CCLXXII.—*Nitration of Chlorinated 3-Hydroxybenzaldehydes and some Consequences of Adjacent Substitution.*

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THE literature of this subject describes only the 6-chloro-3-hydroxy-2- and -4-nitrobenzaldehydes (Friedländer and Schenk, *Ber.*, 1914, **47**, 3044).

The present investigation has revealed the potent influence of chlorine in position 2 on adjacent groups; *e.g.*, by comparing the volatility in steam of 6-nitro-3-hydroxybenzaldehyde (non-volatile), 6-nitro-3-methoxybenzaldehyde (volatile), and 2-chloro-6-nitro-3-methoxybenzaldehyde (non-volatile) and of 4-nitro-3-hydroxybenzaldehyde (volatile), 4-nitro-3-methoxybenzaldehyde (non-volatile), and 2-chloro-4-nitro-3-methoxybenzaldehyde (volatile), it is seen that the methoxy-group has been made to function as a phenolic hydroxyl group, for the former chloro-compound displays the non-volatility of a *p*-nitrophenol, and the latter the ready volatility of an *o*-nitrophenol. Again, the nitration of 2-chloro-3-methoxybenzaldehyde gives a mixture of 2-chloro-3-methoxy-4- and -6-nitrobenzaldehydes only, whereas from Rubinstein's work (J., 1925, **127**, 2268) the formation of 2-chloro-5-nitro-3-methoxybenzaldehyde might have been expected.

On treatment with aqueous sodium hydroxide, 6-chloro-2 : 4-dinitro-3-hydroxybenzaldehyde-*p*-nitrophenylhydrazone develops a vivid royal-blue colour, whilst 2-chloro-4 : 6-dinitro-3-hydroxybenzaldehyde-*p*-nitrophenylhydrazone gives a claret colour only on warming, and then but slowly, thereby differing from all other *p*-nitrophenylhydrazones which have been examined. The behaviour of the latter recalls that of 2 : 5-dichloro-6-nitrobenzaldehydephenylhydrazone, which was the only exception to Chattaway and Clemo's generalisation (J., 1923, **123**, 3043); in both cases the anomalous behaviour may be connected with the presence of a chlorine atom in position 2.

Chlorinated 4-nitro-3-hydroxybenzaldehydes are in general sparingly soluble in water and readily soluble in non-hydroxylic solvents (benzene, chloroform, etc.). The reverse holds for the 6-nitro-isomerides.

The constitutions of the chloronitro-3-hydroxybenzaldehydes have been established by further nitration: 2-chloro-3-hydroxy-4- and -6-nitrobenzaldehydes give the same dinitro-compound, 2-chloro-4 : 6-dinitro-3-hydroxybenzaldehyde; 4-chloro-3-hydroxy-2- and -6-nitrobenzaldehydes give 4-chloro-2 : 6-dinitro-3-hydroxybenzaldehyde; and 6-chloro-3-hydroxy-2- and -4-nitrobenzaldehydes give 6-chloro-2 : 4-dinitro-3-hydroxybenzaldehyde.

By working with a much larger quantity of material, we have been able to show that 2 : 6-dichloro-3-hydroxybenzaldehyde is the main constituent of the mixture of dichloro-compounds produced by the chlorination of 6-chloro-3-hydroxybenzaldehyde (this vol., p. 152).

4-Chloro-2 : 6-dinitro-3-hydroxybenzaldehyde and its derivatives explode with much greater violence than the corresponding 2- and 6-chloro-isomerides; the silver salts are the most explosive derivatives. The 6-nitro-compounds, and even the silver salts when powdered, have pronounced sternutatory properties.

EXPERIMENTAL.

General Procedure.—The silver salts described below were prepared by treating the hydroxy-compounds, dissolved in the theoretical quantity of 1% aqueous ammonia, with the requisite quantities of 5% aqueous silver nitrate. These precautions were taken to prevent any possible displacement of chlorine from the various chloronitro-compounds investigated. On account of their highly explosive nature, the silver salts were analysed by warming them with dilute hydrochloric acid and washing the silver chloride with ether until its weight became constant.

The p-*nitrophenylhydrazones* were made by the authors' general method (J., 1925, **127**, 880). The characteristic colour produced by addition of aqueous sodium hydroxide to an aqueous suspension of the hydrazone is given in brackets immediately after the m. p.

The oximes and methyl ethers were respectively obtained by the methods employed for the preparation of the oximes of the bromo-compounds (*loc. cit.*, p. 878) and the methyl ethers of the chloro-compounds (this vol., p. 153).

Mononitration of 2-Chloro-3-hydroxybenzaldehyde.

