

1057. Studies on Sesquiterpenoids. Part VIII.¹ The Structure of Carabrone, a New Component of *Carpesium abrotanoides*, Linn.²

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A new sesquiterpene lactone, carabrone, was isolated from powdered fruits of *Carpesium abrotanoides* Linn. and established to be perhydro-5a-methyl-3-methylene-5-(3-oxobutyl)-cyclopropa[*f*]benzofuran-2-one (I).

A NEW type sesquiterpenic lactone, carabrone (I), m. p. 90—91°, [α]_D +116·9°, isolated from powdered fruits of *Carpesium abrotanoides* Linn.*,³ had the molecular formula, C₁₅H₂₀O₃ and gave a 2,4-dinitrophenylhydrazone, m. p. 197—199°.

Carabrone and dihydrocarabrone (II) possessed two and three C-CH₃ groups (Kuhn-Roth), respectively. The infrared spectrum of carabrone showed frequencies at 1712 cm.⁻¹ (ketonic C=O) and at 1758 cm.⁻¹ (γ -lactonic C=O). Therefore, one of the oxygen atoms is present as a ketone group and the remaining two oxygens are present in a γ -lactone function. Moreover, carabrone showed absorption bands near 3100, 1665, 1266, and 822 cm.⁻¹ corresponding to a double bond in the infrared spectrum and showed an absorption maximum at 213 m μ (ϵ 8150) in the ultraviolet spectrum. All these absorption bands disappeared in dihydrocarabrone (II). These results suggest that carabrone possesses an $\alpha\beta$ -unsaturated γ -lactone function.

* Kariyone *et al.* isolated carpesia lactone from fruits of this plant (T. Kariyone and N. Kawano, *J. Pharm. Soc. Japan*, 1949, **69**, 317; 1955, **75**, 39; T. Kariyone, S. Naito, and J. Chatani, *Chem. and Pharm. Bull. (Japan)*, 1954, **2**, 339; S. Naito, *J. Pharm. Soc. Japan*, 1955, **75**, 93, 325).

¹ Part VII, K. Takeda, H. Minato, K. Hamamoto, I. Horibe, T. Nagasaki, and M. Ikuta, *J.*, 1964, 3577.

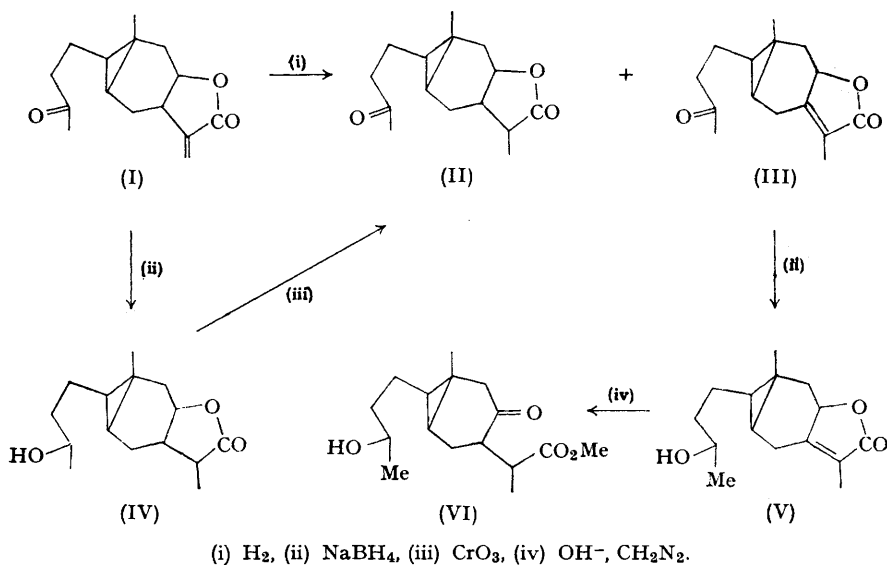
² Preliminary communication, *Proc. Chem. Soc.*, 1964, 120.

³ Y. L. Chu, C. L. Hsue, P. S. Liu, and T. H. Tang, *Acta Pharm. Sinica*, 1957, **5**, 155; (*Chem. Abs.*, 1962, **56**, 541).

Therefore, carabrone is a bicyclic sesquiterpenic lactone. When carabrone was hydrogenated in ethanol with 10% palladium-charcoal, 0.6–0.8 mol. of hydrogen was taken up and the reduction product was a mixture of dihydrocarabrone (II), m. p. 50–53°, $[\alpha]_D + 30.8^\circ$, and an oily lactone (III). On the other hand, under alkaline conditions 1 mol. of hydrogen was taken up smoothly and only dihydrocarabrone was obtained.

