

They were a mobile straw-colored liquid with an odor similar to that of coriander oil. A portion of the alcohols was converted into acetates. The following proportions were used for this conversion: alcohols 10 g., fused sodium acetate 10 g. and acetic anhydride 40 g. Eight grams of acetates, with an acetyl number of 131, was obtained.

In the next step alcohols were converted into iodides. From 10 g. of alcohols, 1 g. of red phosphorus and 10 g. of iodine, 10 g. of iodides was obtained. The iodides were reduced to hydrocarbons by the Zelinskii method with zinc dust in an aqueous alcoholic medium; 5 g. of hydrocarbons was obtained. The distillation range of these hydrocarbons at 45 mm. pressure was 160–260°. The hydrocarbons did not dissolve in sulfuric acid and did not discolor bromine.

Anal. Calcd. for C_nH_{2n} : H, 14.38; C, 85.62. Found: H, 14.04; C, 85.84.

The hydrocarbons were dehydrogenated with sulfur and brominated with aluminum bromide according to Gustavson's method. Hydrogen sulfide evolved during the dehydrogenation and an oil was obtained as the reaction product. The bromination was accompanied by evolution of hydrogen bromide and resulted in a salve-like product. The hydrocarbon radical of these carboxylic acids is therefore of the naphthene type, mostly of the monocyclic type judging by the analytical data.

Summary

Oleic acid was cracked in presence of water and alumina. Esters, alcohols and iodides were prepared and the latter finally converted to hydrocarbons. These corresponded to structures of octonaphthene and nonanaphthene type.

Emba gas oil was oxidized by air blowing at 90 to 100° in presence of catalysts, giving oxy and carboxy acids of monocyclic naphthene type.

[CONTRIBUTION FROM THE LABORATORY FOR PURE RESEARCH OF MERCK AND CO., INC.]

PREPARATION AND PROPERTIES OF ALPHA- AND BETA-METHYLCHOLINE AND GAMMA-HOMOCHOLINE¹

BY RANDOLPH T. MAJOR AND JOSEPH K. CLINE

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A good deal of work has been devoted to the study of choline, its homologs and derivatives because of their interesting physiological properties.² Among the more important of the homologs of choline that have been investigated are those in which the hydroxyethyl group of choline has been replaced by the hydroxypropyl or hydroxyisopropyl group. Thus, α -methylcholine, $(CH_3)_3N(OH)CH(CH_3)CH_2OH$, β -methylcholine, $(CH_3)_3N(OH)CH_2CH(OH)CH_3$, and γ -homocholine, $(CH_3)_3N(OH)CH_2CH_2CH_2OH$, have been synthesized. A search through the literature has shown that there is considerable disagreement as to the properties of each of these compounds. Also, various investigators have

¹ Presented at the Indianapolis Meeting of the American Chemical Society April, 1931.

² Fraenkel, "Arzneimittel-Synthese," Julius Springer, Berlin, 1927, p. 336.

not agreed as to which isomer they have obtained when they have used the same method of preparation.

Morley³ prepared what he termed "trimethyloxyisopropylammonium chloride" with the formula $(\text{CH}_3)_3\text{N}(\text{Cl})\text{CH}(\text{CH}_3)\text{—CH}_2\text{OH}$ by the action of a solution of trimethylamine in alcohol on propylene chlorohydrin. Later Morley and Green⁴ pointed out that Morley's propylene chlorohydrin was largely $\text{CH}_3\text{CHOH—CH}_2\text{Cl}$, which suggested that the compound to which Morley gave the structure $(\text{CH}_3)_3\text{N}(\text{Cl})\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$ was at least to a large extent $(\text{CH}_3)_3\text{N}(\text{Cl})\text{CH}_2\text{CH}(\text{CH}_3)\text{OH}$.

In 1911 Menge⁵ prepared a compound which he called " α -methylcholine" by the action of a solution of trimethylamine in alcohol on a propylene chlorohydrin, prepared by the method of Henry,⁶ which was supposed to have the formula $\text{CH}_3\text{CHClCH}_2\text{OH}$. Later Smith⁷ showed that the propylene chlorohydrin, prepared by Henry's method, as well as the chlorohydrin used by Morley, consisted largely of $\text{CH}_3\text{CHOHCH}_2\text{Cl}$ with some of its isomer $\text{CH}_3\text{CHClCH}_2\text{OH}$. This suggests that Menge's " α -methylcholine" was probably the same as the compound or compounds obtained by Morley.