2-Chloro-3-hydroxybenzaldehyde (25 g.) dissolved in 50% aqueous acetic acid (70 c.c.) was nitrated at 45—55° by the gradual addition of nitric acid (25 c.c.; *d* 1·3). After 15 minutes, the mixture was cooled and poured on to ice (150 g.). The mixture of 2-chloro-3-hydroxy-4- and -6-nitrobenzaldehydes, obtained in quantitative yield, was treated with 600 c.c. of water at 90°, which dissolved the 6-nitro-compound and a little of the 4-nitro-isomeride; the latter was removed by steam distillation. The residue was almost pure 2-chloro-4-nitro-3-hydroxybenzaldehyde. The yields of the 4- and 6-nitro-compounds were 17 g. and 12 g., respectively.

2-*Chloro*-4-*nitro*-3-*hydroxybenzaldehyde* forms deep yellow needles, m. p. 166°, from glacial acetic acid (Found : Cl, 17·4. $C_7H_4O_4NCl$ requires Cl, 17·6%). The *silver* salt crystallises from hot water in red micro-needles (Found : Ag, 34·6. $C_7H_3O_4NClAg$ requires Ag, 35·0%). The p-*nitrophenylhydrazone* separates from hot glacial acetic acid, in which it is sparingly soluble, in deep orange needles, m. p. 294—295° (decomp.). (Violet.) (Found : Cl, 10·4. $C_{13}H_9O_5N_4Cl$ requires Cl, 10·5%.) The *semicarbazone* forms sulphur-yellow needles, m. p. 271—272° (decomp.), from hot alcohol (Found : Cl, 13·5. $C_8H_7O_4N_4Cl$ requires Cl, 13·7%). The *oxime*, which is insoluble in water, crystallises from hot alcohol in stout yellow needles, m. p. 170° (Found : Cl, 16·2. $C_7H_5O_4N_2Cl$ requires Cl, 16·4%).

2-*Chloro*-4-*nitro*-3-*methoxybenzaldehyde* crystallises from dilute acetic acid or dilute alcohol in colourless needles, m. p. 107° (Found : Cl, 16·4. $C_8H_6O_4NCl$ requires Cl, 16·5%).

2-*Chloro*-6-*nitro*-3-*hydroxybenzaldehyde* crystallises from water in colourless needles, m. p. 153° (Found : Cl, 17·6. $C_7H_4O_4NCl$ requires Cl, 17·6%). The *silver* salt forms cinnamon-brown needles from hot water, in which it is much more soluble, and the ammonium salt is much less soluble, than the corresponding 4-nitro-isomerides (Found : Ag, 34·6%). The p-*nitrophenylhydrazone* is obtained as a dull orange-red gelatinous substance which crystallises from hot dilute acetic acid in needles, m. p. 232—233°. (Claret.) (Found : Cl, 10·2%.) The *semicarbazone* forms pale yellow needles, m. p.

234° (decomp.), from alcohol (Found: Cl, 13·6%). The *oxime*, which is exceedingly soluble in alcohol and water, crystallises from chloroform in colourless needles, m. p. 175° (Found: Cl, 16·3%).

2-*Chloro*-6-*nitro*-3-*methoxybenzaldehyde* crystallises from glacial acetic acid in colourless needles, m. p. 134° (Found: Cl, 16·6%).

Preparation of 2-*Chloro*-3-*methoxy*-4- *and* -6-*nitrobenzaldehydes by Direct Nitration.*—2-Chloro-3-methoxybenzaldehyde (3 g.) dissolved in concentrated sulphuric acid (14 g.) was nitrated at 30—40° by the gradual addition of finely powdered potassium nitrate (2 g.); the mixture was kept for 10 minutes at 50—60° and then poured on to ice. The 2-chloro-4-nitro-3-methoxybenzaldehyde (m. p. 107°) was separated quantitatively from the 6-nitro-compound (m. p. 134°) by means of its volatility in steam.

