XL.—*The Condensation of Chloral Hydrate and Orcinol.*

By JOHN THEODORE HEWITT, M.A., D.Sc., Ph.D., and
FRANK DIXON, B.Sc.

IN two papers communicated to the Society (Trans., 1896, 69, 1265 ; 1897, 71, 1084), one of the authors has shown, in conjunction with F. G. Pope, that chloral hydrate and resorcinol, when warmed in dilute aqueous solution, condense with formation of the lactone of tetrahydroxydiphenylacetic acid. The same product had previously been examined by A. Michael (*Amer. Chem. J.*, 1883—1884, 5, 350 ; 1887, 9, 134) and H. Causse (*Bull. Soc. Chim.*, 1890, [iii], 3, 861); the former investigator had, however, assigned to the substance a wrong molecular formula, $C_8H_6O_3$, whilst the latter, although expressing the composition by the formula $C_{14}H_{10}O_5$, was incorrect with regard to the constitution. Under these circumstances, it seemed desirable to reinvestigate the substance obtained by Michael and J. P. Ryder by the condensation of chloral hydrate with orcinol, especially as they had assigned to it the *à priori* improbable constitution represented by the formula $C[CH_3 \cdot C_6H_2(OH)_2]_3 \cdot CH(OH)_2$.

The result of our work has been to show that the first product of the reaction between orcinol and chloral hydrate in aqueous solution at 100°, potassium hydrogen sulphate being used as a condensing agent, is not, as in the case of resorcinol, a lactone, but a colourless acid, which is only lactonised by heating in the dry state. This acid undoubtedly has the composition $C_{16}H_{16}O_6$; the analyses and molecular weight determination agreeing with this formula. When heated in an indifferent atmosphere to 150°, it loses $1H_2O$, and is converted into the corresponding lactone, $C_{16}H_{14}O_5$; this lactone contains three hydroxyl groups, as is readily shown by the fact that three acetyl or benzoyl groups may be introduced in the usual way. The benzoate exhibits, however, a peculiar behaviour, in that it readily passes into the dibenzoyl derivative of the acid $C_{16}H_{16}O_6$ when left in an alcoholic solution containing water: some caution has therefore to be

exercised in the preparation of the tribenzoate. Having ascertained the above-mentioned facts, we were in a position to assign a structural formula to the acid and its lactone. The former is produced according to the equations

Orcinol is 1:3:5-methyldihydroxybenzene, so that the methane carbon atom of the chloral hydrate has the chance of entering the orcinol molecule in the 2, 4, or 6 positions; of these, however, the 2 and 6 positions are equivalent. That it is the 2 or 6 position in which substitution takes place is rendered evident by the fact that, on heating the acid, either by itself or with acetic anhydride or benzoic chloride to their respective boiling points, either the lactone or derivatives of the lactone are produced, and in no case is the formation of xanthene derivatives observed. The acid and its lactone are therefore to be represented by the structural formula

respectively.

The comparative difficulty with which this acid lactonises, and the ease with which the lactone ring is broken, are matters of considerable interest.

Victor Meyer and his pupils have shown that, if a substituted benzoic acid has two substituent groups in the ortho-positions relatively to the carboxyl group, it can either not be etherified at all or only with difficulty by the ordinary method of heating with an alcohol and a mineral (hydrochloric) acid. Again, Sudborough has observed that 2:6-dibromobenzamide is recovered unaltered after heating for several hours in a sealed tube with 80 per cent. sulphuric acid at 170° (Trans., 1895, 67, 603).

Meyer and Sudborough (compare *Ber.*, 1894, 27, 510, 512, 1580, 3146) are both inclined to attribute this negative behaviour under ordinary conditions of etherification and hydrolysis to want of space within the molecule owing to the volume taken up by the two ortho-substituents. If this be so, it seems feasible to suppose that should A, B, and C represent groups occupying the positions 1, 2, and 3 respectively in a benzene nucleus

group B would exert an outward pressure on groups A and C, and have a tendency to weaken their attachment or to prevent their being increased in volume, although, should A or C be absent, there would be space for both C and B or A and B.