In 1922 Karrer⁸ described the preparation of an " α -methylcholine" which had entirely different properties from Menge's " α -methylcholine." He obtained the iodide of his compound by the action of methyl iodide on the reduction product of the ethyl ester of N-dimethylalanine, $\text{CH}_3\text{CH}(\text{N}(\text{CH}_3)_2)\text{COOC}_2\text{H}_5$.

We have repeated the synthesis of the α -methylcholine chloride described by Karrer⁸ and have obtained the same results that he did. However, we did find that his intermediate, the ethyl ester of N-dimethylalanine, could be somewhat more easily synthesized by the condensation of dimethylamine with ethyl α -bromopropionate than by his process.

The preparation of a so-called " β -methylcholine," first described in 1910 by Malengreau and Lebailly,¹⁰ was effected by the action of a solution of trimethylamine in alcohol on propylene chlorohydrin, b. p. 128°. The properties of this " β -methylcholine" were very much like those of Menge's " α -methylcholine." Malengreau himself later pointed this out in a personal communication to the editors of Beilstein's "Handbuch der organischen Chemie,"¹¹ and suggested that since his " β -methylcholine" was the

³ Morley, *Ber.*, 13, 1805 (1880); *Compt. rend.*, 91, 333 (1880).

⁴ Morley and Green, *Ber.*, 18, 24 (1885).

⁵ Menge, *J. Biol. Chem.*, 10, 400 (1911).

⁶ Henry, *Bull. sci. acad. roy. Belg.*, 410 (1903); 734 (1906).

⁷ Smith, *Z. physik. Chem.*, 93, 83 (1918).

⁸ Karrer, *Helv. Chim. Acta*, 5, 477 (1922).

⁹ Ref. 8, 476.

¹⁰ Malengreau and Lebailly, *Z. physiol. Chem.*, 67, 40 (1910).

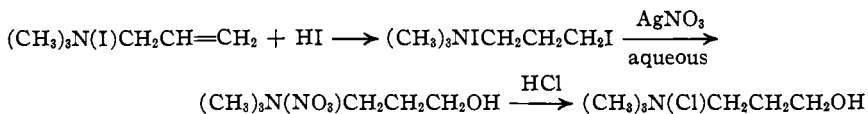
¹¹ F. Beilstein, "Handbuch der organischen Chemie," Julius Springer, 1929, 4th ed., Vol. 4, First Supplement, p. 433.

same as Morley's and Menge's " α -methylcholine," the propylene chlorohydrin with the formula $\text{CH}_3\text{CH}(\text{OH})-\text{CH}_2\text{Cl}$ must suffer rearrangement when it interacts with trimethylamine and gives $(\text{CH}_3)_3\text{N}(\text{Cl})\text{CH}(\text{CH}_3)-\text{CH}_2\text{OH}$ instead of $(\text{CH}_3)_3\text{N}(\text{Cl})\text{CH}_2\text{CH}(\text{CH}_3)\text{OH}$ as would be expected.

Berlin¹² in 1911 obtained a compound which he called " β -methylcholine" that had different properties from those ascribed to it by Malengreau and Lebailly. The salts of this " β -methylcholine" had the same properties as those ascribed by Partheil¹³ to one of his " γ -homocholines" which will be discussed later. Berlin suggested that Partheil's " γ -homocholine" must also be " β -methylcholine."

We have found that catalytic reduction of trimethylacetylammmonium chloride, prepared by a slight modification of the method of Niemilowicz,¹⁴ gave a compound which presumably must be β -methylcholine chloride, $(\text{CH}_3)_3\text{N}(\text{Cl})\text{CH}_2\text{CHOHCH}_3$. The properties of this compound as well as those of its salts and esters corresponded in every way with those of a compound obtained by the condensation of a solution of trimethylamine in benzene with a propylene chlorohydrin which boiled at 125–128°. The properties of the salts and esters of this β -methylcholine compared very closely to those of the corresponding derivatives of Menge's¹⁵ " α -methylcholine" and of Malengreau and Lebailly's¹⁰ " β -methylcholine."

Weisz described the first preparation of " γ -homocholine."¹⁶ Partheil¹⁷ in 1892 reported that he could not repeat Weisz's work but that he had synthesized " γ -homocholine" by a modification of Weisz's method. He also synthesized " γ -homocholine" in two other ways.¹⁸ The first method may be represented schematically as follows



This " γ -homocholine" corresponded in properties to that which he synthesized by his modification of Weisz's method. Partheil synthesized a " γ -homocholine" which had different properties than his first one by the condensation of a solution of trimethylamine in alcohol with trimethylene chlorohydrin.¹⁹ The chloroaurate of this compound melted at 180°.