Mononitration of 4-*Chloro*-3-*hydroxybenzaldehyde.*

4-Chloro-3-hydroxybenzaldehyde was conveniently obtained by the following modification of the method previously described (this vol., p. 150). 4-Nitro-3-hydroxybenzaldehyde (31 g.) suspended in water (500 c.c.) was reduced by sodium hyposulphite (140 g.), added as rapidly as the violence of the reaction permitted. The mixture was kept for 15 minutes at 90°, cooled to 0°, mixed with concentrated hydrochloric acid (100 c.c.), and diazotised below 5° with solid sodium nitrite (40 g.). Concentrated hydrochloric acid (50 c.c.) and sodium nitrite (15 g.) were then added, the mixture was kept for 30 minutes, and the free nitrous acid destroyed by carbamide. The diazo-solution was added slowly to a boiling mixture of cuprous chloride (40 g.), concentrated hydrochloric acid (100 c.c.), and water (100 c.c.), and the whole was boiled under reflux for 2 hours and finally extracted with benzene (600 c.c.) at about 70°, the bisulphite compound of the aldehyde being probably most dissociated at this temperature (compare Erhart, D.R.-P. 116124, on the separation of *o*- and *m*-nitrobenzaldehydes). The yield was 17 g. (60%) and the product, after crystallisation from 50% aqueous acetic acid, melted at 121°.

Nitration. This was effected as in the case of 2-chloro-3-hydroxybenzaldehyde. The mixture (4 g.) of 4-chloro-3-hydroxy-2- and -6-nitrobenzaldehydes obtained was boiled under reflux with chloroform (16 g.) for 30 minutes, cooled, and filtered. The residue (3·8 g.) was almost pure 4-chloro-6-nitro-3-hydroxybenzaldehyde, whilst the filtrate gave 0·2 g. of the 2-nitro-isomeride. Separation of these two by fractional steam distillation entailed serious loss.

4-*Chloro*-2-*nitro*-3-*hydroxybenzaldehyde* crystallises from glacial acetic acid in yellow needles, m. p. 161° (Found: Cl, 17·4. $C_7H_4O_4NCl$ requires Cl, 17·6%). The *silver* salt forms orange-red needles from hot water (Found : Ag, 34·7%). The p-*nitrophenylhydrazone* forms deep red needles, m. p. 281—282° (decomp.), from hot glacial acetic acid. (Violet.) (Found : Cl, 10·4%.) The *semicarbazone* crystallises from dilute alcohol in pale yellow needles, m. p. 270—271° (decomp.) (Found : Cl, 13·6%).

4-*Chloro*-6-*nitro*-3-*hydroxybenzaldehyde* crystallises from glacial acetic acid in thick, colourless, elongated prisms, m. p. 175° (Found : Cl, 17·3. $C_7H_4O_4NCl$ requires Cl, 17·6%). The *silver* salt forms orange needles from hot water (Found : Ag, 34·8%). The p-*nitrophenylhydrazone* forms deep maroon needles, m. p. 275—276° (decomp.), from hot glacial acetic acid. (Reddish-violet.) (Found : Cl, 10·5%.) The *semicarbazone* crystallises from alcohol in light orange needles, m. p. 265—266° (decomp.) (Found : Cl, 13·5%).

Mononitration of 6-*Chloro*-3-*hydroxybenzaldehyde.*

Friedländer and Schenk's process (*loc. cit.*) was repeated and their results were confirmed.

6-Chloro-2-nitro-3-hydroxybenzaldehyde forms yellow needles, m. p. 136°, from dilute acetic acid (F. and S. give m. p. 138°). The *silver* salt crystallises in brick-red needles from hot water, in which it is readily soluble (Found : Ag, 34·8%). The p-*nitrophenylhydrazone* forms deep orange needles, m. p. 256—257° (decomp.), from dilute acetic acid. (Brilliant red.) (Found : Cl, 10·3%.) The *semicarbazone* forms yellow needles, m. p. 249—250° (decomp.), from alcohol (Found : Cl, 13·7%).

6-Chloro-3-hydroxy-4-nitrobenzaldehyde crystallises from glacial acetic acid in deep yellow needles, m. p. 104° (F. and S. give m. p. 104°). The *silver* salt forms brownish-purple leaflets from hot water, in which it is difficultly soluble (Found : Ag, 34·7%). The p-*nitrophenylhydrazone* crystallises from glacial acetic acid in deep brick-red needles, m. p. 284—286° (decomp.). (Violet.) (Found : Cl, 10·5%.) The *semicarbazone* forms yellow plates, m. p. 266—267° (decomp.), from hot alcohol, in which it is only slightly soluble (Found : Cl, 13·6%).

Mononitration of 2 : 4- *and* 2 : 6-*Dichloro*-3-*hydroxybenzaldehyde.*

Either compound (3 g.), dissolved in glacial acetic acid (12 c.c.), was nitrated at 65° with nitric acid (3 c.c.; *d* 1·42); the mixture was kept for 15 minutes and then worked up in the usual way.

2 : 4-*Dichloro*-6-*nitro*-3-*hydroxybenzaldehyde* separates in colourless needles, m. p. 107°, from its deep yellow solution in glacial acetic acid or hot water (Found : Cl, 29·7. $C_7H_3O_4NCl_2$ requires Cl, 30·0%). The *silver* salt is precipitated in pale yellow microneedles insoluble in hot or cold water (Found : Cl, 20·4.