Dihydrocarabrone (II) showed no absorption maximum above 200 $m\mu$ and a frequency at 1764 cm^{-1} corresponding to γ -lactonic grouping.

The difference between the frequencies ($\nu_{C=O}$) for dihydrocarabrone (II) and carabrone (I), 6 cm^{-1} (1764–1758 cm^{-1}), is in good agreement with a shift of 7 cm^{-1} ,[†] mentioned by Horak.⁴ The lactone (III) showed an absorption maximum at 221 $m\mu$ (ϵ 10,260) in the ultraviolet spectrum and characteristic bands at 1755 (lactonic C=O), 1712 (ketonic C=O), and 1687 cm^{-1} ($>C=C<$) in the infrared spectrum. It is usually recognized that the (III)-type $\alpha\beta$ -unsaturated γ -lactones show absorption maxima at 218–221 $m\mu$ ($\log \epsilon$ 3.9–4.1) in the ultraviolet spectra, and it is characteristic of this type of lactone that the C=C stretching band exhibits a strong intensity and appears at an unusually high frequency (1687 cm^{-1}) in the infrared spectrum. Therefore, this oily lactone (III) should possess the (III)-type $\alpha\beta$ -unsaturated γ -lactone structure.



Reduction of carabrone (I) with sodium borohydride in methanol yielded the dihydroxy-derivative (IV), which was oxidized with chromium trioxide to give dihydrocarabrone (II). Since carabrone afforded the saturated lactone by reduction with sodium borohydride, it is reasonable, as already reported,⁵ to suppose that it has an exocyclic methylene- $\alpha\beta$ -unsaturated γ -lactone system.

Moreover, carabrone (I) showed an absorption band at 1.623 μ , corresponding to a vinyl-type double bond, in the near-infrared spectrum, and afforded formaldehyde on ozonolysis.

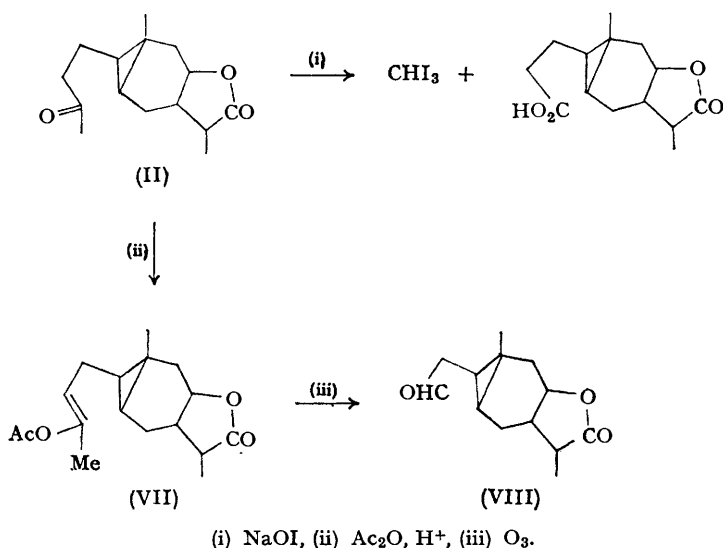
From these results, it was elucidated that carabrone possesses the (I)-type $\alpha\beta$ -unsaturated γ -lactone function. In the nuclear magnetic resonance spectra, the multiplet signals centred at τ 9.56, 9.62, and 9.77 in (I), (II), and (III) are presumably due to protons on the cyclopropane rings.

[†] This shift of about 7 cm^{-1} was determined by comparison of the frequency ($\nu_{C=O}$) of the α,β -unsaturated methylene- γ -lactone with that of its dihydro-derivative.