In 1910 Malengreau and Lebailly²⁰ also condensed a solution of tri-

¹² Berlin, *Z. Biol.*, **57**, 15, 24 (1911).

¹³ Partheil, *Ann.*, **268**, 176 (1892).

¹⁴ Niemilowicz, *Monatsh.*, **7**, 241 (1886).

¹⁵ Menge, *J. Biol. Chem.*, **10**, 401 (1911).

¹⁶ Weisz, *Z. Naturwissenschaft*, **60**, 275 (1887).

¹⁷ Partheil, *Ann.*, **269**, 179 (1892).

¹⁸ Partheil, *ibid.*, **268**, 169 (1892).

¹⁹ Partheil, *ibid.*, **268**, 184 (1892).

²⁰ Malengreau and Lebailly, *Z. physiol. Chem.*, **67**, 39 (1910).

methylamine in alcohol with trimethylene chlorohydrin. The chloroaurate of their " γ -homocholine" melted at 183°.

The next year Berlin²¹ reported that he had also carried out the same condensation but that not only was " γ -homocholine chloride" formed but that a less soluble fraction could be isolated from the products of the reaction. He stated that this less soluble portion contained the ether of " γ -homocholine chloride." The chloroaurate of his " γ -homocholine" melted at 193–194°.

Berlin also reported that Zinnius²² in 1910 had described the condensation of hypochlorous acid with trimethylallylammonium chloride. Apparently he obtained a mixture of $(\text{CH}_3)_3\text{N}(\text{Cl})\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{Cl}$ and of $(\text{CH}_3)_3\text{N}(\text{Cl})\text{CH}_2\text{CH}(\text{Cl})\text{CH}_2\text{OH}$. One of these compounds could not be reduced satisfactorily by zinc and sulfuric acid. The other, which probably had the formula $(\text{CH}_3)_3\text{N}(\text{Cl})\text{CH}_2\text{CH}(\text{Cl})\text{CH}_2\text{OH}$, was reduced to a homocholine the chloroaurate of which melted at 194° and which corresponded apparently in every way with Berlin's " γ -homocholine."

Berlin also obtained some " γ -homocholine" alone with some " β -methylcholine" by a condensation between methyl iodide, sodium alcoholate and a mixture of 1-hydroxy-3-aminopropane and of 1-amino-2-hydroxypropane.

In 1916 von Braun²³ synthesized a " γ -homocholine" whose chloroaurate melted at 193° and which corresponded very closely to that made by Berlin.

We have made γ -homocholine by the condensation of a solution of trimethylamine in benzene with trimethylene chlorohydrin. The properties of this γ -homocholine corresponded very closely to those of the " γ -homocholine" obtained by von Braun²³ and by Berlin.²⁴ We did not obtain any of the ether of γ -homocholine that Berlin found but this may be due to the fact that we used a solution of trimethylamine in benzene rather than in alcohol as he did. We found that in general a solution of trimethylamine in alcohol was not as satisfactory for most of these reactions as one in benzene since there was a greater tendency for the alkyl halide to dissociate in alcohol and for trimethylamine hydrohalide to be formed.

We have also attempted to repeat the preparation of the " γ -homocholine" that was obtained by Partheil²⁵ by the action of an aqueous solution of silver nitrate on "trimethyl- γ -iodopropylammonium iodide." Instead of obtaining, as he reported, a " γ -homocholine" whose chloroaurate melted at 162–164°, we obtained a mixture of true β -methylcholine and of ammonium salts.

²¹ Berlin, *Z. Biol.*, **57**, 20 (1911).

²² Zinnius, Marburg Dissertation, 1910; Berlin, *Z. Biol.*, **57**, 10 (1911).

²³ Von Braun, *Ber.*, **49**, 970 (1916).

²⁴ Berlin, *Z. Biol.*, **57**, 18 (1911).

²⁵ Partheil, *Ann.*, **268**, 175 (1892).

Experimental Part

Preparation of Ethyl α -Dimethylaminopropionate, $\text{CH}_3\text{CHN}(\text{CH}_3)_2\text{COOC}_2\text{H}_5$.—A 33 $\frac{1}{3}$ % solution of dimethylamine in absolute alcohol was added in small portions to a solution of 100 g. of ethyl α -bromopropionate in 300 cc. of dry ether. The mixture was at first cooled in ice and then allowed to stand in a warm place (35°) overnight. The dimethylamine hydrobromide which precipitated was filtered off and the ethereal solution extracted with cold dilute sodium hydroxide. The ethereal layer was separated and dried over anhydrous sodium sulfate. This solution was then distilled. The fraction, b. p. 154–157° at 759 mm., was collected.²⁶ The ester was a colorless liquid with a slightly ammoniacal odor; yield, 57%.

