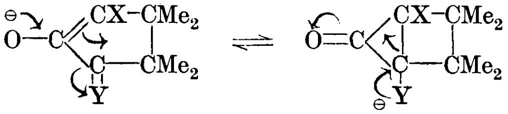
CCXLII.—*On the Possibility of Ring-chain Valency Tautomerism, and of a Type of Mobile-hydrogen Tautomerism analogous to the Wagner–Meerwein Re-arrangement. Part III. Orientation of some Cyclic Derivatives of Phorone.*

By CHRISTOPHER KELK INGOLD and CHARLES WILLIAM SHOPPEE.

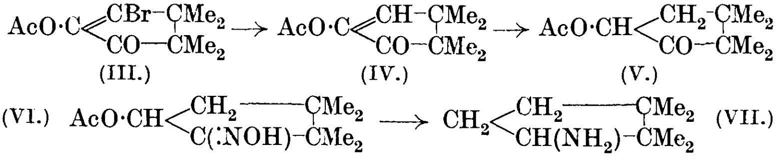
FRANCIS and WILLSON (J., 1913, **103**, 2238), who first examined the cyclic derivatives of phorone, ascribed formulæ of type II, but in Part I (this vol., p. 365) it was shown that formulæ of type I are also necessary in order fully to account for the reactions of the substances.

(I.)

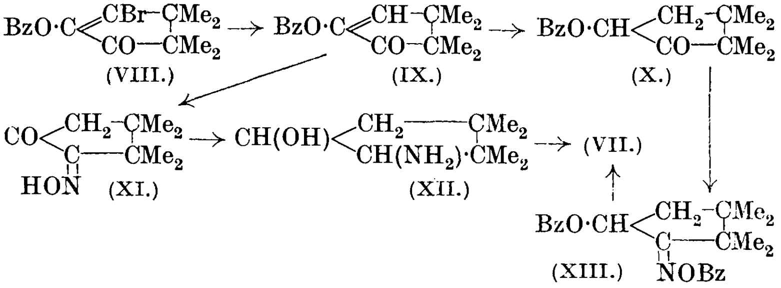


(II.)

Amongst the derivatives studied in Part I was a series of acyl and alkyl derivatives of " bromohydroxyphorone " and hydroxyphorone (X = H, Br; Y = O). The acetoxy- and methoxy-compounds were definitely shown to have structure I, and this has now been confirmed as regards the acetoxy-derivatives (III) and (IV) by the preparation of the crystalline *oxime* (VI) of the dihydro-compound (V) : the oxime, on complete reduction, yields 2 : 2 : 3 : 3-tetramethyl*cyclo*pentylamine (VII).



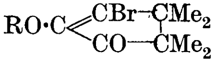
The benzoyloxy-derivatives (VIII) and (IX) were not definitely oriented in the previous communication, but a number of reactions were studied, and of these the most significant is the formation of an oxime, to which formula (XI) was assigned, from the benzoyloxy-compound (IX) with extrusion of the benzoyl group.



The reaction was illustrated by means of Francis and Willson's formula, but it was pointed out that definite structural conclusions could not be reached without knowledge as to whether the oximino-group enters the same position as, or another position than, that from which the extruded benzoyl group had been removed. This point has now been elucidated. In the first place, the constitution assigned to the oxime has been confirmed by reduction *via* the hydroxy-amine (XII) to 2 : 2 : 3 : 3-tetramethyl*cyclo*pentylamine (VII). Secondly, the benzoyloxy-compound, although unaffected both by zinc and by sodium amalgam in acetic acid, was successfully reduced to a dihydro-derivative (X) by means of hydrogen in the presence of palladised barium sulphate. This compound is identical with the more fusible benzoyl derivative of tetramethyl*cyclo*-pentanolone, described in Part II (this vol., p. 1662), in which the constitution of the derivative was definitely established by the conversion of its benzoyloxime (XIII) into 2 : 2 : 3 : 3-tetramethyl*cyclo*pentylamine. These reactions show that the benzoyloxybromo- and benzoyloxy-compounds possess the structures (VIII) and (IX) and that in the oximination of the latter the benzoyl group is extruded from another position than that into which the oximino-group is introduced.

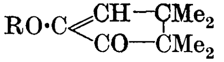
The action of hydroxylamine in causing the fission of an ester grouping in this and in some other parallel cases which are recorded in the experimental portion appears to be analogous to the process of hydrolysis, and we have confirmed the fact that hydroxylamine may exhibit this action on simple substances by showing that phenyl benzoate is broken down into phenol and benzoic acid by boiling with hydroxylamine in alcohol.

