preliminary calculations of Gulbransen and Robinson. The new S^0 values are in satisfactory agreement (0 to 5%) with limiting slopes calculated from the Debye–Hückel theory and Wyman's dielectric constant data.

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[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE DEPARTMENT OF SURGERY, COLLEGE OF PHYSICIANS AND SURGEONS, COLUMBIA UNIVERSITY]

On the Synthesis of Taurine

BY FRANK CORTESE

Thus far, the most practical synthesis of taurine is that of Marvel, Bailey and Sparberg,[1] who obtained it in over-all yields of 32 to 45% from ethylene bromide, sodium sulfite and ammonia. To the other methods summarized by these authors may be added the recently described procedure of Schoeberl,[2] who obtained taurine by oxidation of cystamine in yields of 40%.

The following is an adaptation of the method of Reychler,[3] who employed, however, a somewhat inconvenient procedure.

Experimental

β-Aminoethyl Bromide Hydrobromide.—This was prepared by Gabriel[4] by heating aminoethanol and fuming hydrobromic acid in a sealed tube at 170°. With certain precautions, the reaction may be effected at atmospheric pressure.

Ordinary 48% hydrobromic acid is distilled until 10 cc. of the distillate weighs at least 14.2 g. The relative narrowness of the boiling range is not a reliable indication of the strength of the acid. One hundred grams of colorless β-aminoethanol (b. p. 167–169° uncorr.) obtained by fractionation of commercial monoethanolamine (cork stoppers cannot be used) is slowly stirred into 700 cc. of ice cold redistilled 48% hydrobromic acid, ignoring the rise in temperature. The reaction mixture is distilled with the aid of porous plate and a Wurtz column until 185 cc. is collected. It is then gently refluxed, without reversing the condenser, for one hour, and then further distilled until another 70 cc. is collected. This procedure is repeated until further 60-, 30-, 25-, 15-, 10- and 5-cc. portions are obtained. Each fraction includes the amount of water distilled during both reflux and distillation periods. The mixture is finally refluxed for three hours. The process may be interrupted any time up to this point; 230 cc. of distillate is now collected, as crude hydrobromic acid. In all, the volume of distillate collected should not be less than 627 nor more than 633 cc. If less is distilled the yield is seriously impaired, if more, decomposition sets in, resulting in a worthless product.

Three hundred and thirty cubic centimeters of acetone is now thoroughly mixed with the residue in the flask, after it has cooled to about 70°. If necessary, crystallization should be induced by freezing and stirring. After remaining in the refrigerator overnight, the material is filtered by suction, washed well with acetone, air-dried until the odor of acetone just vanishes and stored in a desiccator. The colorless crystals weigh 230–240 g. The filtrate concentrated to 100 cc. on the steam-bath, seeded, etc., yields another 25–40 g.; a third somewhat colored crop may be obtained from the mother liquor by concentrating to a sirup on the steam-bath, seeding, etc. The total yield varies from 290 to 303 g., or 87–90%. The first two fractions are pure β-aminoethyl bromide hydrobromide, while the last contains 5–10% unchanged aminoethanol hydrobromide, as indicated by titration with standard silver nitrate. All three crops may be used without further purification for the preparation of taurine.

β-Aminoethyl bromide hydrobromide crystallizes from a mixture of 95% alcohol and ethyl acetate either in small pointed rhombohedra or in pearly leaflets; m. p. 174–175° (corr.) with discoloration (Gabriel,[4] 172.5–173.5°).

0.6453 g. in water consumed 31.47 cc. of 0.1 *N* silver nitrate, equivalent to 38.98% ionizable bromine. (Calcd. 39.00%.)

Taurine.—A solution of 205 g. (1 mol.) of β-aminoethylbromide hydrobromide and 277 g. (1.1 mol.) of crystalline sodium sulfite, or an equivalent quantity of the much cheaper exsiccated variety, in 800 cc. of water is concentrated on the steam-bath to a minimum volume (fifteen to twenty-four hours; small runs take much less time). Time may be saved by refluxing for three hours and evaporating under reduced pressure. The cold moist cake is mashed well in a mortar and then thoroughly stirred with 500 cc. of concentrated hydrochloric acid. The salt residue is filtered upon a thick asbestos mat on a Büchner funnel and washed with ten 50-cc. portions of concentrated acid. (The pump should be flushed well with water afterward.) The filtrate is mixed well, decanted from any salt, concentrated with the aid of an ebullition tube in a 2-liter beaker over a free flame to 200 cc. and then mixed, while still hot, with 800 cc. of 95% alcohol. After fifteen minutes the product is filtered, washed with alcohol, air-dried and recrystallized by dissolving in four times its weight of hot water and adding five volumes of 95% alcohol. The yield of colorless practically pure taurine will be 100–102 g., or 80%. A further 6 g. may be obtained by working up the last filtrate. The use of five mols of sulfite increases the yield of taurine to 91%, but it is more inconvenient to work up the salt cake.

Anal. Calcd. for $C_2H_7O_3NS$: S, 25.63. Found: S, 25.64.