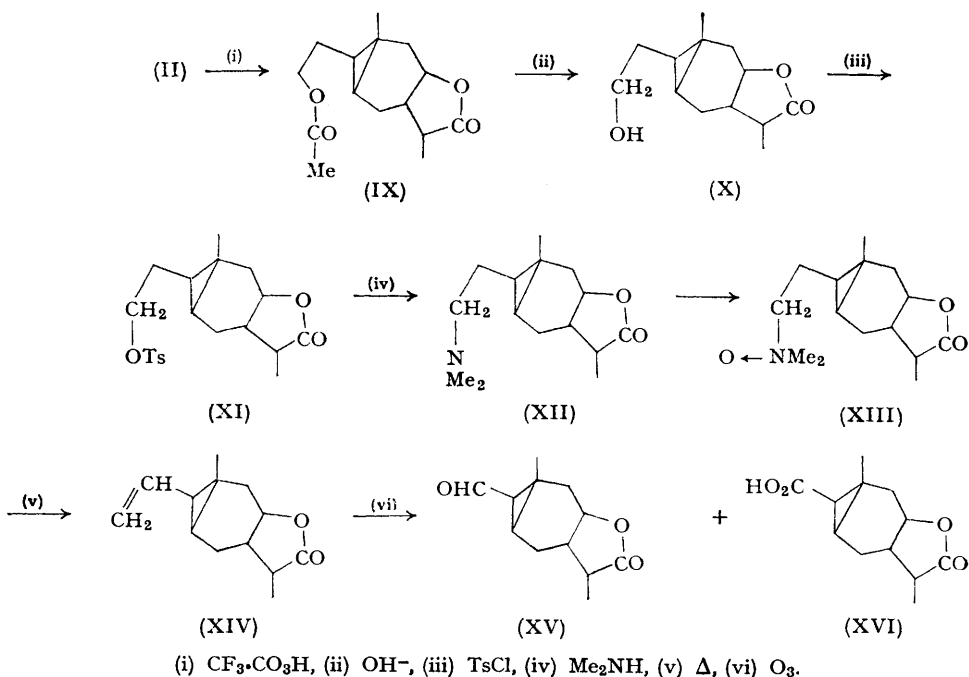
⁴ Horak and Pliva, *Chem. and Ind.*, 1960, 102.

⁵ K. Takeda, H. Minato, and M. Ishikawa, *J.*, 1964.

A keto-ester (VI), λ_{\max} 283 $m\mu$ (ϵ 65), was obtained by reduction of (III) with sodium borohydride, followed by hydrolysis with 10% potassium hydroxide in methanol and by esterification with diazomethane. The infrared spectrum of (VI) showed an absorption band at 1708 cm^{-1} corresponding to the six- or seven-membered ring ketone, and the ultraviolet



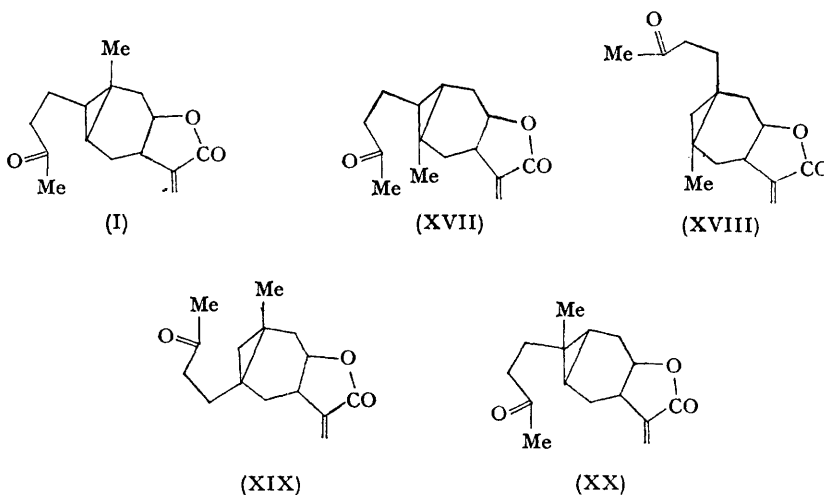
spectra of (III) and (VI) both showed no absorption maxima corresponding to a cyclopropane-enone and a cyclopropane-one chromophore. Therefore, the skeleton of carabrone (I) should be represented by a six- or seven-membered ring containing a cyclopropane ring isolated from the $\alpha\beta$ -unsaturated γ -lactone function.



Carabrone has an acetyl group, since it gave iodoform by sodium hypiodite oxidation. When dihydrocarabrone (II) was treated with acetic anhydride-toluene-*p*-sulphonic acid, it gave an enol acetate (VII), ν_{\max} . 1753 cm^{-1} , in which a band at 1714 cm^{-1} due to the acetyl grouping disappeared. Ozonolysis of the enol-acetate (VII) afforded an oily aldehyde (VIII), ν_{\max} . 2740, 1755, and 1723 cm^{-1} . The ultraviolet spectrum of the aldehyde (VIII) did not show the presence of a cyclopropane ring or a double bond conjugated with the aldehyde grouping, and a maximum at 359 $\text{m}\mu$ (ϵ 27,000) in 2,4-dinitrophenylhydrazone of (VIII) is in good agreement with that of the isolated aldehyde; thus carabrone possesses a $\text{CH}_3\cdot\text{CO}\cdot\text{CH}_2$ grouping.

