

XL.—*Derivatives of Taurine.* Part I.

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Action of Primary, Secondary, and Tertiary Monamines on their respective Salts of β -Chlorethylsulphonic Acid.

TAURINE was synthesised by Kolbe in 1863, by heating either the silver or ammonium salt of β -chlorethylsulphonic acid with excess of ammonia. Some years later, Dittrich succeeded in preparing methyltaurine from the methylamine salt of the above acid and excess of methylamine (*J. pr. Chem.* [2], 18).

Since it has been shown that the necessary chlorethylsulphonic acid may be readily obtained by oxidation of ethylene chlorothiocyanate (Trans., 1879, 806), a further study of the derivatives of so interesting a body as taurine seemed desirable.

Taurine, which from its synthetical formation is β -amidoethylsulphonic acid, $\text{NH}_2\cdot\text{CH}_2\cdot\text{CH}_2\cdot\text{SO}_3\text{H}$, is the most important sulphonic analogue of glycocine (amidoacetic acid), and as di-substituted amidoacetic acids are not known in the free state, but only in combination with HI or HCl (Kraut and Hartmann, *Annalen*, 133, 103), the preparation of a dimethyltaurine or diethyltaurine would have more than ordinary interest. The preparation of a trimethyl-derivative of taurine also offered considerable attraction, as by its reactions some insight would probably be obtained as to its constitution, *i.e.*, whether it should be regarded as the methyl ether of dimethyltaurine,

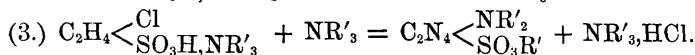
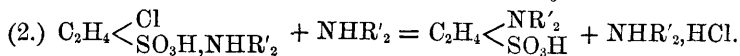
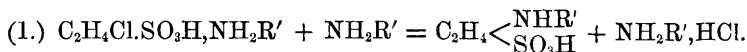
$\text{NMe}_2\cdot\text{C}_2\text{H}_4\cdot\text{SO}_2\cdot\text{OMe}$, or a body of the formula $\begin{array}{c} \text{CH}_2\cdot\text{NMe}_3 \\ | \\ \text{CH}_2-\text{SO}_2 \end{array} \text{O}$. I hope to discuss this in a future communication.

I have investigated the action of mono-, di-, and tri-amines on their respective salts of β -chlorethylsulphonic acid, with most satisfactory results.

General Method for the Preparation of Mono-, Di-, and Tri-substituted Taurines.

The following experiments will show that mono-, di-, and tri-substituted taurines with monad positive radicles can be readily prepared by means of a general method, and as it will considerably curtail subsequent description I will describe it before giving the experimental details.

It consists in heating the amine salt of β -chlorethylsulphonic acid with the necessary quantity of amine in a closed tube for 10 hours at a temperature of 160° , when the following general reactions take place:—



In the case of mono- and di-substituted taurines, excess of barium hydroxide is added to decompose the hydrochloride, and the liberated amine distilled off in a current of steam, after which the mixture is poured into the calculated quantity of boiling dilute sulphuric acid. On filtering, and evaporating the liquid repeatedly with addition of water until all hydrochloric acid is removed, the substituted taurine is obtained in the crude state, and may be purified by crystallisation from water or alcohol as the case may be.

The trimethyl-derivative is easily decomposed by alkalis, and another method has to be employed for removing the trimethylamine hydrochloride.

Ethyltaurine, $\text{NHEt}.\text{C}_2\text{H}_4.\text{SO}_3\text{H}.$

10 grams of ethylamine in 33 per cent. aqueous solution were neutralised with a dilute solution of β -chlorethylsulphonic acid prepared from its lead salt with sulphuretted hydrogen. After filtering from a small quantity of lead hydroxide (see p. 366), the liquid was evaporated to a syrup; on cooling, this set to a mass of silky needles, which are extremely deliquescent.