$C_7H_2O_4NCl_2Ag$ requires Cl, 20·7%). The p-*nitrophenylhydrazone* crystallises from hot glacial acetic acid in orange needles, m. p. 279—280°. (Red.) (Found: Cl, 19·0. $C_{13}H_8O_5N_4Cl_2$ requires Cl, 19·1%.) The *semicarbazone* separates from dilute alcohol in yellow needles which soften at 140—150° and contain water (Found: Cl, 22·8. $C_8H_6O_4N_4Cl_2,H_2O$ requires Cl, 22·8%).

2 : 6-*Dichloro*-4-*nitro*-3-*hydroxybenzaldehyde* forms bright yellow needles from dilute acetic acid and plates from water; m. p. 80° (Found: Cl, 29·9%). It is very slowly volatile in steam. The *silver* salt crystallises in crimson needles from hot water (Found: Ag, 31·2. $C_7H_2O_4NCl_2Ag$ requires Ag, 31·4%). The p-*nitrophenylhydrazone* forms deep red needles, m. p. 279—280° (decomp.), from hot glacial acetic acid. (Claret.) (Found: Cl, 19·0%.) The *semicarbazone* separates from hot alcohol in light yellow leaflets, m. p. 255—256° (Found: Cl, 24·1. $C_8H_6O_4N_4Cl_2$ requires Cl, 24·2%). The *oxime* forms deep yellow needles, m. p. 195°, from dilute alcohol (Found: Cl, 28·2. $C_7H_4O_4N_2Cl_2$ requires Cl, 28·3%).

Dinitration of 2-, 4-, *and* 6-*Chloro*-3-*hydroxybenzaldehydes.*

The nitrations were carried out as in the preceding case. The 2-chloro-compound gave pure 2-chloro-4 : 6-dinitro-3-hydroxybenzaldehyde, but pure 4-chloro-2 : 6-dinitro-3-hydroxybenzaldehyde and pure 6-chloro-2 : 4-dinitro-3-hydroxybenzaldehyde were best obtained in two stages by way of the respective mononitro-compounds.

2-*Chloro*-4 : 6-*dinitro*-3-*hydroxybenzaldehyde* forms very pale yellow needles, m. p. 110°, from glacial acetic acid (Found: Cl, 14·5. $C_7H_3O_6N_2Cl$ requires Cl, 14·4%). The *ammonium* salt is only moderately easily soluble in water. The *silver* salt crystallises from water in bright orange needles, which are easily soluble in water, acetone, or alcohol. The p-*nitrophenylhydrazone* forms dark crimson needles, m. p. 277—279° (with explosive decomp.), from glacial acetic acid (Found: Cl, 9·2. $C_{13}H_8O_7N_5Cl$ requires Cl, 9·3%). The *semicarbazone* crystallises from dilute alcohol in yellow needles, m. p. 240—242° (decomp.) (Found: Cl, 11·4. $C_8H_6O_6N_5Cl$ requires Cl, 11·7%). The *oxime* forms pale yellow needles, m. p. 142°, from alcohol (Found: Cl, 13·4. $C_7H_4O_6N_3Cl$ requires Cl, 13·6%).

4-*Chloro*-2 : 6-*dinitro*-3-*hydroxybenzaldehyde* forms very pale yellow needles, m. p. 118—119°, from water (Found: Cl, 14·7%). The *silver* salt forms orange-yellow needles from water, in which it is very soluble. The p-*nitrophenylhydrazone* crystallises from dilute acetic acid in deep orange-red needles, which explode at 235—236°. (Claret.) (Found: Cl, 9·1%.) The *semicarbazone* separates from hot dilute alcohol in stout, deep yellow needles, which explode at about 200° (Found : Cl, 11·6%).

6-*Chloro*-2 : 4-*dinitro*-3-*hydroxybenzaldehyde*. The dinitration product required three crystallisations from dilute acetic acid before it was obtained pure in bright yellow needles, m. p. 121·5° (Found : Cl, 14·2. $C_7H_3O_6N_2Cl$ requires Cl, 14·4%). The *silver* salt is a deep red substance which is very soluble in water. The p-*nitrophenylhydrazone* crystallises in dark crimson needles, m. p. 285—286° (decomp.), from glacial acetic acid (Found : Cl, 9·2%). The *semicarbazone* forms yellow needles, m. p. 267—269° (decomp.), from alcohol (Found : Cl, 11·5%).

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