Preparation of Trimethylacetonylammonium Chloride, $(\text{CH}_3)_3\text{N}(\text{Cl})\text{CH}_2\text{COCH}_3$.—To 10 g. of monochloroacetone was added in small portions a slight excess of a 33% solution of trimethylamine in benzene. The temperature of the mixture was maintained at 0° until the reaction was complete. The product was collected and purified by dissolving it in absolute alcohol and reprecipitating it with dry ether. Trimethylacetonylammonium chloride was obtained in the form of white hygroscopic needle-like crystals, soluble in water and alcohol but insoluble in ether, m. p. 140°; yield, 80%.

Anal. Calcd. for $\text{C}_6\text{H}_{14}\text{ONCl}$: N, 9.27; Cl, 23.40. Found: N, 9.57, 9.63; Cl, 23.30.

The properties of the chloroplatinate, m. p. 238–240°, and chloroaurate, m. p. 139.5°, corresponded with those ascribed to them by Niemilowicz.²⁷

Reduction of Trimethylacetonylammonium Chloride.—Five grams of trimethylacetonylammonium chloride in 25 cc. of absolute alcohol was catalytically reduced in the presence of 0.1 g. of platinum oxide (Adams) and one drop of a normal solution of ferric chloride in water. After the theoretical amount of hydrogen had been absorbed the solution was filtered from platinum and all the alcohol evaporated *in vacuo*. The oil that remained was kept in a vacuum desiccator for three days, during which time it all crystallized. The solid was dissolved in absolute alcohol which had previously been saturated with hydrogen sulfide. The small amount of iron sulfide which precipitated was removed by shaking the solution with activated charcoal. β -Methylcholine chloride was precipitated as an oil from the filtrate of the mixture by the addition of dry ether. The ether layer was decanted and the oil repeatedly washed with small portions of dry ether until crystallization started. The product was further purified by recrystallization from a small amount of butyl alcohol. It appeared in the form of white hygroscopic needles, soluble in water and alcohol but insoluble in ether; m. p. 165°; yield, 50%.

Anal. Calcd. for $\text{C}_6\text{H}_{16}\text{ONCl}$: N, 9.13; Cl, 23.10. Found: N, 9.23, 9.37; Cl, 23.15.

The properties of the chloroplatinate, m. p. 257° with decomposition, and the chloroaurate, m. p. 196°, of this β -methylcholine corresponded very closely to those ascribed by Menge¹⁵ to the corresponding salts of " α -methylcholine."

Preparation of β -Methylcholine Chloride and γ -Homocholine Chloride.—A mixture of 15 g. of the appropriate chlorohydrin, propylene chlorohydrin, b. p. 125–128° for the preparation of β -methylcholine chloride, and trimethylene chlorohydrin for γ -homocholine chloride, and a slight excess of a 33% solution of trimethylamine in benzene was heated in a sealed tube at 100° for eight hours. The reaction product was dissolved in a small amount of warm absolute alcohol and the solution decolorized with

²⁶ Karrer, Ref. 8, gives 154° at 740 mm. as the b. p. of ethyl α -dimethylaminopropionate.

²⁷ Niemilowicz, *Monatsh.*, 7, 241 (1886).

activated charcoal. Dry ether was added to the filtrate from this mixture. The precipitate was washed with small portions of dry ether. White needle-like crystals were obtained which were soluble in alcohol and water but insoluble in ether.

β -Methylcholine chloride was further purified by recrystallization from butyl alcohol; yield, 48%; m. p. 165°. The melting point of a mixture of this compound with the β -methylcholine chloride obtained by the reduction of trimethylacetylammmonium chloride also melted at 165°.

Anal. Calcd. for $C_8H_{16}ONCl$: N, 9.13. Found: N, 9.18. *Chloroplatinate*: Calcd. for $C_{12}H_{22}O_2N_2PtCl_6$: Pt, 30.22. Found: Pt, 30.28. *Chloroaurate*: Calcd. for $C_8H_{16}ONAuCl_4$: Au, 43.07. Found: Au, 43.12.