Investigation of the *p*-bromobenzyloxybromo- and *p*-bromobenzyloxy-compounds (XIV) and (XV) has shown that these possess structures similar to those of the benzoyl derivatives. The *p*-bromobenzyloxy-compound (XV) is extremely resistant to reduction and it had been found (this vol., p. 376) to yield an oxime (XVI) which, when reduced, gave a hydroxy-amine isomeric with that obtained by reduction of the oxime (XI). The former hydroxyamine has now been reduced to 2 : 2 : 3 : 3-tetramethyl*cyclo*pentylamine and must therefore be a geometrical and not a position isomeride.



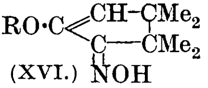
$\mathrm{RO{\cdot}C}\Big\langle\begin{array}{l}\mathrm{CBr-CMe_2}\\ \mathrm{CO-CMe_2}\end{array}$

(XIV.)



$\mathrm{RO{\cdot}C}\Big\langle\begin{array}{l}\mathrm{CH-CMe_2}\\ \mathrm{CO-CMe_2}\end{array}$

(XV.)

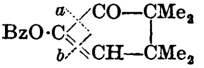
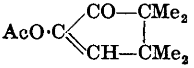
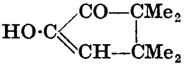
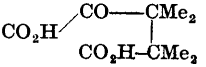
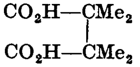
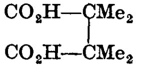
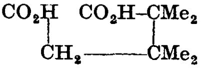
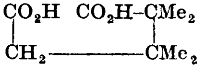


$\mathrm{RO{\cdot}C}\Big\langle\begin{array}{l}\mathrm{CH-CMe_2}\\ \mathrm{C-CMe_2}\\ \mathrm{\|}\\ \mathrm{NOH}\end{array}$

(XVI.)

($R = C_7H_6Br$.)

Part I recorded a study of the oxidation of hydroxybromo- and hydroxy-phorone and certain derivatives, and it was suggested that the observations could best be interpreted on the assumption that the monocyclic unsaturated forms of these substances could undergo oxidative fission in two directions (*a*) and (*b*) (formulæ below). These studies have now been extended with results which are shown in the table below and appear to suggest that the normal mode of fission produced by oxidation with potassium ferricyanide is at (*b*) whilst fission with hydrogen peroxide occurs preferentially at (*a*).

Substance oxidised.	 $\mathrm{BzO{\cdot}C}\Big\langle\begin{array}{l}\overset{a}{}\mathrm{CO-CMe_2}\\ \overset{b}{}\mathrm{CH-CMe_2}\end{array}$	 $\mathrm{AcO{\cdot}C}\Big\langle\begin{array}{l}\mathrm{CO-CMe_2}\\ \mathrm{CH-CMe_2}\end{array}$	 $\mathrm{HO{\cdot}C}\Big\langle\begin{array}{l}\mathrm{CO-CMe_2}\\ \mathrm{CH-CMe_2}\end{array}$
Product with ferricyanide.	 $\mathrm{CO_2H}\diagup\begin{array}{l}\mathrm{CO-CMe_2}\\ \mathrm{CO_2H-CMe_2}\end{array}$	 $\begin{array}{l}\mathrm{CO_2H-CMe_2}\\ \mathrm{CO_2H-CMe_2}\end{array}$	 $\begin{array}{l}\mathrm{CO_2H-CMe_2}\\ \mathrm{CO_2H-CMe_2}\end{array}$
Product with hydrogen peroxide.	 $\begin{array}{ll}\mathrm{CO_2H} & \mathrm{CO_2H-CMe_2}\\ \mathrm{CH_2} & \mathrm{-CMe_2}\end{array}$	—	 $\begin{array}{ll}\mathrm{CO_2H} & \mathrm{CO_2H-CMe_2}\\ \mathrm{CH_2} & \mathrm{-CMe_2}\end{array}$

EXPERIMENTAL.

5-*Acetoxy*-2 : 2 : 3 : 3-*tetramethyl*cyclo*pentanoneoxime* (VI).—The pure dihydroacetoxy-derivative, b. p. 120—121°/10 mm. (3·0 g.), hydroxylamine hydrochloride (1·2 g.), and anhydrous sodium acetate (1·4 g.) were heated together in absolute alcoholic solution on the steam-bath for 3 hours. On pouring the product into water, an oil was precipitated, the ethereal extract of which was washed with sodium hydrogen carbonate solution, dried, and evaporated. The pale yellow oil obtained did not crystallise after being kept for 2 months; the ethereal solution was therefore treated with dry hydrogen chloride at 0°, and the *oxime hydrochloride* was obtained as a colourless crystalline solid, m. p. 136—137° (with evolution of hydrogen chloride).