20 grams of the salt were then treated as described under the general method with 5 grams of ethylamine 33 per cent. solution in water. The crude ethyltaurine is exceedingly difficult to purify, the sulphur estimation giving too high, and the nitrogen too low a result. By pouring absolute alcohol on the surface of its aqueous solution evaporated to a syrupy consistency, it may be obtained in the crystalline state. A sample which had been crystallised four times gave the following numbers on analysis, after drying at 110° :—

- I. 0.102 gram substance gave 0.0601 gram Pt.
 II. 0.214 ,, ,, 0.3290 ,, BaSO₄.

	Calculated for $\text{NH}(\text{C}_2\text{H}_5).\text{C}_2\text{H}_4.\text{SO}_3\text{H}.$	Found.	
		I.	II.
N	9.15	8.67	—
S	20.91	—	21.02

Ethyltaurine crystallises from water in fine prisms (rhombic?), but contains no water in combination. It has a bitter sooty taste; melts at 147° . Its aqueous solution has an acid reaction.

A specimen of ethyltaurine was also prepared from the silver salt of chlorethylsulphonic acid and excess of ethylamine. The yield is poor, and ethylamine hydrochloride and metallic silver are produced, which necessitates the ultimate use of barium hydroxide.

Allyltaurine, $\text{NH}(\text{C}_3\text{H}_5).\text{C}_2\text{H}_4.\text{SO}_3\text{H}$.

10 grams of the allylamine salt, which is deliquescent, were treated with the calculated quantity of an aqueous solution of allylamine. The crude allyltaurine was well ground in a mortar with cold strong alcohol, which removes nearly all the brown colouring matter, leaving a white residue. This was dissolved in boiling 90 per cent. alcohol, and, on cooling, the solution deposited fine long prisms. Two sulphur estimations showed that these were not yet pure (III). They were therefore crystallised three times from strong alcohol, and dried at 110° , when the following analytical results were obtained:—

- I. 0.2171 gram substance burnt with CuO , PbCrO_4 , and Cu gave 0.1310 gram H_2O and 0.2886 gram CO_2 .
 II. 0.2210 gram substance by soda-lime method gave 0.1300 gram Pt .

Calculated for $\text{C}_3\text{H}_5.\text{HN}.\text{C}_2\text{H}_4.\text{SO}_3\text{H}$.		Found.		
		I.	II.	III.
C	36.4	36.2	—	—
H	6.7	6.7	—	—
N	8.5	—	8.4	—
S	19.3	—	—	20.1; 20.1
O	29.1	—	—	—
<hr/> 100.0				

Allyltaurine is very easily soluble in water, but only sparingly in strong alcohol. It crystallises from alcohol in beautiful rhombic prisms. It melts at 190 – 195° , and has a slightly bitter taste. Its reaction with litmus is acid.

Phenyltaurine, $\text{NHPh}.\text{C}_2\text{H}_4.\text{SO}_3\text{H}$.

The phenylamine salt of β -chlorethylsulphonic acid was readily prepared by acting on the acid with excess of aniline, which excess was afterwards removed in a current of steam. It crystallises from water in large colourless needles, which on exposure to air do not deliquesce, but become of a fine pink colour.

20 grams of this salt were heated in sealed tubes with 8 grams of aniline and a little water. The crude phenyltaurine finally obtained after several crystallisations from water was air-dried and analysed.

- I. 0.2216 gram burnt with CuO , PbCrO_4 , and Cu produced 0.1153 gram H_2O and 0.3864 gram CO_2 .
 II. 0.1704 gram fused with KHO and KNO_3 gave 0.202 gram BaSO_4 .

	Calculated for $\text{C}_6\text{H}_5\cdot\text{HN}\cdot\text{C}_2\text{H}_4\cdot\text{SO}_3\text{H}$.	Found.	
		I.	II.
C	47.7	47.5	—
H	5.5	5.7	—
S	15.9	—	16.2

Phenyltaurine is moderately soluble in water, the solution becoming red. It crystallises from water in beautiful thin silky leaves without water of crystallisation. It is sparingly soluble in strong alcohol, and, on cooling, separates in microscopic crystals, apparently rhombic prisms. It has a strongly acid reaction and taste, and dissolves copper hydroxide easily. It melts with decomposition at 277 — 280° . Its aqueous solution gives an intense violet coloration with a solution of bleaching powder, even when very dilute. Ferric chloride produces no marked colour until warmed; the liquid then becomes green, gradually turning to indigo-blue. An attempt to prepare a nitroso-derivative gave an unsatisfactory result.