Taurine decomposed at 300–305° (corr.) without melt-

(1) Marvel, Bailey and Sparberg, THIS JOURNAL, **49**, 1833 (1927).
(2) Schoeberl, *Z. physiol. Chem.*, **216**, 193 (1933).
(3) Reychler, *Bull. soc. chim. Belg.*, **32**, 247 (1923).
(4) Gabriel, *Ber.*, **50**, 826 (1917).

ing. N-Phenylcarbamyltaurine prepared according to Schoeberl[2] decomposed at 195–200° (corr.) without melting (Schoeberl, 195°).

Summary

Practical details have been described for convenient and inexpensive preparations of larger quantities of β-aminoethyl bromide hydrobromide and taurine in yields of 90 and 80%, respectively.

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[CONTRIBUTION FROM THE COBB CHEMICAL LABORATORY, UNIVERSITY OF VIRGINIA]

The Addition of Organomagnesium Halides to Pseudocodeine Types. I. Desoxycodeine-C[1]

BY LYNDON SMALL AND KECHEE C. YUEN

Thebaine reacts with phenylmagnesium bromide to give a phenolic base, phenyldihydrothebaine,[2] of uncertain structure. The location of the phenyl group is not known, nor is there evidence to show whether structural changes other than scission of the ether linkage have taken place. Phenyldihydrothebaine is of particular theoretical interest because it is remarkably indifferent to catalytic hydrogenation,[3] although its empirical formula indicates that two alicyclic double linkages must still be present. The recently described methyldihydropseudocodeinone[4] shows a similar inexplicable reluctance toward reduction, whether catalytic or by metal combinations.

In the belief that the ability of thebaine to react with organomagnesium halides depends upon the conjugation of the 6,7-double bond with the ether oxygen in a system resembling that of an α,β-unsaturated ketone,[5] we have undertaken a study of the parallel reaction of other bases containing this grouping. Desoxycodeine-C was chosen as the simplest available representative of the type; the extension of the study to the phenyldihydrothebaine problem will be described in other communications.

Desoxycodeine-C (II),[6] though containing no group obviously open to attack by Grignard's reagent, reacts with methylmagnesium iodide to yield a phenolic product, methyldihydrodesoxycodeine, differing in composition from the starting material by CH_4. The desoxycodeine methoxyl group is still present, and the appearance of the phenolic hydroxyl proves that the ether-linked oxygen of desoxycodeine-C is involved in the reaction. Only two modes of addition of RMgX to the system appear to come into question: a 1,4-addition, comparable to that observed with many α,β-unsaturated ketones, which would locate the entering methyl group at C-7 of the phenanthrene skeleton (III); or a 1,2-addition, facilitated by an activating influence of the double bond on the ether linkage similar to that which undoubtedly operates in certain reduction reactions. The 1,2-mechanism would locate the methyl group on C-5 (IV).[7]

A decision between the 5- and 7-positions must rest on degradation to known phenanthrene derivatives. Zinc-dust distillation of methyldihydrodesoxycodeine gave as the principal indifferent product a colorless liquid, the picrate of which could be separated into two apparently homogeneous fractions. One of these had the melting point of 2-(or 7)-methylphenanthrene picrate, the other that of 4-(or 5)-methylphenanthrene picrate.[8] Both of these gave melting-point depressions with authentic samples generously supplied by Dr. Haworth, and may be products of incomplete

(1) The work reported in this paper is part of a unification of effort by a number of agencies having responsibility for the solution of the problem of drug addiction. The organizations taking part are: The Rockefeller Foundation, the National Research Council, the U. S. Public Health Service, the U. S. Bureau of Narcotics, the University of Virginia and the University of Michigan.

(2) Freund, *Ber.*, **38**, 3284 (1905); Freund and Speyer, *ibid.*, **49**, 1287 (1916); German Patent 181,510 (1907), also mentions the reaction of benzylmagnesium chloride.

(3) Hoek, Dissertation, Munich, 1926; verified in this Laboratory.

(4) Lutz and Small, THIS JOURNAL, **57**, 2651 (1935).

(5) Bases of the morphine series having the alicyclic unsaturation in the 7,8-position, for example codeine methyl ether, are unaffected by prolonged treatment with methylmagnesium iodide.

(6) Small and Cohen, THIS JOURNAL, **53**, 2214 (1931); Small and Morris, *ibid.*, **55**, 2874 (1933).

(7) In contrast to thebaine and other unsaturated morphine bases, phenyldihydrothebaine shows no tendency to lose the entire ethanamine side chain in degradation reactions; to account for this, it has been suggested that the phenyl group may occupy a position such that it blocks aromatization (*i. e.*, C-14) (Small and Lutz, "Chemistry of the Opium Alkaloids," p. 333). Unless a 1,6-addition of RMgX to thebaine be conceded, a reaction mechanism leading to such a result is not obvious, and in the case of desoxycodeine-C can scarcely be considered.

(8) Haworth, *J. Chem. Soc.*, 1125 (1932).