Solution in 2*N*-sodium carbonate and extraction with ether yielded the *oxime* as a rapidly solidifying oil. It separated from ligroin (b. p. 40—60°) in well-formed prisms, m. p. 93° (Found: C, 61·9; H, 9·2. $C_{11}H_{19}O_3N$ requires C, 62·0; H, 9·0%).

Reduction of the oxime (VI). The oxime (1·0 g.) was reduced with $2\frac{1}{2}$% sodium amalgam (50 g.) by the method given in Part I (this vol., p. 393), and the product identified as 2 : 2 : 3 : 3-tetramethyl*cyclo*pentylamine.

Reduction of the oxime (XI). The oxime was first reduced in the usual manner with sodium amalgam and glacial acetic acid; the basic portion of the product was then boiled with hydriodic acid (*d* 1·7) and red phosphorus under reflux for 2 hours. The product was distilled in steam, the distillate being disregarded; the contents of the flask were then made strongly alkaline and again steam-distilled. The ethereal extract of the distillate, dried with anhydrous potassium carbonate, was evaporated to small bulk under a column, and treated with ethereal picric acid. The resulting picrate was identified as that of 2 : 2 : 3 : 3-tetramethyl*cyclo*pentylamine.

Reduction of 5-Benzoyloxy-2 : 2 : 3 : 3-tetramethyl-Δ^4-cyclo*pentenone with Palladium and Hydrogen* (IX).—When an acetic acid solution of the pure derivative, m. p. 68° (1·9 g.), was shaken with palladised barium sulphate (equivalent to 0·5 g. palladium) in an atmosphere of hydrogen at ordinary pressure, absorption ceased after 1 hour, 150 c.c. being taken up (calc. for 1 mol. of hydrogen, 160 c.c.). The mixture was poured into water, and an ethereal extract of the product was washed twice with ice-cold 5% sodium hydroxide solution and dried with calcium chloride. Evaporation yielded the reduction product as a rapidly crystallising oil. It separated from ligroin (b. p. 40—60°) in pearly plates, m. p. 60°. Identity was established by mixed melting points and by analysis (Found: C, 73·6; H, 8·0. Calc. for $C_{16}H_{20}O_3$: C, 73·8; H, 7·7%).

Reduction of 5-p-*Bromobenzyloxy*-2 : 2 : 3 : 3-*tetramethyl*-Δ^4-cyclo*pentenone* (XV).—The pure derivative (1·5 g.) in glacial acetic acid solution was shaken with palladised barium sulphate and hydrogen (pressure, 30 lb./sq. in.). Little absorption took place, and the bulk of the product was recovered unchanged. A substance, m. p. 26—27°, was isolated, but the quantity was insufficient for analysis.

Reduction of the Acetyl Derivative of 5-p-*Bromobenzyloxy*-2 : 2 : 3 : 3-*tetramethyl*-Δ^4-cyclo*pentenoneoxime* (XVI).—The acetoxime (1·0 g.) was reduced with 2½% sodium amalgam (100 g.) in acetic acid in the usual manner, and the basic portion of the product isolated and converted into the picrate of 5-hydroxy-2 : 2 : 3 : 3-tetramethyl-*cyclo*pentylamine, m. p. 210—215° (decomp.) (compare this vol., p. 403). The picrate was boiled for 2 hours under reflux with hydriodic acid (*d* 1·7) and red phosphorus, and the liquid was made alkaline and steam-distilled. The reduction product was isolated by extraction with ether and identified as 2 : 2 : 3 : 3-tetramethyl-*cyclo*pentylamine by conversion into the picrate.

Fission of Esters in Presence of Hydroxylamine.—Phenyl benzoate. The ester (2·0 g.), dissolved in absolute alcohol (20 c.c.), was treated with hydroxylamine hydrochloride (0·7 g.) and anhydrous sodium acetate (0·85 g.) on the steam-bath for 1 hour. The product was worked up into neutral, acid, and quasi-acid fractions : the latter two yielded benzoic acid and phenol respectively. The benzoic acid weighed 0·23 g., which is equivalent to 20% hydrolysis. A blank experiment in which the hydroxylamine hydrochloride was omitted yielded no trace of benzoic acid or phenol.