On comparing the constitution of the acid $C_{16}H_{16}O_6$ with that of the lower homologue $C_{14}H_{12}O_6$,

one can see that, whereas, in the latter case, if lactonisation takes place between carboxyl and hydroxyl and there is in consequence displacement of the methane carbon atom, there is no ortho-substituent on the other side to hinder this motion, in the former case there is the bulkier methyl group standing in the way and tending to resist such displacement.

Similarly, we should expect the influence of these methyl groups to exert themselves in the sense that it would be more difficult to introduce acidyl groups in the place of hydrogen in the case of the ortho-hydroxyl groups than in those in the para-position; and, supposing these groups to be once introduced, for hydrolysis to take place with far greater ease.

Such considerations agree well with the observed facts in that the acid is less readily converted into lactone than the lower homologue; that the lactone is immediately hydrolysed when dissolved in caustic alkalis, and that the tribenzoate of the lactone easily passes into the dibenzoate of the acid in aqueous alcoholic solution.

Preparation of the Acid $C_{16}H_{16}O_6$.—Two parts of chloral hydrate, 2 parts of potassium hydrogen sulphate, and 3 parts of orcinol are dissolved in 12 parts of water and heated for about 16 hours at 100° ; on cooling, a nearly colourless or pale yellow substance separates in small crystals, which were collected and washed with cold water. On reheating the filtrate with 1 part of chloral hydrate, more of the acid may be obtained; and this operation can be repeated as long as acid of not too dark a colour is deposited. To purify the acid, it may be dissolved in the smallest possible quantity of warm acetone and precipitated as a colourless, crystalline powder by the addition of water; it takes some time to separate completely. It crystallises in microscopic prisms which have a bitter taste. The results of the analysis corresponded with the formula $C_{16}H_{16}O_6$.

Calculated C = 63.15; H = 5.26 per cent.

Found..... C = 63.17; 63.59. H = 5.68; 5.17 per cent.

The second analysis was carried out with a specimen which had stood in a desiccator over concentrated sulphuric acid for six weeks ; lactonisation had therefore not proceeded to any appreciable extent.

Michael found $C = 64.58$ and 64.33 ; $H = 5.29$ and 5.34 ; his substance must therefore have been partially converted into lactone. In conjunction with A. M. Comey (*Amer. Chem. J.*, 1884, 5, 349), he gives the melting point as 250° . The corrected melting points for our specimens varied between 252° and 263° , the latter temperature being the melting point of the corresponding lactone.

The acid is very sparingly soluble in cold water, fairly easily in hot water, and separates out on cooling. It also dissolves in alcohol, benzene, carbon bisulphide, and acetone, but not in light petroleum. The acid dissolves in fairly strong caustic soda solution with a deep blue coloration ; this nearly disappears on moderate dilution with water. Cold, strong sulphuric acid gives no colour reaction.

The molecular weight was found from the boiling point of an alcoholic solution. Alcohol employed 13.96 grams.

0.5703 gram raised boiling point 0.14° corresponding with mol. wt. 336.
1.0801 " " " 0.30° " " " 296.

The calculated molecular weight is 304. We may point out here that Michael's formula corresponds with a molecular weight of 428.

Attempts to prepare salts of the acid were not very satisfactory ; the acid dissolved in a hot solution of potassium carbonate with evolution of carbon dioxide (1 acid : 0.22 potassium carbonate : 10 of water), but nothing separated on cooling ; evaporation did not give a satisfactory result, as the potassium salt is very soluble, and the solution rapidly turned brown. No precipitates were obtained by adding barium chloride, silver nitrate, copper sulphate, ferric chloride, lead acetate or mercuric chloride to this solution.

On treating an aqueous solution of the acid with ferric chloride, a brown precipitate is obtained ; this precipitate is soluble in alkali, and reprecipitated by acids.

Preparation of the Lactone.—A weighed quantity of substance was carefully heated in an atmosphere of coal gas for $1\frac{1}{4}$ hours at a temperature of 150° .