The melting points of mixtures of the chloroplatinate, m. p. 257°, and the chloroaurate, m. p. 196°, of this β -methylcholine with the corresponding salts of the β -methylcholine formed by the reduction of trimethylacetylammmonium chloride were the same as those of the constituents of the mixtures.

β -Methylcholine Picrate.—A slight excess of the theoretical amount of silver oxide was shaken with a solution of 1 g. of β -methylcholine chloride (obtained by the action of trimethylamine on propylene chlorohydrin) in 10 cc. of water. The temperature was kept at 0° in order to prevent the formation of trimethylamine. Silver chloride and the excess of silver oxide were filtered off and the calculated amount of a solution of picric acid in absolute alcohol was added to the filtrate. The solution was evaporated to a small volume on the steam-bath. When absolute alcohol was added to the residue and the solution cooled, yellow needle-like crystals were precipitated; m. p. 163°. ²⁸

Anal. Calcd. for $C_{12}H_{18}O_8N_4$: N, 16.18. Found: N, 16.00, 16.32.

γ -Homocholine chloride melted at 173°; yield, 92%.

Anal. Calcd. for $C_8H_{16}ONCl$: C, 46.80; H, 10.40; Cl, 23.15. Found: C, 46.51; H, 10.13; Cl, 23.00.

TABLE I

ESTERS OF α - AND β -METHYLCHOLINE CHLORIDE AND γ -HOMOCHOLINE CHLORIDE

No.	Choline chloride	Anhydride	Hours heated	M. p., °C., of ester	Yield, %
1	α -Methyl- ^a	Acetic	12	152–154	..
2	β -Methyl- ^b	Acetic	6	172–173	..
3	β -Methyl- ^c	Acetic	6	172–173 ^d	80
4	β -Methyl- ^c	Propionic	3
5	γ -Homo-	Acetic	6	142–143	80

No.	Carbon, %		Hydrogen, %		Nitrogen, %		Chlorine, %	
	Calcd.	Found	Calcd.	Found	Calcd.	Found	Calcd.	Found
1	7.17	7.01	18.15	18.32
2	18.15	17.93
3	49.00	49.14	9.20	9.29	18.15	17.97
4	6.68	6.54
5	7.17	6.99	18.15	18.18

^a Prepared by the method of Karrer, Ref. 8. ^b Prepared by the reduction of trimethylacetylammmonium chloride. ^c Prepared by the action of propylene chlorohydrin upon trimethylamine. ^d A mixture of this acetyl- β -methylcholine chloride with that obtained by the acetylation of the β -methylcholine chloride obtained by the reduction of trimethylacetylammmonium chloride also melted at 172–173°.

²⁸ The picrate of the β -methylcholine which was obtained by the reduction of trimethylacetylammmonium chloride also melted at 163° as did a mixture of the two picrates.

The properties of the chloroaurate, m. p. 193°, and the chloroplatinate, m. p. 237°, of this γ -homocholine chloride were the same as those ascribed to these compounds by Berlin²¹ and by von Braun.²³

Acylation of α - and β -Methylcholine Chloride and of γ -Homocholine Chloride.—The three homologs of choline chloride were acylated by heating a mixture of one molecular portion of the homo- or methylcholine with seven molecular portions of the acid anhydride at 100°. After the acylation was complete dry ether was added to the cooled solution. The precipitate was washed several times with ether and then dissolved in absolute alcohol. This solution was first decolorized with activated charcoal and then the acylated compound reprecipitated by the addition of dry ether. The products were white hygroscopic solids which were readily soluble in water.

Attempted Preparation of Partheil's " γ -Homocholine."—The equivalent amount of silver nitrate in 300 cc. of water was added to 25 g. of trimethyliodopropylammonium iodide.²⁹ The precipitated silver iodide was filtered off and a second equivalent of silver nitrate added to the filtrate. The mixture was placed in a blackened flask and heated on a steam-bath. During the course of the reaction the precipitated silver iodide was removed from time to time until no more of it was formed (five days). Sufficient dilute hydrochloric acid was then added to precipitate the small amount of silver nitrate that remained. The silver chloride was removed and the solution evaporated in a vacuum desiccator over calcium chloride and solid sodium hydroxide. When the solution reached a volume of 150 cc. it was saturated with hydrogen sulfide to remove the small amount of silver salts still in solution. The silver sulfide was removed by shaking the solution with activated charcoal and the hydrogen sulfide removed by boiling *in vacuo*. Dilute hydrochloric acid and platinic chloride in excess were now added to the filtrate from this mixture. A small amount of precipitate was obtained which increased in amount if the reaction between the silver nitrate and the trimethyliodopropylammonium nitrate continued for a longer time than five days.

