231. *The Interaction of β-Ionone with Halides in the Presence of Lithium, and a Synthesis of* 1 : 6-*Dimethylnaphthalene.*

By F. B. Kipping and F. Wild.

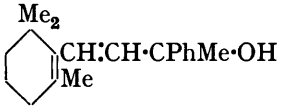
The interaction of β-ionone and methyl iodide in the presence of lithium is shown to give a tertiary *alcohol* (by simple addition to the carbonyl group), which has been dehydrated to a *triene*; the structure of these compounds is proved by chemical and physical evidence. Bromobenzene reacts in a similar manner. A new unambiguous synthesis of 1 : 6-dimethylnaphthalene is described.

Karrer, Salomon, Morf, and Walker (*Helv. Chim. Acta*, 1932, **15**, 878) found that the reaction between allylmagnesium bromide and β-ionone gave a compound which was not the expected tertiary alcohol. We have found that in the cases of methyl- and phenylmagnesium halides no carbinols were present in the complex reaction mixture (Zerewitinoff), the constituents of which were unidentified.

The normal compounds have been obtained from β-ionone and halides, lithium replacing magnesium in the reaction. A typical example is that between methyl-lithium and β-ionone; instead of preparing the metal alkyl in the usual manner, a mixture of the ketone and methyl iodide in dry ether was slowly added to lithium clippings in anhydrous ether containing a trace of methyl-lithium. The product contained a hydroxyl group, and from its ozonolysis products geronic acid was isolated as the semicarbazone. This compound, δ-2 : 6 : 6-*trimethyl*-Δ^1-cyclo*hexenyl*-β-*methyl*-Δ^γ-*buten*-β-*ol* (I), on elimination of water yielded the *triene* (II). Chromic acid oxidation of the triene produced acetic acid, and after titration this was isolated as the sodium salt and characterised by the formation of the *p*-nitrobenzyl ester. Ozonolysis of (II) produced geronic acid, which shows the presence of the β-ionone nucleus, and a Diels–Alder reaction between (II) and maleic anhydride established that two double bonds are in conjugation. Additional evidence in

(I.)

(II.)



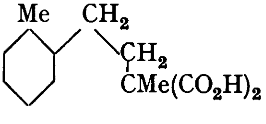
(III.)

favour of structure (II) was provided by the formation of 1 : 6-dimethylnaphthalene by treatment with selenium, and from spectroscopic evidence, which gave absorption bands in the expected region.

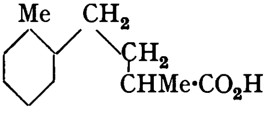
A similar reaction was carried out with bromobenzene, and the tertiary *alcohol* (III) obtained in good yield.

The reaction with allyl iodide produced a very small amount of distillable substance, which contained no hydroxyl group and was identified as the compound isolated by Karrer. The residue on treatment with methylmagnesium iodide liberated methane, indicating the presence of hydroxyl groups; as distillation was found to be impossible, dehydration of the crude residue was carried out, but no pure compound could be isolated.

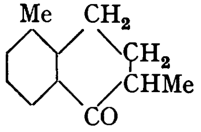
As an unambiguous synthesis of 1 : 6-dimethylnaphthalene has never been described, the following was devised: β-*o*-Tolylethyl alcohol, obtained from magnesium, *o*-bromotoluene, and ethylene oxide (cf. McQuillin and Robinson, J., 1938, 1099), was converted by the action of phosphorus tribromide (modification of Shoesmith and Connor, J., 1927, 1771) into the corresponding bromide, which was condensed with ethyl methylmalonate, and the product hydrolysed to *methyl-β-o-tolylethylmalonic acid* (IV); on heating, this was converted into the substituted butyric acid (V), cyclisation of which yielded 1 : 6-dimethyltetralone (VI); reduction gave 1 : 6-dimethyl-5 : 6 : 7 : 8-tetrahydronaphthalene (VII) (Mayer and Schultze, *Ber.*, 1922, **55**, 2164), and 1 : 6-dimethylnaphthalene was then obtained in good yield by a selenium dehydrogenation.



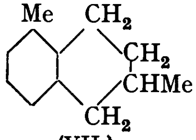
(IV.)



(V.)



