CCIII.—*The Reduction Products of Certain Cyclic Methyleneamines.*

By John Graymore.

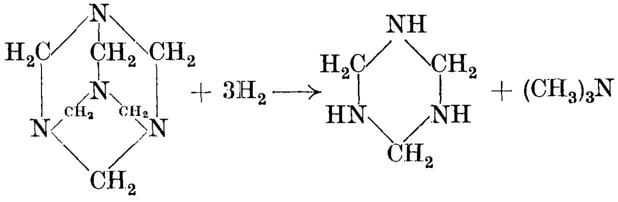
The cyclic methyleneamines used in this investigation are those resulting from the condensation of formaldehyde with ammonia and the monoalkylamines.

The reduction of hexamethylenetetramine with zinc in acid solution is stated by Trillat and Fayollat (*Compt. rend.*, 1893, **117**, 628) to give ammonia and methylamine and by Delépine (*Bull. Soc. chim.*, 1895, **13**, 136) to give ammonia and trimethylamine. It therefore seemed profitable to re-explore this field and to examine the allied compounds, the trialkyltrimethylenetriamines.

Hexamethylenetetramine, heated under reflux with an excess of hydrochloric acid, decomposed with production of formaldehyde and the hydrochlorides of ammonia and methylamine. The hydrochlorides were obtained in relatively small yield, increasing with the time of reaction. No trimethylamine could be detected.

On the other hand, hexamethylenetetramine, reduced with zinc dust in presence of an excess of hydrochloric acid, gave ammonia and trimethylamine as main products. Where the reduction was allowed to proceed slowly, or under reflux, a varying quantity of methylamine was also obtained, with in some cases a little dimethylamine.

It seems probable, therefore, that the reduction of hexa methylenetetramine with zinc dust in acid solution proceeds as follows,



trimethylenetriamine and trimethylamine being the initial products. The unstable cyclic compound would then break to give ammonia and formaldehyde in equilibrium with methyleneimine and water :

$$CH_2O + NH_3 \rightleftarrows CH_2{:}NH + H_2O.$$

Reduction of methyleneimine by formaldehyde or by zinc and hydrochloric acid would yield methylamine with a small amount of dimethylamine (compare Werner, J., 1917, **111**, 844).

In order to discover whether any of the amines resulted from the interaction of the liberated formaldehyde with the hexamethylenetetramine remaining, the latter substance in the form of its picrate was heated with formaldehyde in alcoholic solution. Dimethylpentamethylenetetramine picrate resulted. Formaldehyde did not appear to react further with this compound, as might be expected (compare Knudsen, *Ber.*, 1914, **47**, 2694).

The trialkyltrimethylenetriamines of general formula $(\cdot CH_2\cdot NR\cdot)_3$ were prepared directly by treating the primary amine either in the anhydrous state or in aqueous solution with a 40% solution of formaldehyde, with subsequent separation of the base by dehydration over caustic potash.

Reduction by means of zinc dust and hydrochloric acid gave in each case the corresponding secondary methylalkylamine as a main product together with a small proportion of the primary alkylamine, the proportion of the latter decreasing with increasing molecular weight. This would seem to indicate the greater stability of the higher alkylmethyleneimines.

The results suggest that reduction is brought about in the following manner,

$$(\cdot CH_2\cdot NMe\cdot)_3 \longrightarrow 3CH_2{:}NMe \xrightarrow{3H_2} 3CH_3\cdot NHMe$$

methylenealkylamine, $CH_2{:}NR$, being first of all produced. Decomposition of a portion of this would give the primary amine and formaldehyde.

Heated with hydrochloric acid alone, the cyclic bases break to give the corresponding primary amine together with formaldehyde.

In common with the trimethyl and the triethyl derivative, tripropyltrimethylenetriamine exhibits a strong solvent action on uric acid, and also forms additive compounds with bromine and iodine.

The reduction of these compounds appears comparable with the reduction of similar compounds of the type R·CH:NR obtained from the condensation of the higher aldehydes with alkylamines (Stoermer and Lepel, *Ber.*, 1896, **29**, 2110).

Since the reaction would appear capable of general application, the preparation of other cyclic trialkyltrimethylenetriamines is being attempted with a view to the study of their reduction compounds.

EXPERIMENTAL.

Reduction of Hexamethylenetetramine.—Hexamethylenetetramine (20 g.) in cold aqueous solution was treated with zinc dust (60 g.), and cooled in ice while hydrochloric acid in slight excess of the calculated quantity (250 c.c.; *d* 1·16) was added slowly with shaking, continued for ½ hour. The mixture was then warmed slowly and finally boiled for 1 hour until the odour of formaldehyde had disappeared. An excess of caustic soda having been added, a mixture of ammonia and amines was distilled into hydrochloric acid. The hydrochlorides obtained from this solution, after removal of the bulk of the ammonium chloride by extraction with alcohol, were estimated by the method of Bertheaumé, the mean of several estimations being 8 g. of trimethylamine hydrochloride, 6 g. of methylamine hydrochloride, 20 g. of ammonium chloride, and a trace of dimethylamine hydrochloride.

Hexamethylenetetramine Picrate.—This was obtained from its components in alcoholic solution or, better, by the addition of formaldehyde to concentrated ammonia solution in the presence of alcoholic picric acid. It crystallised in long yellow needles, m. p. 179° (decomp.) (Found : C, 39·0; H, 4·0. Calc. for $C_{12}H_{15}O_7N_7$: C, 39·0; H, 4·1%).