This precipitate was recrystallized several times from water which contained a little hydrochloric acid. It was obtained finally in the form of yellow regular crystals almost insoluble in cold water and but slightly soluble in boiling water; m. p. above 300°. The odor of ammonia was detected when caustic alkali was added to this solid.

Anal. Calcd. for $(\text{NH}_4)_2\text{PtCl}_6$: Pt, 44.00. Found: Pt, 43.80.

Alcohol was added to the filtrate from which the ammonium chloroplatinate was originally separated. A precipitate formed which was recrystallized several times from water containing a small amount of dilute hydrochloric acid. A chloroplatinate which melted at 257° was obtained. This corresponded with β -methylcholine chloroplatinate and not with γ -homocholine chloroplatinate which melts at 237°.

Anal. Calcd. for $\text{C}_{12}\text{H}_{32}\text{O}_2\text{N}_2\text{Cl}_6\text{Pt}$: Pt, 30.22. Found: Pt, 30.41, 30.44.

A small portion of this chloroplatinate was dissolved in water and the solution was saturated with hydrogen sulfide. Platinic sulfide was removed by filtration and the filtrate evaporated to dryness *in vacuo* (20 mm.). The oil which remained was dissolved in water and a small amount of platinic sulfide removed with activated charcoal. The solution was boiled *in vacuo* to remove a slight amount of hydrogen sulfide and auric chloride was then added in slight excess. β -Methylcholine chloroaurate which was slightly impure was obtained. Upon repeated recrystallization it appeared in the form of golden yellow leaflets; m. p. 196°. The melting point of a mixture of this chloroaurate with pure β -methylcholine chloroaurate remained at 196°. The compound, however, was slightly impure as it sintered at a temperature of 180° although it did not melt until 196°. Evidently the amount of contaminating material was slight or con-

²⁹ Prepared according to the method of Partheil, Ref. 18.

sisted of an isomeric substance since it was not noticeable analytically. Possibly ammonium chloroaurate which is less soluble than the chloroaurate of β -methylcholine persisted in spite of the many recrystallizations.

Anal. Calcd. for $C_8H_{16}ONCl_4Au$: Au, 43.07. Found: Au, 43.15, 43.08.

The authors wish to express their appreciation to Mr. Douglass F. Hayman for most of the analyses which are recorded in this paper.

Summary

1. It has been shown that the only true α -methylcholine that has ever been made was that made by Karrer,⁸
2. True β -methylcholine chloride has been prepared by the reduction of trimethylacetylammmonium chloride.
3. It has been shown that β -methylcholine chloride may be obtained by the condensation of propylene chlorohydrin and trimethylamine.
4. γ -Homocholine chloride has been obtained by the condensation of trimethylene chlorohydrin with a solution of trimethylamine in benzene.
5. We have repeated the process used by Partheil to make his " γ -homocholine," the chloroaurate of which melted at 162° . We were not able to isolate any of the salts of γ -homocholine from the reaction mixture but have found salts of ammonia and of β -methylcholine in it.

RAHWAY, NEW JERSEY

[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE UNIVERSITY OF COLORADO]

OPTICAL CRYSTALLOGRAPHIC DATA FOR SOME SALTS OF STRYCHNINE

BY CHARLES F. POE AND JESSE E. SELLERS

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Introduction and Historical

The literature reveals that very few optical data have been reported for the salts of strychnine. Some of these are reported by Groth¹ and Bolland² and include two of the refractive indices for the nitrate and the hydriodide and one for the sulfate. Several investigators have studied the optical properties of other alkaloids, usually the bases themselves. Wherry and Yanovsky³ made such measurements for the cinchona alkaloids. Other investigators along these lines include Kley,⁴ Wright,⁵ Wherry,⁶ and Keenan.⁷

¹ Groth, "Chemische Krystallographie," 1906-1919.

² Bolland, *Monatsh.*, 31, 387 (1910).

³ Wherry and Yanovsky, *THIS JOURNAL*, 40, 1063 (1918).

⁴ Kley, *Z. anal. Chem.*, 43, 160 (1904).

⁵ Wright, *THIS JOURNAL*, 38, 1647 (1916).

⁶ Wherry, *U. S. Dept. of Agric. Bull.*, 679 (1918).

⁷ Keenan, *J. Am. Pharm. Assoc.*, 16, 837 (1927).