5-*Benzoyloxy*-2 : 2 : 3 : 3-*tetramethyl*cyclo*pentanone* (X). The derivative (1·0 g.), hydroxylamine hydrochloride (1·0 g.), and anhydrous sodium acetate (1·2 g.), when similarly treated for 3 hours, gave an oily oxime (compare this vol., p. 1669) and practically pure benzoic acid (yield, 0·25 g.).

5-*Methoxy*-2 : 2 : 3 : 3-*tetramethyl*-Δ^4-cyclo*pentenone.* When the methoxy-compound was similarly treated with hydroxylamine hydrochloride (several mols.) and anhydrous sodium acetate for 3 hours, the product consisted mainly of a solid, together with a trace of oil. The solid was washed with ligroin and crystallised twice from boiling alcohol; it then had m. p. 210—211° (decomp.) (Found : C, 58·6, 58·7; H, 8·8, 8·7; N, 14·6, 14·6. Calc. for $C_9H_{16}O_2N_2$: C, 58·7; H, 8·7; N, 15·0%) and was identified as the dioxime of 3 : 3 : 4 : 4-tetramethyl*cyclo*pentan-1 : 2-dione by direct comparison and by mixed melting point.

Oxidation of 5-*Benzoyloxy*-2 : 2 : 3 : 3-*tetramethyl*-Δ^4-cyclo*pentenone* (IX).—(A) *With potassium ferricyanide.* The benzoyloxy-compound (1·0 g.) and anhydrous potassium carbonate (2·0 g.), dissolved in dilute alcohol, were treated at 60° with potassium ferricyanide (9·3 g.) in alcoholic solution during 5 days, and the mixture was left for 5 days at the same temperature. The solution was acidified and the acid products were removed with ether; on evaporation a mixture of solid acids was obtained. After successive removals of benzoic acid, by solution in water, cooling to 0° and filtration, an acid was obtained which, after crystallisation from ethyl acetate–ligroin, had m. p. 140° and was identified as the lactonic acid of $\gamma\gamma$-dihydroxy-$\alpha\alpha\beta\beta$-tetramethylglutaric acid by mixed melting point and by hydrolysis (Found: C, 53·2; H, 6·9. Calc. for $C_9H_{14}O_5$: C, 53·4; H, 6·9%).

(B) *With hydrogen peroxide.* The derivative (0·5 g.), dissolved in an aqueous acetone solution of sodium carbonate containing a trace of ferrous sulphate, was treated with 2·4 c.c. of 3% hydrogen peroxide at 0°. Benzoic acid was precipitated on acidification and removed by filtration. From the filtrate, an acid was obtained which, after two crystallisations from ethyl acetate–ligroin, had the characteristic form and m. p. (144°) of $\alpha\alpha\beta\beta$-tetramethylglutaric acid. The melting point of a mixture with a genuine specimen was 143—144°, but that of a mixture with the above lactonic acid was depressed to 115—120°.

Oxidation of 5-Acetoxy-2 : 2 : 3 : 3-tetramethyl-Δ^4-cyclo*pentenone* (IV).—The pure acetoxy-compound was prepared from the hydroxyketone by treatment with acetyl chloride in pyridine solution. The pale yellow oil (0·5 g.) and anhydrous potassium carbonate (1·0 g.), dissolved in dilute alcohol, were treated with alcoholic potassium ferricyanide (5·0 g.), added during 3 days, and the mixture was left for 3 days at 45°. After extraction with ether, the liquid was acidified and again extracted with ether. This extract yielded a solid acid which, after crystallisation from ethyl acetate–ligroin, had m. p. 190° and was identified as tetramethylsuccinic acid. The yield was poor and the neutral ethereal extract gave some unchanged acetoxy-compound on evaporation.

Oxidation of 2 : 2 : 3 : 3-Tetramethyl-Δ^5-cyclo*penten-5-ol-4-one* (*2 : 2 : 3 : 3-Tetramethyl-*[0,1,2]-dicyclo*pentan-4-ol-5-one*).—This was carried out with the quantities and by the procedure given above for the acetoxy-compound. A good yield of tetramethylsuccinic acid, m. p. 190° after crystallisation from ethyl acetate–ligroin, was obtained.

One of us (C. W. S.) wishes to record his indebtedness to the Royal Commission of 1851 for a Senior Studentship.

THE UNIVERSITY, LEEDS. [*Received, May 25th,* 1928.]