(VI.)



(VII.)

EXPERIMENTAL.

δ-2 : 6 : 6-*Trimethyl*-Δ^1-cyclo*hexenyl-β-methyl*-Δ^{γ}-*buten-β-ol* (I).—A mixture of β-ionone (10 g.) and methyl iodide (8 g.) in absolute ether (50 c.c.) was added to lithium clippings (1 g.) and dry ether (20 c.c.), containing a trace of methyl-lithium, at such a rate that the ether was kept gently refluxing. The mixture was then refluxed for 15 minutes and kept overnight. Isolation of the product was carried out in the usual manner; distillation then gave 6—8 g. (56—73%) of (I), b. p. 89—90°/0·2 mm. (Found: C, 80·7; H, 11·4. $C_{14}H_{24}O$ requires C, 80·75; H, 11·5%). Estimation of hydroxyl group (Zerewitinoff), 1·05. Estimation of double bonds by catalytic reduction, 1·94.

Ozonolysis of (I) (cf. Heilbron, Johnson, and Jones, J., 1939, 1563).—A solution of (I) (1·5 g.) in dry carbon tetrachloride (40 c.c.) was ozonised during 12 hours, the solid which was deposited dissolved by the addition of glacial acetic acid (40 c.c.), and ozonisation continued during a further 12 hours. Water (150 c.c.) was added, and the mixture refluxed (1 hour); after evaporation to dryness the residue was refluxed with water (150 c.c.) during 1 hour. An ethereal extract was shaken with small amounts of saturated sodium bicarbonate solution, and the alkaline layer neutralised with phosphoric acid and extracted with ether. The residue after the removal of ether was boiled with water (10 c.c.), and to the filtered solution, semicarbazide hydrochloride (0·5 g.) and sodium acetate (1 g.) in water (5 c.c.) were added. Geronic acid semicarbazone was precipitated immediately; after recrystallisation from alcohol and ethyl acetate it had m. p. and mixed m. p. with an authentic specimen 163° (Found: N, 18·0. Calc. for $C_{10}H_{19}O_3N_3$: N, 18·3%).

δ-2 : 6 : 6-*Trimethyl*-Δ^1-cyclo*hexenyl-β-methyl*-$\Delta^{\alpha\gamma}$-*butadiene* (II).—The carbinol (I) (5 g.) and fused potassium hydrogen sulphate (2·7 g.) were heated (oil-bath at 135°) during ½ hour in an atmosphere of nitrogen. The temperature was gradually increased (170—180°), the pressure gradually reduced, finally to 15 mm., and a mixture of the *triene* and water collected. The triene was washed with water, dried over calcium chloride, and fractionated in a vacuum; yield, 1·9—2·7 g. (44—60%), b. p. 113—115°/15 mm. (Found: C, 87·5; H, 11·3. $C_{14}H_{22}$ requires C, 88·4; H, 11·6%).

Maleic anhydride (0·8 g.) in dry benzene (15 c.c.) was added to (II) (1·5 g.) in dry benzene (5 c.c.); the solution immediately became bright yellow. After being kept for 2 days at room temperature, the benzene was removed under reduced pressure, and the thick oil washed with warm water for 5 minutes. The gum solidified after a short time, but recrystallisation was impossible owing to polymerisation taking place at about 50° (cf. Farmer and Warren, J., 1931, 3234). The m. p. of the crude material was 155° (decomp.), and a mixed m. p. with maleic acid showed a depression (125°).

Ozonolysis of (II) was carried out in a similar manner to that of (I). Geronic acid was isolated as the semicarbazone, m. p. and mixed m. p. 163° (Found : N, 18·5. Calc. : N, 18·3%).

Chromic acid (7 g. in 100 c.c. of water and 30 c.c. of 10% sulphuric acid) and (II) (2·2 g.) were refluxed for 3 hours, and the volatile product removed in steam. Titration of the distillate with sodium hydroxide showed the presence of 1 mol. of acetic acid, which was characterised by the preparation of the *p*-nitrobenzyl ester, m. p. and mixed m. p. with an authentic specimen 78° (Found : N, 7·1. Calc. for $C_9H_9O_4N$: N, 7·2%).

