a dark-colored liquid, and ultimately pure tetrabromoquinone sublimes in beautiful yellow crystals melting at 298°. The yield is poor.

Aniline.—To a mixture of bromine and nitric acid, aniline is added gradually, when a vigorous reaction takes place. The mixture is then warmed on the water-bath for 15 to 20 hours with the occasional addition of further quantities of bromine and nitric acid. The solid gradually passes through black and becomes brown. The brown mass is subjected to sublimation when pure crystals of bromanil are obtained melting at 298°, leaving the other products behind as a charred mass. The yield is very poor, as much of the original substance is decomposed to give bromonitro derivatives of methane.

Aniline Black.—Two g. of aniline black is placed in a flask and to it 10 cc. of conc. nitric acid and excess of bromine are added. The mixture is then warmed on the water-bath, when a deep brown, oily product is obtained. This oily product is subjected to the prolonged action of bromine and nitric acid for 10 to 12 hours. The resulting dark colored product, on sublimation, gives pure crystals of tetrabromoquinone, melting at 298°.

Phenylhydrazine, *p*-Nitrophenol and *p*-diamido-diphenylamine.—All these substances when treated with bromine and nitric acid on the water-bath gradually change to a brown or yellow mass which on sublimation yields tetrabromoquinone. In all cases, a considerable portion of the material is converted into bromonitro derivatives of methane.

CALCUTTA, INDIA

[CONTRIBUTION FROM THE BUREAU OF CHEMISTRY, UNITED STATES DEPARTMENT OF AGRICULTURE, AND THE DEPARTMENT OF CHEMISTRY OF THE GEORGE WASHINGTON UNIVERSITY]

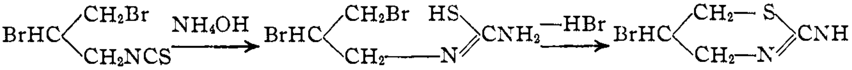
THE INTERACTION OF ALIPHATIC ALCOHOLS AND BETA-GAMMA-DIBROMOPROPYL ISOTHIOCYANATE[1]

BY RAYMOND M. HANN

Received September 30, 1922

Dibromopropyl isothiocyanate was first isolated and purified by Dixon[2] who prepared it by the addition of bromine to allyl isothiocyanate.

In pursuing his study of the substance he attempted to prepare the corresponding dibromopropyl-thio-urea, which had already been described by Maly[3] as resulting from the addition of bromine to allyl-thio-urea. Failure to obtain the expected derivative led to a comprehensive study, and some time later Dixon[4] published work which left little doubt that Maly's compound was the hydrobromide of the base resulting from the action of ammonia on dibromopropyl isothiocyanate. From further study of the carbimide and its reactions with various bases, and in consideration of the work of Gabriel[5] and others upon the ring-closing tendency of mono- and disubstituted thioureas containing monobrominated paraffin radicals, it seemed probable that ammonia reacted in the following manner.



$$\mathrm{BrHC}\left\langle\begin{matrix}\mathrm{CH_2Br}\\ \mathrm{CH_2NCS}\end{matrix}\right. \xrightarrow{\mathrm{NH_4OH}} \mathrm{BrHC}\left\langle\begin{matrix}\mathrm{CH_2Br} & \mathrm{HS}\\ \mathrm{CH_2}\text{——} & \mathrm{N}\end{matrix}\right\rangle\mathrm{CNH_2} \xrightarrow{-\mathrm{HBr}} \mathrm{BrHC}\left\langle\begin{matrix}\mathrm{CH_2}\text{—} & \mathrm{S}\\ \mathrm{CH_2}\text{—} & \mathrm{N}\end{matrix}\right\rangle\mathrm{CNH}$$

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[1] Presented at the Pittsburgh meeting of the American Chemical Society, September 4–8, 1922.

[2] Dixon, *J. Chem. Soc.*, **61**, 545 (1892).

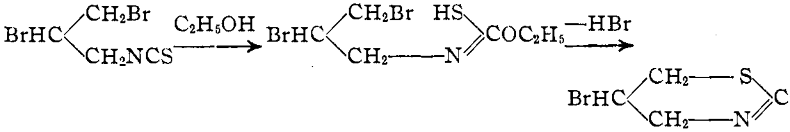
[3] Maly, *Z. Chem.*, **1867**, 42.