Phenyltaurine is also easily prepared by heating aniline chlorethylsulphonate with aniline under the ordinary pressure.

Dimethyltaurine, $\text{NMe}_2\cdot\text{C}_2\text{H}_4\cdot\text{SO}_3\text{H}$.

Dimethylamine chlorethylsulphonate is difficult to crystallise, and forms an extremely deliquescent mass of silky needles. 20 grams of the salt were acted on with 5 grams of aqueous dimethylamine 33 per cent. solution. The crude dimethyltaurine was dissolved in water, and after evaporating to a syrup, placed in a desiccator. In a few days, a large quantity of fine but indistinct crystals had formed, which after separation from the mother-liquor were redissolved in water and treated as above. In a short time, several large rhombic tables had formed, which were dried by pressing between filter-paper, and submitted to analysis.

- I. 0.4145 gram substance lost 0.0440 gram H_2O over sulphuric acid; at 100 — 110° the weight did not alter.
 II. 0.2806 gram similarly treated lost 0.0296 gram H_2O .

Calculated for		Found.	
$(\text{CH}_3)_2\text{N.C}_2\text{N}_4.\text{SO}_3\text{H} + \text{H}_2\text{O}.$		I.	II.
H_2O	10.5	10.6	10.5

III. 0.2168 gram dry substance on combustion with CuO , PbCrO_4 , and Cu gave 0.1448 gram H_2O and 0.2481 gram CO_2 .

IV. 0.3385 gram dry substance after fusion with KHO and KNO_3 produced 0.5220 gram BaSO_4 .

Calculated for		Found.	
$(\text{CH}_3)_2\text{N.C}_2\text{H}_4.\text{SO}_3\text{H}.$		III.	IV.
C	31.4	31.2	—
H	7.1	7.4	—
S	20.9	—	21.1

Dimethyltaurine is very easily soluble in water, from which it may be crystallised in large rhombic (oblique?) tables containing 1 mol. water, which is completely removed by standing over concentrated sulphuric acid or by dissolving in strong alcohol. It crystallises from the alcoholic solution in snow-like tufts of needles. It is insoluble in ether, and does not deliquesce in air. Dimethyltaurine has a peculiar, not unpleasant taste, which is not at all bitter. It does not melt, but from 270 — 280° becomes dark coloured, and finally decomposes. It has an acid reaction.

Dimethyltaurine forms no combination with hydrochloric acid or platinum tetrachloride. It combines with a molecule of cyanamide, forming dimethyltaurocyamine, which will be described later on.

Diethyltaurine, $\text{NEt}_2.\text{C}_2\text{H}_4.\text{SO}_3\text{H}.$

The diethylamine salt of chlorethylsulphonic acid forms a gelatinous mass of laminæ, which is very deliquescent. The crude dimethyltaurine could not be crystallised from water, owing to extreme solubility—on standing over sulphuric acid it set to a crystalline mass. This was boiled with absolute alcohol, which dissolved it, and from this solution it was obtained in fine rhombic tables. After three crystallisations, a sample was dried at 100° and analysed:—

I. 0.1710 gram substance gave 11.8 c.c. moist nitrogen at 15° and 767.7 mm.

II. 0.2210 gram gave 0.2925 gram BaSO_4 .

Calculated for		Found.	
$(\text{C}_2\text{H}_5)_2\text{N.C}_2\text{H}_4.\text{SO}_3\text{H}.$		I.	II.
N	7.7	8.0	—
S	17.7	—	18.1

Diethyltaurine, although very easily soluble in water, is not deliquescent. It has a somewhat bitter taste, and melts at 151° . Its reaction is acid.

Methylphenyltaurine, $\text{NMePh.C}_2\text{H}_4.\text{SO}_3\text{H}$.