Action of Formaldehyde on Hexamethylenetetramine Picrate.—The picrate (5 g.) was dissolved in warm alcohol, an excess of formaldehyde solution (40%) added, and the mixture heated on a water-bath for ½ hour; reddish crystals then began to separate. On cooling, dimethylpentamethylenetetramine picrate (5 g.) separated in deep orange-red needles, m. p. 196° (decomp.) (Found : C, 40·5; H, 4·9. Calc. for $C_7H_{16}N_4,C_6H_3O_7N_3$: C, 40·5; H, 4·9%).

Reduction of Trimethyltrimethylenetriamine.—The base was prepared by the slow addition to an ice-cold solution of methylamine (100 pts. of 33%) of an ice-cold solution of formaldehyde (70 pts. of 40%). It separated as an oily upper layer on addition of stick potash, the solution being cooled in ice. After 48 hours the layer was removed and distilled (b. p. 166°) over barium oxide. Yield, 80% of the theoretical.

A solution of the base in water (20 g. in 200 c.c.) was cooled, zinc dust (35 g.) added, followed by hydrochloric acid (160 c.c.; *d* 1·16), added slowly with cooling. The mixture was shaken at room temperature for ½ hour, heated gradually with continuous shaking to boiling (1 hour), boiled for ½ hour until no further formaldehyde was evolved, and then cooled and separated from undissolved zinc. The mixture of amines was isolated as crystalline hydrochlorides, which were estimated by Bertheaumé's method. The yield of dimethylamine hydrochloride was 24 g., and of methylamine hydrochloride 10 g.

Reduction of Triethyltrimethylenetriamine.—The base was prepared in 90% yield by the method described above, a 33% solution of ethylamine being used. It was reduced and the reduction products were collected in hydrochloric acid as before. Hardly any formaldehyde was perceptible. The amines were liberated by addition of caustic soda to the solution cooled in a freezing mixture. Separated, and distilled over barium oxide, they gave a little methylamine, b. p. 18°, followed by a good yield (80% of the theoretical) of methylethylamine, b. p. 35° (platinochloride, m. p. 208°). The *picrate* crystallised from alcohol in yellow needles, m. p. 196°, soluble in acetone and chloroform and insoluble in ether (Found: C, 37·4; H, 4·15. $C_3H_9N,C_6H_3O_7N_3$ requires C, 37·5; H, 4·1%).

Preparation of Tripropyltrimethylenetriamine.—The base was prepared by the gradual addition of an ice-cold solution of formaldehyde (25 g. of 40% solution) to anhydrous propylamine (20 g.) cooled in a freezing mixture; it immediately began separating as an upper layer, considerable heat being developed. The base was also prepared from paraformaldehyde and anhydrous propylamine, the reaction being started by gentle warming, but the yield was much lower. The cyclic compound, the separation of which was completed by addition of stick potash, was distilled over barium oxide and obtained in theoretical yield (23 g.).

Tripropyltrimethylenetriamine urate dissolves in 8 parts of water at 15°. It is an amorphous powder which decomposes without melting when heated [Found: C, 53·5; H, 8·1. $(C_3H_7{\cdot}N{\cdot}CH_2{\cdot})_3,C_5H_4O_3N_4$ requires C, 53·5; H, 8·1%].

Tripropyltrimethylenetriamine di-iodide was obtained when a solution of the base in chloroform was added drop by drop to a saturated solution of iodine in chloroform until the colour just disappeared. Evaporation yielded colourless needles, m. p. 85° [Found: I, 54·3. $(C_3H_7{\cdot}N{\cdot}CH_2{\cdot})_3I_2$ requires I, 54·4%]. Excess of iodine produces a dark red oil of variable composition.

Tripropyltrimethylenetriamine dibromide was obtained when a solution of bromine in carbon disulphide was added gradually to a solution of the base in the same solvent. The orange-red oil which immediately separated was repeatedly washed with carbon disulphide to remove uncombined bromine. It could not be induced to crystallise [Found: Br, 42·8. $(C_3H_7{\cdot}N{\cdot}CH_2{\cdot})_3Br_2$ requires Br, 42·8%].

Reduction of Tripropyltrimethylenetriamine.—No propylamine was obtained. The base yields an almost theoretical quantity of methylpropylamine, m. p. 62—64°, identified by conversion into the nitrosoamine, b. p. 175° (*Ber.*, 1896, **29**, 2110), and platinochloride, m. p. 200—202° (decomp.).

Methylpropylamine picrate, obtained by the addition of picric acid to the base in dry ether, crystallised slowly from a syrup after removal of the ether, in squat needles, m. p. 43°, soluble in alcohol, acetone and water (Found: C, 39·7; H, 4·6. $C_4H_{11}N,C_6H_3O_7N_3$ requires C, 39·7; H, 4·6%).

Methylpropylamine oxalate, prepared by adding an alcoholic solution of oxalic acid to the anhydrous base, separated in pearly flakes, m. p. 155° (Found: C, 44·2; H, 7·95. $C_4H_{11}N,C_2H_2O_4$ requires C, 44·2; H, 8·0%).

Methylpropylamine hydrochloride, prepared in dry ether, crystallised in deliquescent plates, m. p. 140° (Found: Cl, 32·4. $C_4H_{11}N,HCl$ requires Cl, 32·4%).

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