897, Pfaff<sup>1</sup> prepared an alcoholic extract of leaves and branches of Rhus Toxicodendron from which he ultimately obtained a nearly white precipitate by means of lead acetate. This precipitate yielded a very toxic, non-volatile oil, toxicodendrol. Pfaff went no further with the chemical study of his product.

In 1906, Acree and Syme<sup>2,3</sup> used material obtained from the leaves and flowers of poison ivy by extraction with ether. They decided that the toxic material, designated by them, toxicodendrin, was a complex glycoside, presumably containing fisetin, rhamnase and gallic acid.

Somewhat later, in 1916, McNair<sup>4</sup> experimented with a gasoline extract of the bark of Rhus Diversiloba, a plant almost indistinguishable from Rhus Toxicodendron. He came to the conclusion that the poison, lobinol, was an unsaturated *o*-dihydroxybenzene derivative. He did not, however, prove its structure, or identify it.

(1) Pfaff, *J. Exp. Med.*, **2**, 181 (1897).

(2) Acree and Syme, *Am. Chem. J.*, **36**, 301 (1906).

(3) Acree and Syme, *J. Biol. Chem.*, **2**, 547 (1906–1907).

(4) McNair, *THIS JOURNAL*, **38**, 1417 (1916); **43**, 159 (1921).

From 1907–22, Majima<sup>5</sup> and his co-workers published a series of papers dealing with the poisonous principle of Japan lac, obtainable from Rhus Vernicifera. From an alcoholic extract of the sap of this tree, Majima obtained a toxic oil of low volatility, which he called urushiol. By a study of the oxidation products of the oil and those of certain of its derivatives, Majima proved urushiol to be a mixture of *o*-dihydroxybenzenes with a normal fifteen carbon atom side chain in position three. Majima was not able to isolate chemical individuals from urushiol by distillation. A small quantity of saturated material is present, dissolved in at least two unsaturated substances with two double bonds in the chain, and possibly accompanied by a more highly unsaturated substance. When urushiol is reduced, all of the components are converted into a single substance, 1-*n*-pentadecyl-2,3-dihydroxybenzene, hydrourushiol. The structure of this substance was established by the synthesis of its dimethyl ether. Majima prepared a number of derivatives of it, and of urushiol.

In the light of these researches, the isolation and identification of the toxic principle of the poi-

(5) Majima, *Ber.*, **55B**, 172 (1922).