The triene (1·5 g.) and selenium (1·5 g.) were heated in a sealed tube at 320—350° during 40 hours. The product was extracted with ether, the solution filtered, the ether removed, and the residue distilled over sodium. The fraction obtained above 200° was added to a warm saturated solution of picric acid in alcohol; an immediate darkening of colour took place and after a short time 1 : 6-dimethylnaphthalene picrate was deposited. Crystallised from alcohol, it had m. p. and mixed m. p. with a synthetic specimen and a specimen obtained by the dehydrogenation of ionene 112—113° (Found : N, 10·8. Calc. for $C_{18}H_{15}O_7N_3$: N, 10·9%). The triene showed absorption bands in the ultra-violet at 2770 A. ($E^{1\%}_{1\,\text{cm.}} = 345$) and 2200 A. ($E^{1\%}_{1\,\text{cm.}} = 400$). With antimony trichloride in anhydrous chloroform a brown colour developed, which became deep blue on standing.

δ-2 : 6 : 6-*Trimethyl*-Δ^1-cyclo*hexenyl*-β-*phenyl*-Δ^γ-*buten*-β-*ol* (III).—A mixture of β-ionone (10 g.) and bromobenzene (10 g.) in absolute ether (50 c.c.) was added to lithium clippings (0·8 g.) in dry ether (30 c.c.), containing a trace of phenyl-lithium, at such a rate that the ether was kept gently refluxing. The mixture was kept overnight, and the *product* isolated in the usual manner; 7·5 g. (53%), b. p. 147—150°/0·1 mm. (Found : C, 84·3; H, 9·9. $C_{19}H_{26}O$ requires C, 84·4; H, 9·6%). Estimation of hydroxyl group (Zerewitinoff), 1·05.

Ozonolysis of (III) was carried out in the usual way; the geronic acid formed was isolated as the semicarbazone, m. p. and mixed m. p. 163° (Found : N, 18·3. Calc. : N, 18·3%).

The above experiment was repeated with allyl iodide and β-ionone : a small fraction was collected (12%) which contained no hydroxyl group (Zerewitinoff); b. p. 139°/12 mm. (Found : C, 81·8; H, 11·0. Calc. for $C_{16}H_{26}O$: C, 82·0; H, 11·1%) (cf. Karrer, Salomon, Morf, and Walker, *loc. cit.*). A qualitative estimation of the undistillable residue (8 g.) showed the presence of a hydroxyl group (Zerewitinoff), but dehydration by fused potassium hydrogen sulphate could not be satisfactorily accomplished.

β-o-*Tolylethyl Alcohol* (cf. McQuillin and Robinson, *loc. cit.*).—Gaseous ethylene oxide (36 g.) was passed into a well-stirred solution of the Grignard reagent prepared from *o*-bromotoluene (120 g.) in ether (250 c.c.) at 0—10°. After standing overnight, the mixture was poured into ice and sulphuric acid, and the product isolated in the usual manner; 63 g. (66%), b. p. 124—125°/14 mm. (Found : C, 79·2; H, 8·8. Calc. for $C_9H_{12}O$: C, 79·4; H, 8·8%). The alcohol (0·5 g.) and phenyl *iso*cyanate (0·5 c.c.) gave the phenylurethane, which was filtered off and recrystallised a number of times from light petroleum (b. p. 80—100°) and then from alcohol; m. p. 82·5° (cf. Grignard, *Compt. rend.*, 1905, **141**, 45) (Found : C, 75·35; H, 6·6; N, 5·8. Calc. for $C_{16}H_{17}O_2N$: C, 75·3; H, 6·7; N, 5·5%).

β-o-*Tolylethyl Bromide* (cf. Shoesmith and Connor, J., 1927, 1771).—Phosphorus tribromide (46 g.) was slowly added to ice cold *o*-tolylethyl alcohol (62 g.). After standing overnight in ice, the mixture was heated on a water-bath for ½ hour and poured on ice. Ether extracted the bromide, which was fractionated under reduced pressure; b. p. 110°/15 mm., yield, 66 g. (71·5%).