0.529, on heating, lost 0.035, corresponding with 6.61 per cent. of water.
0.9528, " " 0.0572, " " 6.00 " "

The calculated percentage loss for $1H_2O$ is 5.92.

The lactone prepared in this way is almost colourless, and melts at 263° (corrected). The lactone is apparently immediately hydrolysed on dissolving it in an alkali.

Calculated for $C_{16}H_{14}O_5$	C = 67·13 ; H = 4·89 per cent.
Found.....	C = 66·94 ; H = 5·01 ,,

Triacetyl Derivative of the Lactone.—A mixture of 1 part of the acid and 5 parts of acetic anhydride, after being heated for 1 hour in a reflux apparatus, was poured while hot into cold water, and the precipitate recrystallised from ethylic acetate ; the substance is thus obtained in small, colourless prisms, melting at 189° (corrected).

Michael and Ryder give the melting point as 185° .

Calculated	C = 64·08 ; H = 4·85 per cent.
Found	C = 64·29 ; H = 4·94 ,,
Michael and Ryder found	C = 63·73 ; H = 5·10 ,,

The acetate is insoluble in water, and is only sparingly soluble in hydrocarbon solvents ; it dissolves, however, in carbon bisulphide, acetic acid, ethylic acetate, and ethylic benzoate. It dissolves on warming with concentrated sulphuric acid, a pale, brown coloration being produced, and on diluting this solution with water, a nearly colourless precipitate is obtained.

Tribenzoate of the Lactone.—This was obtained by boiling the acid for about 10 minutes with 10 times its weight of benzoic chloride ; after a lapse of a few minutes, no further evolution of hydrogen chloride taking place, the slightly yellow solution of the benzoate in excess of benzoic chloride was poured into light petroleum, whereby it was precipitated in a resinous condition ; on pouring off the liquid, adding more light petroleum, and stirring vigorously, the substance is soon obtained in a granular condition. It can be readily purified by dissolving it in ethylic acetate, and adding ethylic alcohol, when it is precipitated as an almost colourless, crystalline powder. It was dried in a vacuum desiccator over sulphuric acid and analysed.

Calculated for $C_{37}H_{26}O_8$...	C = 74·25 ; H = 4·35 per cent.
Found	C = 74·43, 75·06 ; H = 4·73, 4·64 per cent.

On heating in a capillary tube, no definite melting point can be observed ; the substance sinters at about 200° , and apparently undergoes some decomposition. It is easily soluble in acetone, ethylic acetate, warm ethylic benzoate and chloroform, somewhat soluble in glacial acetic acid and benzene, and apparently quite insoluble in water, alcohol, and light petroleum.

The substance dissolves easily in warm caustic soda solution, the lactone ring being split ; it also dissolves in concentrated sulphuric acid, but gives no characteristic colour reaction.

Dibenzoate of the Acid.—In preparing the tribenzoate of the lactone, we at first poured our benzoic chloride solution into 90 per cent. alcohol. On one occasion, having to leave the product for 2 days, we

were surprised to find that the substance had entirely dissolved. We were able, however, to obtain a crystalline substance by the addition of water. This, after repeated treatment with dilute alcohol, to remove benzoic acid and ethylic benzoate, was recrystallised from dilute alcohol, and gave, on analysis, numbers agreeing with those of a dibenzoyl derivative of the acid.

Calculated for $C_{16}H_{14}O_6(C_7H_5O)_2$ C = 70·31 ; H = 4·69 per cent.

Found..... C = 70·92, 70·38 ; H = 4·51, 4·81.

We soon found that it was an acid, and not a lactone, with which we had to deal. The substance dissolves in alcohol very readily ; in this solution, water produces a milkiness which is removed by sodium carbonate solution. The solution of the sodium salt gives precipitates with silver and lead nitrates, the former is, however, fairly soluble in pure water. This dibenzoate melts at 204° (corrected). It dissolves readily in alcohol, ethylic acetate, ether, chloroform, benzene, and glacial acetic acid, but is insoluble in water.

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