[4] Dixon, *J. Chem. Soc.*, **69**, 22 (1896).

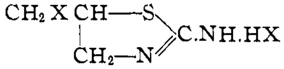
[5] Gabriel, *Ber.*, **22**, 1140 (1889).

Analysis and further work apparently justified the conclusion that ammonia reacted with dibromopropyl isothiocyanate to produce 2-amino-3-bromo-4,6-dihydro-1,3,4-thiazine or, using the nomenclature proposed by Dixon,[6] trimethylene *ψ-n*-thio-urea.

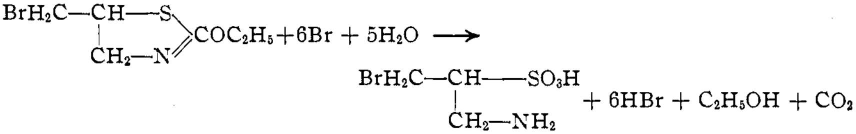
Following the condensation of various bases with the isothiocyanate (every such reaction resulting in closing the ring with formation of what Dixon interpreted to be correspondingly substituted thiazine) the study was extended to include the aliphatic alcohols. By carrying out experiments under pressure, he obtained what he judged to be 2-alkoxy-5-bromo-4,6-dihydro-1,3,4-thiazines. The reaction he formulated as here described, and supposedly prepared the methyl, ethyl and propyl homologs.



About the same time Gadamer[7] demonstrated that on oxidation of allyl thiourea dibromide with hydrochloric acid and potassium chlorate, β-chloro-bromo-methyl-tauro-carbamic acid was obtained. This fact warranted the conclusion that allyl thiocarbamide halides were substitution products of Gabriel's propylene-pseudo-thio-urea and could be designated by the general type formula,



Ten years later Gabriel[8] took up the problem. After obtaining β-bromomethyl-taurine by oxidation of 2-ethoxy-5-bromo-4,6-dihydro-1,3,4-thiazine with bromine, in view of his previous researches along similar lines and citing the work of Gadamer, he advanced the opinion that Dixon's compound was 5-bromomethyl-2-ethoxy-Δ^4-thiazoline and expressed its oxidation as follows.



The present study was undertaken in order to prepare several of the higher homologous thiazolines. Experiments were carried out with *n*-butyl and *iso*-amyl alcohols. The solid crystalline reaction products were obtained and analyzed. Both products melted at about the same temperature, 95–96°, which was deemed extraordinary. Further, Dixon stated that the lower members of the series had melting points very close to those observed (methoxy 95–96°, ethoxy, 96–97°, propoxy, 96–97°). The results of the analyses for nitrogen and bromine were much too high to be interpreted as resulting from an alkyl substituted bromomethyl-thiazoline and, more remarkable still, they were near enough together to lead to the conclusion that they resulted from the analysis of the same substance. Crystallographic and optical examination by Dr. E. T.

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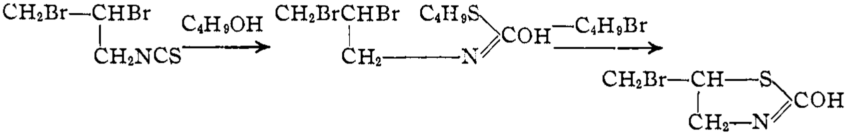
[6] Dixon, *J. Chem. Soc.*, **67**, 564 (1895).

[7] Gadamer, *Arch. Pharm.*, **234**, 1–48 (1896).

[8] Gabriel and Colman, *Ber.*, **39**, 2889 (1906).

Wherry[9] confirmed the opinion that the substances resulting from the action of *n*-butyl and *iso*-amyl alcohols on the dibromopropyl isothiocyanate are identical.

Proof of the identity of these 2 compounds indicated interaction of the alcohol, with formation of a solid product into the constitution of which the alkyl group did not enter. The most plausible alternative assumption was that the hydroxyl group became attached to carbon and that, as an intermediate stage, the alkyl group became attached to sulfur, later to split off with the end bromine in the γ position,[10] with the formation of 5-bromomethyl-2-hydroxyl-Δ^4-thiazoline.[11] The reaction would be formulated thus,



In order that no question should arise concerning the identity of the dibromopropyl isothiocyanate used in the present instance with that of Dixon, the author has repeated his work with piperidine and with ethyl alcohol. Identical results were obtained in the case of the base. Analyses and crystallographic examination of the product from the alcohol indicate that it was identical with the substances obtained from the higher alcohols and therefore agreed with the "hydroxyl substitution" advanced in this paper.

