CLXXI.— β -Hydroxy- $\alpha\beta$ -dimethyladipic Acid and β -Hydroxy- $\alpha\alpha\beta$ -trimethyladipic Acid.

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THE work described in this communication was carried out some years ago, and as the opportunities of continuing this research in the near future seem limited, it has been judged advisable to place on record the results so far obtained. It was hoped at the commencement of this research that β -hydroxy- $\alpha\beta$ -dimethyladipic and β -hydroxy- $\alpha\alpha\beta$ -trimethyladipic acids would prove of value in syn-
 thetical work on the terpenes. Indeed, the latter acid has already been partly investigated from this point of view by Blaise (*Compt. rend.*, 1900, **130**, 1033), who pointed out the extreme readiness with which it underwent lactone formation, and its subsequent stability. The author's results in the main confirm those of Blaise, but one or two of the reactions which it undergoes are of interest in themselves.

Both acids were prepared by the condensation of ethyl lævulate and the corresponding α -bromo-esters by means of zinc. Duden and Freytag (*Ber.*, 1903, **36**, 953) condensed ethyl lævulate and ethyl bromoacetate by means of zinc, and obtained the ethyl ester of the lactone of β -hydroxy- β -methyladipic acid,

in 30—40 per cent. yields. Blaise by a similar condensation of methyl lævulate and methyl α -bromo*isobutyrate* obtained the methyl ester of the lactone of β -hydroxy- $\alpha\alpha\beta$ -trimethyladipic acid,

in yields of 15—17 per cent. In neither case was there isolated any of the corresponding hydroxy-ester.

The formation of lactones from esters of lævulic acid by the Barbier-Grignard reagent is well known (compare Grignard, *Compt. rend.*, 1902, **139**, 639; Jones and Tattersall, *Trans.*, 1904, **85**, 1691).

If the Reformatsky reaction between ethyl lævulate and ethyl α -bromopropionate is carried out in benzene solution, excellent yields are obtained of a condensation product, which consists of a mixture of diethyl β -hydroxy- $\alpha\beta$ -dimethyladipate (I) and the ethyl ester of the lactone of β -hydroxy- $\alpha\beta$ -dimethyladipic acid (II),

the use of the benzene as a diluent evidently hindering the formation of lactone.

A similar mixture of hydroxy-ester (III) and lactone (IV) is obtained by the condensation of ethyl lævulate and ethyl α -bromo-

isobutyrate by means of zinc in benzene solution, the yields being 70—80 per cent., whereas Blaise, using the methyl esters without the use of any diluent, obtained only the lactone in very poor yields. A redistillation of the products of reaction has no effect on the proportion of hydroxy-ester and lactone present.

The acid hydrolysis of these mixtures of hydroxy-esters and lactones yields the corresponding acid lactones, the condensation mixture from α -bromopropionic acid giving the lactone of β -hydroxy- $\alpha\beta$ -dimethyladipic acid (V), and that from α -bromo-*isobutyric* acid furnishing the lactone of β -hydroxy- $\alpha\alpha\beta$ -trimethyladipic acid (VI):

Both acids crystallise well from dry ether. The author, however, is unable to confirm Blaise's statement that hydrolysis by means of alkali completely decomposes the ester of the lactone of β -hydroxy- $\alpha\alpha\beta$ -trimethyladipic acid into lævulic and *isobutyric* acids. The

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alkaline hydrolysis of the mixed hydroxy-ester and lactone yields β -hydroxy- $\alpha\alpha\beta$ -trimethyladipic acid, which can be distilled with the production of only a small amount of the acid lactone. The decomposition of β -hydroxy- $\alpha\alpha\beta$ -trimethyladipic acid into lvulic and isobutyric acids, however, was observed if the acid was distilled in a rapid current of steam in the presence of 20 per cent. sulphuric acid.

Attempts to prepare β -bromo- $\alpha\alpha\beta$ -trimethyladipic acid were unsuccessful. The action of aqueous hydrobromic acid saturated at 0 on diethyl β -hydroxy- $\alpha\alpha\beta$ -trimethyladipate (III) yielded only the lactone of β -hydroxy- $\alpha\alpha\beta$ -trimethyladipic acid (VI). The successive actions of phosphorus pentabromide, ethyl alcohol, and diethylaniline on diethyl β -hydroxy- $\alpha\alpha\beta$ -trimethyladipate resulted in the formation of the ethyl ester of the lactone of β -hydroxy- $\alpha\alpha\beta$ -trimethyladipic acid (IV). The formation of the lactone instead of the expected unsaturated ester by this method is interesting.

