417. *Quaternary Ammonium Salts. Part II.* A Novel Feature associated with Decomposition of Some Quaternary Ammonium Salts.*

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4-Carboxy-2-nitrophenyltrimethylammonium salts are prepared by oxidation, etc., of 4-formyl-2-nitrophenyltrimethylammonium chloride. In these nitro-compounds decomposition with alcoholic sodium alkoxides affects the nitro- before the quaternary ammonium group. Further, *p*-formylphenyltrimethylammonium chloride or iodide partly undergoes Cannizzaro's reaction with sodium ethoxide or *n*-propoxide. *p*-Dimethylaminobenzaldehyde is reduced to the alcohol by sodium ethoxide or *n*-propoxide, but with the latter it also undergoes Cannizzaro's reaction to a very small extent.

The present investigation concerns ammonium salts in which (i) alcoholic sodium alkoxides cause reaction primarily at a group (*e.g.*, NO_2 or CHO) other than the quaternary group and (ii), in some cases, the stability is enhanced by the presence of a formyl or carboxyl group in a phenyl nucleus with an *o*-nitro-group (cf. Zaki and Fahim, *J.*, 1942, 271; Fahim and Galabi, *J.*, 1950, 3529).

Zaki and Tadros (*J.*, 1941, 562) reported failure to prepare quaternary salts from 4-dimethylamino-3-nitrobenzoic acid. These have now been obtained by oxidation of 4-formyl-2-nitrophenyltrimethylammonium chloride. The quaternary salt was formed from the aldehyde and methyl sulphate with great vigour at 135°, and moderation of the reaction by cooling or dilution with excess of methyl sulphate or, best, nitrobenzene was necessary. Attempts to prepare quaternary salts from the acid or its ester in nitrobenzene at 140—145° gave only the ester, and at higher temperatures decomposition occurred.

p-Formylphenyltrimethylammonium chloride was shown by Zaki and Tadros (*J.*, 1941, 350) to afford with ethanolic sodium ethoxide *p*-ethoxybenzaldehyde, *p*-dimethylaminobenzaldehyde, and a trace of *p*-dimethylaminobenzoic acid. We now find, by use of sodium ethoxide or *n*-propoxide, that Cannizzaro's reaction to some extent precedes degradation of the quaternary salt, for the products include *p*-dimethylamino-benzyl alcohol and -benzoic acid as well as the alkoxybenzaldehyde; some dimethylaminobenzaldehyde is also formed and its origin is being investigated (cf. Smith and Welch, *J.*, 1934, 730).

p-Dimethylaminobenzaldehyde is merely partly reduced to the alcohol by sodium ethoxide under our conditions (cf. Braun and Kruber, *Ber.*, 1912, **45**, 2977; cf. Clemo and Smith, *J.*, 1928, 2423), but with sodium *n*-propoxide the Cannizzaro reaction probably occurs also to some extent, a small quantity of *p*-dimethylaminobenzoic acid being isolated in addition to the main product, the alcohol.

Our findings are thus that *p*-dimethylaminobenzaldehyde undergoes Cannizzaro's reaction less readily than its quaternary salts, but that this reaction in both cases occurs at temperatures leading to degradation at the quaternary nitrogen atom. Further work is in progress. It may be noted that Alexander (*J. Amer. Chem. Soc.*, 1948, **70**, 2592) reported a Cannizzaro reaction with the methiodide of α-dimethylamino*iso*butaldehyde.

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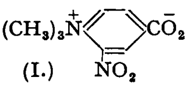
* Part I, *J.*, 1949, 3337.

Sodium 4-dimethylamino-3-nitrobenzoate is unaffected by boiling methanolic sodium methoxide, but the methochloride or methobromide of the acid yields 5 : 5′-dicarboxy-2 : 2′-bisdimethylaminoazoxybenzene. [Attempts to prepare this azoxy-compound by Nisbet's (*J.*, 1927, 2081) or by de Kiewiet and Stephen's method (*J.*, 1931, 82) failed, and dextrose in alkaline solution (Vogel, " A Textbook of Practical Organic Chemistry," Longmans, Green and Co., London, 1948, p. 604) reduced the nitro-acid to the amino-acid.] 4-Dimethylamino-3-nitrobenzaldehyde and sodium methoxide gave the acid and a basic oil (possibly the amino-alcohol), but the methochloride of the aldehyde afforded an amorphous orange product, m. p. 332—334° (decomp.), probably a mixture but containing the intact Ar·NMe$_2$ group. The aldehyde and acid metho-salts thus afford further examples of reaction at the nitro-group preceding that at the quaternary ammonium group.