Experimental Work

Crystallographic and Optical Properties.—Dr. E. T. Wherry, of the Bureau of Chemistry, whose assistance was of great value in drawing the conclusions herewith published, has kindly contributed the following data.

The crystals of bromomethyl-hydroxy-thiazoline obtained are too minute for measurement of their angles, but they are well adapted to study under the polarizing microscope.

In ordinary light they are seen to consist of flat rods and irregular grains, probably belonging to the orthorhombic system; n_D: $\alpha = 1.530$, $\beta = 1.650$, $\gamma = 1.830$, $\gamma - \alpha = 0.300$, all ± 0.005. Index α is usually shown lengthwise and γ crosswise. The remarkably high value of the double refraction, $\gamma - \alpha$, is noteworthy.

In parallel polarized light, nicols crossed: double refraction extraordinarily strong, high order colors being shown even on thin grains. Extinction is parallel and elongation negative.

In convergent polarized light, nicols crossed: parts of biaxial figures with large axial angle are occasionally seen; sign +.

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[9] Crystallographer of the Bureau of Chemistry.

[10] Paal [*Ber.*, **24**, 4253 (1891)] has shown that the bromine is more easily removed from the γ than the β position.

[11] Extension of the plan adopted by Bogert and Abrahamson [THIS JOURNAL, **44**, 826 (1922)] for numbering the positions of the thiazole and benzothiazole nuclei permits designation of the compound as 5-bromomethyl-2-hydroxy-Δ^4-thiazoline.

The crystals of the piperidyl derivative are plates about 1 mm. in diameter, with fairly well developed faces. Under the polarizing microscope they show the following features.

In ordinary light they are seen to consist of irregular angular flakes, the system of which is not obvious; n_D: $\alpha = 1.625$, $\beta = 1.685$, $\gamma = 1.745$, $\gamma - \alpha = 0.120$, all ± 0.005. Mean values are usually shown, but the individual indices are not difficult to find.

In parallel polarized light, nicols crossed: double refraction extreme, the colors being of rather high orders. Extinction and elongation indeterminate.

In convergent polarized light, nicols crossed: parts of biaxial figures are occasionally seen, the axial angle being so large that the sign is indeterminate.

***n*-Butyl Alcohol and β-γ-Dibromopropyl Isothiocyanate.**—Five g. of the isothiocyanate and 10 g. of *n*-butyl alcohol were heated together in a sealed tube at 100–110° for 2 hours. Slight pressure and some fuming were observed on opening the tube, and immediately afterward solid matter began to precipitate. The mixture was allowed to stand overnight. The crystalline deposit was separated, recrystallized from absolute alcohol and obtained as small white prisms which melted at 95–96° (uncorr.).

Analyses. Subs., 0.4118: (Kjeldahl)[12] 20.8 cc. of 0.1 *N* acid. Subs., 0.2280: AgBr, 0.2140. Calc. for $C_4H_6ON.SBr$: N, 7.14; Br, 40.76%. Found: N, 7.08; Br, 40.38.

***Iso*-amyl Alcohol and β-γ-Dibromopropyl Isothiocyanate.**—The reaction was as described for *n*-butyl alcohol; melting point of compound, 95–96° (uncorr.).

Analyses. Subs., 0.4620: 23.3 g. of 0.1 *N* acid. Subs., 0.5115: AgBr, 0.4897. Found: N, 7.07; Br, 40.72.

***Iso*-butyl Alcohol and β-γ-Dibromopropyl Isothiocyanate.**—The crystalline product melted at 95–96°.

Ethyl Alcohol and β-γ-Dibromopropyl Isothiocyanate.—Five g. of the isothiocyanate and 10 g. of absolute ethyl alcohol were heated in a sealed tube for 1 hour. A clear yellowish liquid resulted. The tube was allowed to stand overnight and when opened no pressure or fuming was observed, although the contents were acid to litmus. The clear liquid was passed through a dry filter and after it had stood crystalline crusts separated. The solid (3 g.) was separated and recrystallized from absolute alcohol. It melted at 95–96°, which is 1° lower than the melting point reported by Dixon who designated his compound as the "ethylic salt of β-bromotrimethylene-ψ-*n*-thiocarbamic acid." It gave the analytical results required for 5-bromomethyl-2-hydroxy-Δ^4-thiazoline.

