XXIII.—*The Atmospheric Oxidation of β -Methylhydrindone.*

By ARTHUR H. SALWAY, Ph.D., B.Sc., and F. STANLEY KIPPING.

A SMALL quantity of β -methylhydrindone, $\text{C}_6\text{H}_4\langle\begin{smallmatrix}\text{CH}_2 \\ \text{CO}\end{smallmatrix}\rangle\text{CH}\cdot\text{CH}_3$ (Kipping and Clarke, *Trans.*, 1903, **83**, 913), which had been freely exposed to the atmosphere for some time, was found to have deposited a considerable proportion of a crystalline solid. The object of the present investigation was to ascertain the nature of this transformation, and the results have shown that when this cyclic ketone is exposed to an atmosphere of oxygen, the latter is gradually absorbed with the formation of a mixture of oxidation products; from this mixture two acids, melting at 119 — 120° and 210° respectively, were isolated in small quantity, and these compounds were ultimately identified as benzylmethylketone-*o*-carboxylic acid and phthalic acid respectively. A small proportion of acetic acid and of a neutral compound melting at 211° were also separated; the amount of the latter substance was insufficient for further examination.

Several examples of the atmospheric oxidation of cyclic ketones are already on record. Miller (*Ber.*, 1892, **25**, 2095) has shown that β -phenylhydrindone, when shaken in ethereal solution with aqueous sodium carbonate, is oxidised to phenylbenzylketone-*o*-carboxylic acid, $\text{C}_6\text{H}_5\cdot\text{CO}\cdot\text{CH}_2\cdot\text{C}_6\text{H}_4\cdot\text{CO}_2\text{H}$, and β -hydroxy- β -phenylhydrindone,

but the formation of phthalic acid was not observed. Harries, on the other hand (*Ber.*, 1901, **34**, 2105), has recorded the fact that carvone,

$\text{CMe}\langle\begin{smallmatrix}\text{CH}\cdot\text{CH}_2 \\ \text{CO}-\text{CH}_2\end{smallmatrix}\rangle\text{CH}\cdot\text{CMe}\cdot\text{CH}_2$, is slowly oxidised by atmospheric oxygen in the presence of barium hydroxide solution, with the formation of 1-methyl-4-propenyldihydroresorcinol,

Our experiments seem to indicate that the presence of alkalis has no appreciable influence on the atmospheric oxidation of β -methylhydrindone.

In order to account for this unusual example of the disruption and subsequent degradation of a cyclic compound under the influence of atmospheric oxygen, it is necessary to assume that the ketone is first transformed into the enolic modification, $\text{C}_6\text{H}_4\langle\begin{smallmatrix}\text{CH}_2 \\ \text{C}(\text{OH})\end{smallmatrix}\rangle\text{CMe}$. It is

then highly probable that the unsaturated grouping, $\text{CH}_3 \cdot \dot{\text{C}} : \dot{\text{C}} \cdot \text{OH}$, forms an additive product, $\text{CH}_3 \cdot \dot{\text{C}} - \dot{\text{C}} \cdot \text{OH}$, with oxygen in much the same manner as unsaturated compounds, $\text{R} \cdot \dot{\text{C}} : \dot{\text{C}} \cdot \text{R}$, form ozonides, $\text{R} \cdot \dot{\text{C}} - \dot{\text{C}} \cdot \text{R}$, with ozone; on treatment with water this additive product is decomposed with the formation of benzylmethylketone-*o*-carboxylic acid, the enolic modification of which undergoes a similar series of transformations with the ultimate formation of phthalic and acetic acids:

The fact that under ordinary conditions β -methylhydrindone seems to consist entirely of the ketonic form, which immediately passes into the enolic modification in presence of alkalis (Kipping, Proc., 1902, 18, 34), does not invalidate this view of the mechanism of the oxidation process; the latter change takes place only very slowly, and even after several years' exposure to the atmosphere in an open beaker, a considerable proportion of the ketone is not yet oxidised.

The oxidation products, obtained by the action of potassium permanganate on β -methylhydrindone under varied conditions, were also examined. A considerable quantity of the ketone was always oxidised to phthalic acid, and variable amounts of *o*-carboxybenzoylformic acid, $\text{CO}_2\text{H} \cdot \text{C}_6\text{H}_4 \cdot \text{CO} \cdot \text{CO}_2\text{H}$, were obtained. In no case, however, was it possible to isolate the compound,

which is formed by the atmospheric oxidation of the ketone.