The methylphenylamine salt of chlorethylsulphonic acid forms a thick syrup with water, and does not appear to crystallise.

Methylphenyltaurine is very difficult to crystallise from water. The syrupy aqueous solution was treated with hot 98 per cent. alcohol, and from this solution it was obtained in silky, indistinct crystals on cooling. A sample which had been twice recrystallised gave the following result on analysis, after drying between filter-paper:—

- I. 0.2410 gram substance gave 13.25 c.c. moist nitrogen at 15° and 767.7 mm.
 II. 0.0913 gram produced 0.1017 gram BaSO_4 .

	Calculated for $\text{CH}_3.(\text{C}_6\text{H}_5)\text{N.C}_2\text{H}_4.\text{SO}_3\text{H}$.	Found.	
		I.	II.
N	6.5	6.4	—
S	14.9	—	15.2

Methylphenyltaurine has a very decided acid reaction and taste. Its alcoholic solution becomes violet-coloured. With bleaching powder solution it gives a green, and then a rich blue coloration. Ferric chloride produces no colour until warmed, the liquid then acquires a beautiful green tint.

Trimethyltaurine, $\text{NMe}_2.\text{C}_2\text{H}_4.\text{SO}_3\text{CH}_3$ (?).

The trimethylamine salt of chlorethylsulphonic acid after standing some time over sulphuric acid sets to a compact mass of silky, extremely deliquescent needles.

16 grams of this salt were heated in a sealed tube at 160° for 10 hours, with 20 c.c. of a 25 per cent. solution of trimethylamine in absolute alcohol. On cooling, a quantity of a crystalline substance separated out, which was obviously not the trimethylamine salt. A few preliminary experiments showed that these crystals were insoluble in absolute alcohol, whereas the mother-liquor, which indicated a quantity of chlorine when tested with silver nitrate, was dissolved. The substance insoluble in alcohol contained no chlorine. The whole mass was now digested with absolute alcohol two or three times, until no chlorine could be detected in the alcoholic liquid. The residue was then dissolved in hot water. This solution soon deposited

beautiful crystals, which proved to be pure trimethyltaurine, as the following analyses of the air-dried substance testify.

- I. 0.2006 gram substance on combustion with CuO , PbCrO_4 , and Cu gave 0.1432 gram H_2O , and 0.2628 gram CO_2 .
- II. 0.2920 gram burnt with CuO and copper gauze, with sodium hydrogen carbonate gave 22 c.c. moist nitrogen at 16° and 758.5 mm.

These results worked into percentages agree with the formula for trimethyltaurine:—

	Calculated for $(\text{CH}_3)_2\text{N}.\text{C}_2\text{H}_4.\text{SO}_3\text{CH}_3.$	Found.	
		I.	II.
C	35.9	35.7	—
H	7.8	7.9	—
N	8.4	—	8.6

Trimethyltaurine is easily soluble in water, from which it crystallises in fine rhombic (oblique?) prisms without water of crystallisation. In absolute alcohol and ether, it is insoluble. Strong alcohol precipitates it from its aqueous solution in fine slender tables. It undergoes no change below 300° . It has a sweet, cooling taste, and has a *neutral* reaction. It is decomposed by dilute alkalis, with evolution of trimethylamine. I hope shortly to investigate this reaction carefully, and also to study its action with cyanamide.

Phenyltaurine and Cyanamide. Formation of Phenyltaurocyamine.

Engel has shown that taurine combines with cyanamide, forming a body which he named tauroglycoeyamine, from its analogy to glycoeyamine (*Ber.*, 8, 1597), and Dittrich, who also prepared this compound without being aware of Engel's work, called it taurocyamine; he also made methyltaurocyamine (*J. pr. Chem.* [2], 18) analogous to sarcosine.

It appeared interesting to ascertain whether phenyltaurine and, say, dimethyltaurine, also united with cyanamide.