Ethyl Methyl-β-o-*tolylethylmalonate*.—Ethyl methylmalonate (51 g.) was gradually added to a cooled solution of sodium ethoxide (from sodium, 6·75 g., and alcohol, 110 c.c.), followed by *o*-tolylethyl bromide (65 g.) in 5 g. lots; the reaction was completed by heating on a water-bath until the solution was no longer alkaline, and the product was obtained in the usual manner; 30 g. (33·3%), b. p. 184°/10 mm.

Methyl-β-o-*tolylethylmalonic Acid* (IV).—A mixture of the above ester (30 g.) and 20% alcoholic potash (150 c.c.) was heated under reflux during 4 hours. The residue obtained after evaporation to dryness on a water-bath was acidified (Congo-red); an oil separated which solidified on standing. Recrystallisation from benzene gave the *acid* in small needles, m. p. 138°; yield, 21 g. (87%) (Found : C, 65·9; H, 6·5; equiv., by back titration, 118·4. $C_{13}H_{16}O_4$ requires C, 66·1; H, 6·8%; equiv., 118). The p-*nitrobenzyl* ester, prepared from the sodium salt in the usual manner, had m. p. 86° (from alcohol) (Found : C, 63·7; H, 5·4; N, 5·7. $C_{27}H_{26}O_8N_2$ requires C, 64·0; H, 5·15; N, 5·5%).

γ-o-Tolyl-α-methylbutyric Acid (V).—The crude product from the previous experiment (17 g.) was heated (oil-bath temperature gradually raised from 160° to 200°) until all the carbon dioxide was removed. Attempts to crystallise the dark viscous oily product failed, and it was distilled under reduced pressure, yielding 7·5 g. (54%), b. p. 157°/0·12 mm. (with slight decomp.) (Found: equiv., by back titration, 193·5. Calc.: equiv., 192).

1 : 6-*Dimethyltetralone* (VI).—The acid (V) (7·5 g.) was heated in a water-bath (kept at 75—80°) during ½ hour with concentrated sulphuric acid. The mixture was cooled and poured on ice (150 g.); the solid which separated was filtered off and recrystallised from dilute ethyl alcohol, the ketone being obtained in long, colourless, slender needles, m. p. 47°; yield, 4·5 g. (66·2%). The 2 : 4-*dinitrophenylhydrazone*, crystallised from alcohol, had m. p. 219° (decomp.) (Found: N, 15·75. $C_{18}H_{18}O_4N_4$ requires N, 15·8%).

1 : 6-*Dimethyl*-5 : 6 : 7 : 8-*tetrahydronaphthalene* (VII).—A mixture of 1 : 6-dimethyltetralone (3 g.), granulated zinc (25 g.), and 15% hydrochloric acid (60 c.c.) was heated under reflux during 9 hours; at intervals of 1½ hours 10 c.c. of concentrated hydrochloric acid were added. The liquid was allowed to cool, the oily upper layer removed, and the aqueous layer extracted with ether; after removal of the ether the residue was fractionated under reduced pressure, yielding 1·9 g. (64·5%), b. p. 115°/14 mm. (cf. Mayer and Schultze, *loc. cit.*) (Found: C, 90·3; H, 10·25. Calc. for $C_{12}H_{16}$: C, 90·0; H, 10·0%).

1 : 6-*Dimethylnaphthalene*.—1 : 6-Dimethyltetrahydronaphthalene (1·7 g.) and selenium were heated in a sealed tube during 42 hours at 320—350°. The cooled product was extracted with boiling ether, the ether removed, and the residue fractionated from sodium. 1 : 6-Dimethylnaphthalene was collected between 262° and 263°; yield, 0·92 g. (50%). The recorded b. p. is 262—263°.

A saturated alcoholic solution of picric acid was added to a warm specimen of the oil. After a few minutes the picrate was deposited; it was filtered off and recrystallised several times from alcohol; m. p. 113° (lit., m. p. 110—113°), not depressed by a specimen prepared from the dehydrogenation product of ionene (Found: N, 10·8. Calc.: N, 10·9%).

We wish to thank Prof. Heilbron, F.R.S., for the spectroscopic examination of (II), and one of us (F. W.) is indebted to the Department of Scientific and Industrial Research for a maintenance grant.

UNIVERSITY CHEMICAL LABORATORY, CAMBRIDGE.

[*Received, May 27th,* 1940.]