α -Hydrindone, like β -methylhydrindone, undergoes change on exposure to air, and is slowly converted into a brown oil, but we have not had an opportunity of investigating the nature of this product.

EXPERIMENTAL.

Atmospheric Oxidation of β -Methylhydrindone.

A number of experiments were carried out for the purpose of determining the most favourable conditions for the rapid oxidation of the

ketone by air, but the results were inconclusive. The rate of oxidation was not appreciably increased by agitating ethereal solutions of the ketone with air in the presence of alkalis, and apparently the following method gave the best results. Thin layers of β -methylhydrindone were exposed for a long time to an atmosphere of moist oxygen, which was renewed at frequent intervals. After several months' exposure, the mixture of unchanged ketone and its oxidation products was digested with chloroform and the insoluble solid collected. This solid, which amounted to about 5 per cent. of the ketone employed in the oxidation, was acid in character, and melted, showing some decomposition, at 210° . It was purified by recrystallisation from water, and was thus obtained in clusters of colourless plates, which melted and decomposed at 212° when heated rapidly:

0.1336 gave 0.2834 CO_2 and 0.0473 H_2O . $\text{C} = 57.9$; $\text{H} = 3.9$.

$\text{C}_8\text{H}_6\text{O}_4$ requires $\text{C} = 57.8$; $\text{H} = 3.6$ per cent.

0.0934 required for neutralisation 11.1 c.c. $N/10$ -NaOH. M.W. = 168.

A dibasic acid, $\text{C}_8\text{H}_6\text{O}_4$, requires M.W. = 166.

The analysis and titration indicated phthalic acid, and the identity of this oxidation product with that acid was confirmed by evaporating a portion of the product with acetic chloride, when it was converted into phthalic anhydride melting at 128° .

The chloroform solution, from which the phthalic acid had been removed as above described, was shaken with an aqueous solution of sodium carbonate until all acid had been removed. The alkaline extract was of a yellowish-red colour and, on acidification with dilute sulphuric acid, yielded an oil which rapidly became solid. This was completely extracted with ether, the ethereal solution washed with a little water, dried, and the ether removed, when a light brown, soft solid, amounting to about 20 per cent. of the ketone employed in the oxidation, was obtained. This product was crystallised several times from a mixture of benzene and light petroleum, from which it was deposited in radiating clusters of colourless needles melting at 119 — 120° :

0.1474 gave 0.3636 CO_2 and 0.0744 H_2O . $\text{C} = 67.3$; $\text{H} = 5.6$.

$\text{C}_{10}\text{H}_{10}\text{O}_3$ requires $\text{C} = 67.4$; $\text{H} = 5.6$ per cent.

0.1381 required for neutralisation 7.9 c.c. $N/10$ -NaOH. M.W. = 175.

A monobasic acid, $\text{C}_{10}\text{H}_{10}\text{O}_3$, requires M.W. = 178.

The only possible monobasic acid of the empirical formula $\text{C}_{10}\text{H}_{10}\text{O}_3$, which could be produced by the oxidation of β -methylhydrindone, is benzylmethylketone-*o*-carboxylic acid, $\text{CH}_3 \cdot \text{CO} \cdot \text{CH}_2 \cdot \text{C}_6\text{H}_4 \cdot \text{CO}_2\text{H}$. This compound has been already described by Gottlieb (*Ber.*, 1899, 32, 965), who gives its melting point as 118° . The identity of the above

compound with that of Gottlieb was completely established by the preparation of the oxime, which melted at 163° .

The mother liquors from the crystallisation of the above ketonic acid yielded on evaporation a brown oily substance, which showed no signs of crystallising. It was converted into the barium salt, and the latter fractionated, but we were unable to isolate any definite compound from it.

The chloroform solution containing the neutral products of oxidation was washed free from alkali, dried, and the chloroform evaporated. The residual oil was then distilled in a current of steam to remove unchanged methylhydrindone. There remained a small quantity of a semi-solid oil, amounting to about 3 per cent. of the ketone employed in the oxidation. It was extracted with ether, the ethereal solution dried, and the ether removed. The residue was dissolved in a little hot alcohol, and, after long standing, colourless needles melting at 211° were deposited. This substance was insoluble in water or light petroleum, but readily soluble in alcohol or benzene. It was not obtained in sufficient quantity for further examination. The mother liquors still contained a large proportion of this substance, and an attempt was made to isolate it from these in the form of an oxime, but without success.