EXPERIMENTAL.

Condensation of Ethyl Lvulate and Ethyl--bromopropionate: Diethyl β -Hydroxy- $\alpha\beta$ -dimethyladipate (I).

Fifteen grams of ethyl lvulate were mixed with 17 grams of ethyl -bromopropionate dissolved in twice the volume of dry benzene, and 7 grams of zinc added. The commencement of the reaction was aided by a little iodine and by heating on the water-bath, but when once begun was extremely vigorous, and it was necessary to resort to cooling. The reaction was complete at about the end of two hours, nearly all the zinc having been dissolved. The gelatinous, yellow product was decomposed by ice and dilute hydrochloric acid, extracted with ether, the ethereal extract washed several times with water, dried, and distilled under a pressure of 18 mm. The chief fraction was found to boil at 160170, the yield being 70 per cent. The portion boiling at 166 was used for analysis:

0.1020 gave 0.2210 CO_2 and 0.0769 H_2O . $\text{C}=59.1$; $\text{H}=8.3$.

$\text{C}_{12}\text{H}_{22}\text{O}_5$ requires $\text{C}=58.8$; $\text{H}=8.9$ per cent.

$\text{C}_{10}\text{H}_{16}\text{O}_4$,, $\text{C}=60.0$; $\text{H}=8.0$,, ,,

The results indicate that the condensation product is a mixture of diethyl β -hydroxy- $\alpha\beta$ -dimethyladipate and the corresponding lactone.

Lactone of β -Hydroxy- $\alpha\beta$ -dimethyladipic Acid (V).

The diethyl β -hydroxy- $\alpha\beta$ -dimethyladipate obtained from the previously described Reformatsky reaction was hydrolysed by heating on the water-bath for six hours with concentrated hydrochloric acid, and then pouring into water. The acid was obtained from the aqueous solution by extraction with ether, the ethereal extract dried, and the ether removed by evaporation, when an oil remained, which rapidly solidified. The adhering oil was removed from the crystals by absorption by porous porcelain, and the acid purified by crystallisation from dry ether, from which it separates in large, stout prisms melting at 98° :

0.1341 gave 0.2702 CO_2 and 0.0845 H_2O . $\text{C}=55.6$; $\text{H}=7.0$.

$\text{C}_8\text{H}_{12}\text{O}_4$ requires $\text{C}=55.8$; $\text{H}=7.0$ per cent.

0.2104 required for neutralisation 0.0484 NaOH .

A monobasic acid, $\text{C}_8\text{H}_{12}\text{O}_4$, requires 0.0489 NaOH .

After being boiled for twenty minutes with excess of $N/10$ -sodium hydroxide:

0.2104 required 0.0992 NaOH .

A lactonic acid, $\text{C}_8\text{H}_{12}\text{O}_4$, requires 0.0978 NaOH .

All attempts to prepare an ester of the lactonic acid by direct esterification were unsuccessful.

Condensation of Ethyl Laevulate and Ethyl α -Bromoisobutyrate: Diethyl β -Hydroxy- $\alpha\alpha\beta$ -trimethyladipate (III).

This condensation was carried out in a manner exactly similar to that described in the preparation of its lower homologue. It is an almost colourless, odourless oil, boiling at $171\text{--}175^{\circ}/18$ mm. Analysis shows that, like its lower homologue, it is a mixture of the hydroxy-ester and the ester of the acid lactone:

I. 0.1621 gave 0.3585 CO_2 and 0.1241 H_2O . $\text{C}=60.3$; $\text{H}=8.5$.

II. (Redistilled) 0.1485 gave 0.3302 CO_2 and 0.1140 H_2O .
 $\text{C}=60.6$; $\text{H}=8.5$.

$\text{C}_{13}\text{H}_{24}\text{O}_5$ requires $\text{C}=60.0$; $\text{H}=9.2$ per cent.