It is noteworthy that, whereas 4-carboxy-2-nitrophenyltrimethylammonium bromide and iodide are stable, like *p*-carboxyphenyltrimethylammonium chloride (Zaki and Tadros, *loc. cit.*), the corresponding chloride is unstable, gradually changing into the corresponding betaine (I). This is also readily obtained by the oxidation of 4-formyl-2-nitrophenyltrimethylammonium chloride with hydrogen peroxide.


(I.)

EXPERIMENTAL.

M. p.s are uncorrected. Microanalysis was by Drs. Weiler and Strauss (Oxford).

4-Formyl-2-nitrophenyltrimethylammonium methosulphate was not isolated; it was converted directly into the corresponding picrate.

4-*Formyl*-2-*nitrophenyltrimethylammonium Salts and their Derivatives.*—(*a*) When a mixture of 4-dimethylamino-3-nitrobenzaldehyde (20 g., 1 mol.) and methyl sulphate (13 g., 1 mol.) was heated in an oil-bath, a reaction started at 135° and at 140° a violent explosion took place. (*b*) A mixture of the aldehyde (20 g., 1 mol.) and methyl sulphate (52 g., 4 mols.) was heated in an oil-bath; a vigorous reaction started at 135° and then subsided after a few minutes. Raising the temperature above 140° caused charring. (*c*) The aldehyde (5 g., 1 mol.) and methyl sulphate (8 g., 2·5 mols.) in xylene (15 c.c.) were heated at 140°. A black material separated. The xylene solution was decanted and the residue was washed twice with a few c.c. of xylene. The yield of picrate in (*b*) and (*c*) was poor. (*d*) The aldehyde (20 g., 1 mol.) and methyl sulphate (26 g., 2 mols.) in nitrobenzene (90 c.c.) were heated in an oil-bath. Reaction started at 140°, becoming very vigorous at 147—148° but subsiding after 20 minutes. The mixture was heated at 150° for further 30 minutes, and then left to cool. The nitrobenzene solution was decanted and the viscous residue treated with light petroleum (b. p. 80—100°) until free from nitrobenzene and unchanged material. The residue was dissolved in water and treated with aqueous picric acid. The black resinous precipitate was filtered off and to the filtrate more aqueous picric acid was added, the *picrate* separating in yellow crystals. Recrystallised from water, it had m. p. 175—176° (decomp.) (yield, 20%) (Found : C, 44·5; H, 3·1; N, 16·6. $C_{16}H_{15}O_{10}N_5$ requires C, 43·9; H, 3·4; N, 16·0%).

The corresponding *chloride*, prepared in the usual manner (Zaki and Tadros, *loc. cit.*), had m. p. 199—200° (decomp.) (Found : C, 48·9; H, 5·1; N, 11·6; Cl, 14·9. $C_{10}H_{13}N_2O_3Cl$ requires C, 49·1; H, 5·3; N, 11·4; Cl, 14·5%), and the *bromide*, m. p. 192° (decomp.) (Found : Br, 27·8. $C_{10}H_{13}N_2O_3Br$ requires Br, 27·7%), crystallised from alcohol–ether. The *iodide* separated from absolute alcohol in pale yellow crystals, m. p. 175° (decomp.) (Found : I, 37·6. $C_{10}H_{13}N_2O_3I$ requires I, 37·8%). The halides are soluble in water and alcohol, but insoluble in ether, benzene, or acetone.

The quaternary chloride (1 g.), hydroxylamine hydrochloride (1·2 g.) in the least amount of water, anhydrous sodium carbonate (1 g.), and absolute alcohol (10 c.c.) were refluxed for 3 hours, cooled, and filtered, and the filtrate was evaporated to dryness. The *oxime picrate*, prepared from an aqueous solution of the residue, separated in yellow crystals which had m. p. 200° (decomp.) (Found : C, 42·2. H, 2·8; N, 19·0. $C_{16}H_{16}O_{10}N_6$ requires C, 42·5; H, 3·5; N, 18·6%).

To a solution of the chloride (1 g.) in the least amount of alcohol, a saturated aqueous solution of semicarbazide hydrochloride was added and the product which was at once precipitated was filtered off. The *semicarbazone picrate* was obtained on addition of aqueous picric acid to an aqueous solution of the precipitate and recrystallised from water in yellow crystals, m. p. 210° (decomp.) (Found : C, 41·4; H, 3·1; N, 22·4. $C_{17}H_{18}O_{10}N_8$ requires C, 41·3; H, 3·6; N, 22·7%).