The formation of acetic acid by the atmospheric oxidation of β -methylhydrindone was proved in a separate experiment. A quantity of the ketone was left for some time freely exposed to air in the presence of sodium carbonate, and ultimately acidified and distilled in a current of steam. The distillate was shaken once with ether to remove unchanged ketone, neutralised with barium hydroxide, and concentrated. The concentrated solution gave the reactions of an acetate.

Oxidation of β -Methylhydrindone with Potassium Permanganate.

Ten grams of β -methylhydrindone were shaken with water to form an emulsion, and a 2 per cent. solution of alkaline potassium permanganate (14 grams) added drop by drop with continual agitation at the ordinary temperature. When all had been added, the mixture was distilled in a current of steam to remove unchanged ketone, and then filtered. The alkaline filtrate was concentrated to a small bulk, acidified with dilute sulphuric acid, and extracted several times with ether. From the ethereal solution there was obtained a yellowish-brown oil, which soon became solid. It was digested with chloroform, and the insoluble portion collected. This amounted to 2 grams, and was identified as phthalic acid. The chloroform filtrate yielded on evaporation an oily acid which did not crystallise. It was purified by

conversion into the barium salt, which separated from water in well-formed hexagonal plates :

0.2534, dried at 105° , gave 0.1790 BaSO_4 . $\text{Ba} = 41.5$.

$\text{C}_9\text{H}_4\text{O}_5\text{Ba}$ requires $\text{Ba} = 41.6$ per cent.

The free acid corresponding with this barium salt was regenerated by the addition of dilute sulphuric acid and extracted with ether. The ethereal extract was washed with a few drops of water, dried, and the ether removed. An oily residue was obtained, which, after long standing, solidified to a hard, crystalline mass. It then melted at 143° :

0.1470 gave 0.2991 CO_2 and 0.0450 H_2O . $\text{C} = 55.5$; $\text{H} = 3.4$.

$\text{C}_9\text{H}_6\text{O}_5$ requires $\text{C} = 55.7$; $\text{H} = 3.1$ per cent.

The analysis and the properties of the above compound prove that it is identical with *o*-carboxybenzoylformic acid (compare Scherks, *Ber.*, 1885, **18**, 379, and Henriques, *Ber.*, 1888, **21**, 1609).

Other oxidation experiments, in which the amount of permanganate was varied from one atom of oxygen upwards per molecule of β -methylhydrindone, were carried out, but in all cases phthalic and *o*-carboxybenzoylformic acids were formed in variable amounts, and no other product of oxidation could be isolated.

If, on the other hand, hydrogen peroxide is employed as the oxidising agent, the reaction is apparently not more rapid than in the case of atmospheric oxidation.

The Action of Bromine on β -Methylhydrindone.

Bromine water was caused to react with β -methylhydrindone with the object of ascertaining whether oxidation products other than phthalic acid could be obtained. On adding bromine water to an emulsion of the ketone with water and heating to 100° the bromine was readily absorbed, with the formation of an oily product, which rapidly solidified on cooling. This solid was collected and recrystallised from alcohol, from which it was deposited in large, flat prisms melting at $72-73^{\circ}$:

0.1771 gave 0.3485 CO_2 and 0.0661 H_2O . $\text{C} = 53.7$; $\text{H} = 4.1$.

0.3378 „ 0.2829 AgBr . $\text{Br} = 35.6$.

$\text{C}_{10}\text{H}_9\text{OBr}$ requires $\text{C} = 53.3$; $\text{H} = 4.0$; $\text{Br} = 35.6$ per cent.

These results indicate that the compound is a monobromo-substitution product of β -methylhydrindone.

Monobromo- β -methylhydrindone, $\text{C}_{10}\text{H}_9\text{OBr}$, crystallises from alcohol in colourless, well-formed prisms melting at $72-73^{\circ}$. It is readily soluble in the usual organic solvents, except light petroleum. It is best prepared by adding a slight excess of bromine to β -methyl-

hydrindone in chloroform solution, and removing the excess of halogen by means of dilute sodium hydroxide. When it is oxidised with potassium permanganate in alkaline solution, phthalic acid is formed, which proves that the substitution has not taken place in the nucleus. Its constitution, therefore, is in all probability,

UNIVERSITY COLLEGE
NOTTINGHAM.