$\text{C}_{11}\text{H}_{18}\text{O}_4$ „ $\text{C}=61.7$; $\text{H}=8.5$ „ „

The hydroxy-acid is prepared by the alkaline hydrolysis of ethyl β -hydroxy- $\alpha\alpha\beta$ -trimethyladipate. The diethyl ester was heated for half an hour with alcoholic potassium hydroxide. The solution was then diluted with water, and the alcohol removed by evaporation.

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The alkaline liquid was acidified with dilute hydrochloric acid until it just showed an acid reaction towards Congo-red, and immediately extracted by means of ether. The ethereal extract was dried, the ether removed by evaporation, and the residual oil very rapidly distilled under diminished pressure. In this way the acid was obtained as a yellow oil, which did not crystallise. An analysis showed that it consisted chiefly of free hydroxy-acid:

0.1340 gave 0.2560 CO_2 and 0.0900 H_2O . $\text{C}=52.1$; $\text{H}=7.5$.

$\text{C}_9\text{H}_{16}\text{O}_5$ required $\text{C}=52.9$; $\text{H}=7.8$ per cent.

A determination of the basicity showed that it contained a small amount of lactone:

0.1503 required for neutralisation 0.0432 NaOH .

A dibasic acid, $\text{C}_9\text{H}_{16}\text{O}_5$, requires 0.0589 NaOH .

After being boiled with excess of $N/10$ -sodium hydroxide:

0.1503 required 0.0590 NaOH .

Decomposition of β -Hydroxy- $\alpha\beta$ -trimethyladipic Acid: Production of Lævulic and isoButyric Acids.

Five grams of the oily β -hydroxy- $\alpha\beta$ -trimethyladipic acid were mixed with five times the volume of 20 per cent. sulphuric acid, and submitted to distillation in a rapid current of steam. An oil distilled over, which was identified as isobutyric acid by ether extraction, distillation, and analysis. (Found, $\text{C}=54.1$; $\text{H}=9.3$. Calc., $\text{C}=54.5$; $\text{H}=9.1$ per cent.) The residue from the steam distillation on repeated extraction with ether yielded lævulic acid.

Ethyl Ester of the Lactone of β -Hydroxy- $\alpha\beta$ -trimethyladipic Acid (IV).

This ester was prepared by Blaise by the interaction of the silver salt of the acid lactone and ethyl iodide. It can also be prepared in a pure state by gently heating on the water-bath equimolecular amounts of impure diethyl β -hydroxy- $\alpha\beta$ -trimethyladipate and phosphorus pentabromide. The resulting product was cooled, poured into ethyl alcohol, allowed to remain for some time, and the alcoholic solution poured into water. The oil which separated was extracted with ether, the ether evaporated, and the residue, without any further purification, boiled for four hours with twice its volume of diethylaniline. The resulting solution was then poured into dilute hydrochloric acid, and the lactone ester extracted by means of ether and distilled. The ester is a colourless oil boiling at $165\text{--}168^\circ/18$ mm. (Found, $\text{C}=61.6$; $\text{H}=8.2$. $\text{C}_{11}\text{H}_{14}\text{O}_4$ requires $\text{C}=61.7$; $\text{H}=8.4$ per cent.)

Lactone of β -Hydroxy- $\alpha\alpha\beta$ -trimethyladipic Acid (VI).

This lactone was produced by the action of an aqueous solution of hydrogen bromide saturated at 0° on diethyl β -hydroxy- $\alpha\alpha\beta$ -trimethyladipate by gentle heating on a water-bath for about four hours. At the end of this time the product was poured into water, and the acid extracted by means of ether. On removal of the ether the residual oil crystallised. The acid was freed from adhering oil by means of porous porcelain and purified by recrystallisation from dry ether. It crystallises in large, colourless prisms, melting at $108\text{--}109^\circ$:

0.1180 gave 0.2495 CO_2 and 0.0792 H_2O . $\text{C}=57.6$; $\text{H}=7.5$.

$\text{C}_9\text{H}_{14}\text{O}_4$ requires $\text{C}=58.0$; $\text{H}=7.5$ per cent.

0.2372 required for neutralisation 0.0496 NaOH .

A monobasic acid, $\text{C}_9\text{H}_{14}\text{O}_4$, requires 0.0510 NaOH .

After being boiled with excess of $N/10$ -sodium hydroxide:

0.2372 required 0.1022 NaOH .

A lactonic acid, $\text{C}_9\text{H}_{14}\text{O}_4$, requires 0.1020 NaOH .

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