A saturated solution of benzhydrazide was added to a solution of the chloride (1 g.) in the least amount of alcohol. The precipitated *benzoylhydrazone ammonium hydroxide* which, owing to hydrolysis, separated after some time was filtered off and recrystallised from aqueous alcohol. It had m. p. 226° (decomp.) (Found : C, 60·0; H, 5·5; N, 16·7. $C_{17}H_{20}O_4N_4$ requires C, 59·3; H, 5·8; N, 16·3%).

The *benzoylhydrazone picrate* was obtained from the hydroxide and crystallised from aqueous alcohol in yellow crystals, m. p. 236° (decomp.) (Found : C, 50·6; H, 3·5; N, 17·8. $C_{23}H_{21}O_{10}N_7$ requires C, 49·7; H, 3·8; N, 17·7%).

3-*Nitro*-4-*trimethylaminobenzoic Betaine.*—Hydrogen peroxide (30-vol.; 5 c.c.) was added to an aqueous solution of 4-formyl-2-nitrophenyltrimethylammonium chloride (1 g. in 2 c.c. of distilled water), and the solution was heated on the water-bath for 10 minutes and then left overnight. The *betaine* was precipitated on scratching of the vessel. Recrystallised from water it had m. p. >360° (Found : C, 53·0; H, 4·9; N, 12·6. $C_{10}H_{12}O_4N_2$ requires C, 53·6; H, 5·3; N, 12·5%).

4-*Carboxy*-2-*nitrophenyltrimethylammonium Salts.*—The *picrate*, prepared from the betaine in the usual manner, recrystallised from water in yellow crystals, m. p. 210° (decomp.) (Found : C, 43·2; H, 3·1; N, 15·8. $C_{16}H_{15}O_{11}N_5$ requires C, 42·4; H, 3·3; N, 15·5%).

The picrate was converted into the quaternary chloride, bromide, and iodide in the usual manner. The quaternary chloride and bromide were also obtained on evaporation, to dryness on the water-bath, of a solution of the betaine in concentrated hydrochloric and hydrobromic acid respectively. The chloride, crystallised from alcohol–ether, had m. p. 246° when freshly prepared; it gradually lost hydrochloric acid and after 10, 20, and 30 days the chlorine content had decreased to 12·0, 9·0, and 7·45%, respectively (Calc. for $C_{10}H_{13}O_4N_2Cl$: 13·6%); after a longer time it had changed completely to the betaine. The *bromide*, which proved to be stable, was obtained from alcohol–ether and had m. p. 235—236° (Found : Br, 26·8. $C_{10}H_{13}O_4N_2Br$ requires Br, 26·2%). The *iodide*, also stable, similarly purified, had m. p. 186° (Found : I, 36·2. $C_{10}H_{13}O_4N_2I$ requires I, 36·1%).

Decomposition of p-*Formylphenyltrimethylammonium Chloride or Iodide.*—A mixture of the chloride (10 g., 1 mol.) or iodide (15 g., 1 mol.) and alcoholic sodium ethoxide [sodium 2·7 g. (2 atoms) in alcohol, 100 c.c.] was refluxed on the sand-bath for 5 hours. The solution was subsequently evaporated to dryness on the water-bath, and the residue taken up with water and extracted with ether. Acidification of the alkaline solution with acetic acid precipitated *p*-dimethylaminobenzoic acid (2 g.), which after crystallisation from alcohol had a m. p. 234° alone or mixed with an authentic sample. The ethereal layer was extracted with hydrochloric acid. After removal of the ether, *p*-ethoxybenzaldehyde (2·2 g.) was obtained, identified, after oxidation with 1% potassium permanganate, as *p*-ethoxybenzoic acid, m. p. 195° alone or mixed with an authentic sample. The hydrochloric acid solution was made alkaline and the base extracted with ether. On fractional distillation of the red oil (1·6 g.) obtained after removal of ether, a fraction (1·2 g.) was collected at 125°/1 mm., and proved to be *p*-dimethylaminobenzyl alcohol, identified as its methiodide, m. p. 231—232° alone or mixed with an authentic sample. The residue (0·4 g.) proved to be *p*-dimethylaminobenzaldehyde, giving a methiodide, m. p. 164° alone or mixed with an authentic sample.