Analyses. Subs., 0.2160: 10.8 cc. of 0.1 *N* acid. Subs., 0.3056: AgBr, 0.2916. Found: *N*, 7.01; Br, 40.61.

Piperidine and β-γ-Dibromopropyl Isothiocyanate.—Molecular proportions of the constituents in alcoholic solution were mixed. Vigorous combination took place, as evidenced by the rapid heating of the alcoholic mixture. The solid which separated on cooling was recrystallized from alcohol. It melted at 188°, which is in agreement with the work of Dixon.

Summary

1. 4-Bromo-2-ethoxy-5,6-dihydro-1,3,4-thiazine is not a product of the action of ethyl alcohol on dibromopropyl isothiocyanate.

2. The assumption of Gabriel that Dixon's 2-alkoxy-5-bromo-4,6-

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[12] For the nitrogen analyses reported in this paper the author is indebted to Messrs. Jenkins and Ellis of the Nitrogen Laboratory, Bureau of Chemistry.

dihydro-1,3,4-thiazine is 5-bromomethyl-2-ethoxy-Δ^4-thiazoline is not substantiated by analyses of the compound in question.

3. Primary aliphatic alcohols react with dibromopropyl isothiocyanate with formation of 5-bromomethyl-2-hydroxy-Δ^4-thiazoline.
4. Secondary aliphatic alcohols appear to react similarly.

WASHINGTON, D. C.

[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF CORNELL UNIVERSITY]

PHENOLSULFONEPHTHALEIN AND SOME OF ITS DERIVATIVES

BY W. R. ORNDORFF AND F. W. SHERWOOD

Received October 2, 1922

Remsen[1] in 1884 was the first to note the formation of a substance analogous to fluorescein when resorcinol is heated with *o*-sulfobenzoic acid. In 1895 Remsen and Saunders[2] and in 1898 List and Stein[3] stated that a compound analogous to phenolphthalein, and which they assumed to be phenolsulfonephthalein, was formed when the chlorides of *o*-sulfobenzoic acid were heated with phenol. Phenolsulfonephthalein was first prepared *pure* by Sohon[4] by heating the anhydride of *o*-sulfobenzoic acid with phenol. These two methods are the ones always employed in making the compound.[5]

Most of the phenolsulfonephthalein used in this investigation was prepared by heating the chlorides of *o*-sulfobenzoic acid with an excess of phenol without the aid of a condensing agent.[6] It was found that when the temperature of the bath did not exceed 100°, the diphenyl ester of *o*-sulfobenzoic acid was the main product of the reaction and very little of the sulfonephthalein was formed. At 135–140°, however, yields of 50% of the sulfonephthalein were obtained. The use of a condensing agent, such as zinc chloride, did not increase the yield, though it shortened the time of heating.

Purification of the Phenolsulfonephthalein.—Early in the course of this investigation, it was found that phenolsulfonephthalein purified by the usual method, by dissolving the crude product in a solution of sodium hydroxide, filtering the solution and precipitating the sulfonephthalein with acid, contained sometimes as much as 8% of a substance that was soluble in a solution of sodium hydroxide, but insoluble in the cold in

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[1] Remsen, *Am. Chem. J.*, **6**, 180 (1884).

[2] Remsen and Saunders, *Am. Chem. J.*, **17**, 352 (1895).

[3] List and Stein, *Ber.*, **31**, 1662 (1898).

[4] Sohon, *Am. Chem. J.*, **20**, 257 (1898).

[5] See White and Acree, THIS JOURNAL, **41**, 1190 (1919). Lubs and Clark, *J. Washington Acad. Sci.*, **5**, 609 (1915).

[6] Most of the saccharin used in the preparation of the phenolsulfonephthalein was furnished gratis by the Monsanto Chemical Co. of St. Louis, Mo. It was a very pure product and contained only a trace of *p*-sulfaminobenzoic acid.