Two grams of pure phenyltaurine were dissolved in luke-warm water, and 0.4 gram cyanamide added, the mixture was then heated for five hours at 100 — 110° in a sealed tube. Nothing had crystallised in the tube; on opening it, however, crystals soon began to form, identical in appearance with phenyltaurine. They were washed once or twice with cold water and dried in air. They gave no violet coloration with bleaching powder solution, therefore the substance could not be unaltered phenyltaurine.

On analysis, the following numbers were obtained, which agree with the formula for phenyltaurocyamine:—

- I. 0.1694 gram substance gave 0.0860 gram H_2O and 0.2770 gram CO_2 .
 II. 0.2061 gram gave 30.4 c.c. moist nitrogen at 15° and 767.7 mm.

	Calculated for $\text{C}_6\text{H}_5(\text{CNNH}_2)\text{HN.C}_2\text{H}_4.\text{SO}_3\text{H}$.	Found.	
		I.	II.
C	44.4	44.6	—
H	5.3	5.6	—
N	17.3	—	17.2

Phenyltaurocyamine crystallises from water in glistening leaves, which contain no water of crystallisation. It has no characteristic taste, and is neutral to litmus. It does not melt at 300° , but becomes brown and decomposes at a somewhat higher temperature.

Dimethyltaurine and Cyanamide. Formation of Dimethyltaurocyamine.

1.5 gram of pure dimethyltaurine was dissolved in water, 0.36 gram cyanamide added, and the mixture heated at 100 — 110° in a closed tube. The liquid, which was perfectly clear, was evaporated to a syrup; on standing for a few days, it set to a semi-solid mass of hard indistinct crystals. These were well pressed between filter-paper, and submitted to analysis with this result:—

- I. 0.5126 gram substance lost 0.0456 gram H_2O , by standing over H_2SO_4 .
 II. 0.1702 gram dry substance on combustion gave 0.1058 gram H_2O and 0.1929 gram CO_2 .
 III. 0.1324 gram dry substance produced 25.2 c.c. moist nitrogen at 16° and 758.5 mm.

	Calculated for $(\text{CH}_3)_2(\text{CNNH}_2)\text{N.C}_2\text{H}_4.\text{SO}_3\text{H} + \text{H}_2\text{O}$.	Found.
H_2O	8.45	8.9

In dry substance :—

		II.	III.
C	30.8	30.9	—
H	6.7	6.9	—
N	21.5	—	21.7

Dimethyltaurocyamine is very easily soluble in water, and insoluble in absolute alcohol and ether. It has a slightly bitter taste. It melts with decomposition at 245° . Its reaction is slightly acid.

General Remarks.

The solubility and melting points of some of the above substances, as well as their reactions with litmus, are worthy of note.

Methyltaurine is insoluble in alcohol: dimethyltaurine is moderately soluble in alcohol, by analogy one would suppose that trimethyltaurine would be more easily dissolved by this liquid; it is, however, insoluble. All three dissolve easily in water.

From the above, it would appear probable that the melting points of these substances would show some anomaly, but this is not the case. Methyltaurine melts at 241° , dimethyltaurine decomposes without melting near 275° , and trimethyltaurine is unaltered at 300° . Mono- and di-substituted taurines have an acid reaction, trimethyltaurine is neutral to litmus.

In no case could salts be obtained from mono- or di-substituted taurines and hydrochloric acid, neither could any crystallised combination with platinum tetrachloride be formed. In these reactions, these derivatives of amido-isethionic acid are sharply distinguished from their carboxyl homologues, amido-acetic and amido-propionic acids.

The yield of crude product is in all cases nearly the theoretical, this also holds for the cyanamide compounds. Dittrich recommends a large excess of methylamine in preparing methyltaurine from the corresponding salt; he says, indeed, that it is absolutely necessary for its formation. I have found, on the contrary, that an excess is altogether unnecessary if the amine salt of β -chloroethylsulphonic acid be employed, the calculated quantity producing nearly the theoretical yield of the substituted taurine. When the silver or lead salt of the acid is used, an excess of amine *is necessary*—a proof that these salts are converted into the amine salts before the final reaction takes place.