A similar experiment was carried out with the same quantities of the chloride and iodide and sodium *n*-propoxide (from sodium, 2·7 g.) in *n*-propyl alcohol (100 c.c.), whereby *p*-*n*-propoxybenzaldehyde (2 g.), identified as *n*-propoxybenzoic acid, m. p. 145° alone or mixed with an authentic sample, was obtained. The other fractions (crude *p*-dimethylaminobenzoic acid, 2·6 g.; *p*-dimethylaminobenzyl alcohol, 2·2 g.; and a small quantity of *p*-dimethylaminobenzaldehyde) were obtained as above.

Decomposition of 4-*Formyl*-2-*nitrophenyltrimethylammonium Chloride.*—The chloride (1 g., 1 mol.) and methanolic sodium methoxide [sodium, 0·1 g. (1 atom); methyl alcohol, 20 c.c.] were refluxed on the water-bath for 5 hours, an orange-red precipitate gradually separating. This was filtered off and washed with water, but all attempts to recrystallise it from the common organic solvents were unsuccessful. Acidification of the filtrate with acetic acid gave very little precipitate. Analyses of the red product were not concordant (Found : C, 63·6, 60·1, 60·1; H, 4·4, 4·4, 4·4; N, 16·1, 15·8, 14·9%).

Decomposition of 4-*Carboxy*-2-*nitrophenyltrimethylammonium Chloride and Bromide and* 3-*Nitro*-4-*trimethylaminobenzoic Betaine.*—The chloride, bromide, or betaine (0·4 g.) and methanolic sodium methoxide (sodium, 0·2 g.; methyl alcohol, 25 c.c.) were refluxed on the water-bath for 3 hours. Methyl alcohol was distilled off, and the residue treated with dilute hydrochloric acid. Extraction with ether removed no material. The acid solution was made slightly alkaline and then treated with acetic acid until faintly acidic, whereupon pale orange crystals of 5 : 5′-*dicarboxy*-2 : 2′-*bisdimethylaminoazoxybenzene* slowly separated. This was not soluble in common organic solvents, and was purified by dissolution in alkali and precipitation with acetic acid. Its m. p. was above 360° (Found : C, 58·3; H, 4·7; N, 15·2. $C_{18}H_{20}O_5N_4$ requires C, 58·1; H, 5·1; N, 15·1%).

4-*Dimethylamino*-3-*nitrobenzoic Acid.*—4-Dimethylamino-3-nitrobenzaldehyde (3 g.) and methanolic sodium methoxide (sodium, 0·7 g.; methyl alcohol, 30 c.c.) were refluxed on the water-bath for 5 hours. Methyl alcohol was subsequently evaporated, and the residue taken up with water and extracted with ether. On removal of the ether, an orange-red oil (0·1 g.) was obtained. The alkaline solution was then treated with hydrochloric acid, and the brownish-black residue (0·5 g.) was filtered off. The hydrochloric acid filtrate was made alkaline and then treated with acetic drop by drop, whereby a yellow precipitate (1·2 g.) was obtained. This separated from ethyl alcohol in yellow crystals, m. p. 213° alone or mixed with an authentic sample of 4-dimethylamino-3-nitrobenzoic acid (Found : C, 52·1; H, 4·7; N, 13·5. Calc. for $C_9H_{10}O_4N_2$: C, 51·4; N, 4·8; N, 13·3%).

4-Dimethylamino-3-nitrobenzoic acid, similarly treated, was recovered unchanged.

p-*Dimethylaminobenzyl Alcohol.*—When a solution of *p*-dimethylaminobenzaldehyde (5 g., 1 mol.) with *n*-propanolic sodium *n*-propoxide [sodium 1·6 g. (2 atoms); *n*-propyl alcohol, 50 c.c.] was refluxed on the sand-bath for 5 hours, the solution acquired a dark-red colour. The alcohol was distilled off on the water-bath, and the residue extracted with ether. On acidification of the alkaline solution with acetic acid, *p*-dimethylaminobenzoic acid (0·06 g.) was obtained. The ethereal solution gave a residue which on distillation at 125°/1 mm. afforded *p*-dimethylaminobenzyl alcohol (4 g.), showing that about 80% of the aldehyde was reduced to the alcohol. *p*-Dimethylaminobenzyl alcohol was identified as its methiodide, m. p. 232° alone or mixed with an authentic sample.

A similar experiment in alcoholic sodium ethoxide afforded no *p*-dimethylaminobenzoic acid, and the aldehyde underwent partial reduction (15—20%).

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