An oily alcohol (X) was obtained by oxidation of (II) with trifluoroacetic acid, followed by hydrolysis. When the tosylate of (X) was heated with dimethylamine in ethanol at 90–105° for 3 hr., compound (XII), m. p. 51–54°, was obtained. The *N*-oxide (XIII) which was obtained on treatment of (XII) with 30% hydrogen peroxide gave compound (XIV), ν_{\max} . 3150, 1758, 1630, 990, 962, and 895 cm^{-1} , on heating at 100–120°. Ozonolysis of (XIV) afforded an oily aldehyde (XV), ν_{\max} . 2750, 1770, and 1694 cm^{-1} and a carboxylic acid (XVI), m. p. 175–177°. The ultraviolet spectra of (XIV) and (XV) showed absorption maxima at 207.5 $\text{m}\mu$ (ϵ 8750) and 209 $\text{m}\mu$ (ϵ 4470) corresponding to a cyclopropane-ene and a cyclopropane-one chromophore respectively. From these results, it is concluded that carabrone (I) possesses a $\text{CH}_3\cdot\text{CO}\cdot\text{CH}_2\text{-CH}_2$ grouping on a cyclopropane ring as the side-chain.

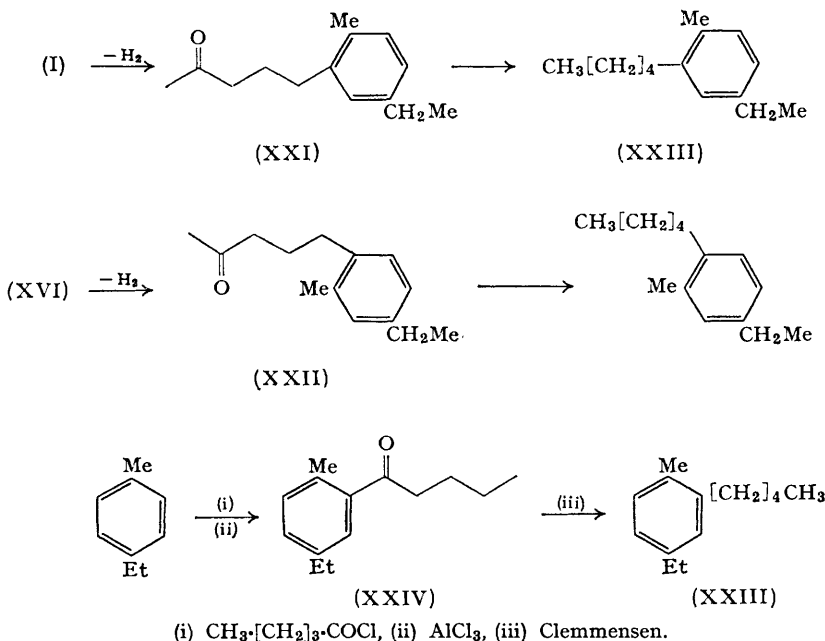
Moreover, another one of two methyl groups of carabrone was found to be a methyl group on a tertiary carbon atom by a singlet at τ 8.93 in the n.m.r. spectrum. Then, the possible structure of carabrone should be represented as (I), (XVII), (XVIII), (XIX), or (XX).



Dehydrogenation of dihydrocarabrone (II) with palladium-charcoal gave a benzene derivative having fourteen carbon atoms, in 20–30% yield. Its ultraviolet spectrum, λ_{\max} . 217 (ϵ 9700), 267 (ϵ 777), and 275.5 $\text{m}\mu$ (ϵ 830), is in good agreement with the spectra of 1,3,4-trisubstituted benzene derivatives, and the n.m.r. spectrum shows one methyl group (τ 7.77) on a benzene ring, one CH_3CO (τ 7.92) and one CH_3CH_2 grouping (a triplet at τ 8.82, $J = 7.4$ c./sec.). From this fact, the dehydrogenation product should be represented by (XXI) or (XXII).

When the dehydrogenation product was reduced by the Huang-Minlon method, a colourless oil, (XXIII), was obtained. The ultraviolet spectrum of this reduction product also is in good agreement with that of a 1,3,4-trisubstituted benzene and this compound (XXIII) should be 4-ethyl-2-*n*-pentyltoluene or 5-ethyl-2-*n*-pentyltoluene as illustrated. Then, 4-ethyl-2-*n*-pentyltoluene was synthesized as shown below.

As it was demonstrated by Taylor and Watts⁶ that Friedel-Crafts reaction of *p*-ethyltoluene afforded 2-substituted 4-ethyltoluenes, its reaction product with pentanoyl chloride should be a 2,4-disubstituted toluene (XXIV). Clemmensen reduction of (XXIV)



afforded 4-ethyl-2-*n*-pentyltoluene which was identical with the compound (XXIII) obtained from carabrone in all respects (comparisons of infrared and ultraviolet spectra and gas chromatograms). Therefore, carabrone should be represented by formula (I).

EXPERIMENTAL

N.m.r. spectra were taken on deuteriochloroform solutions with a Varian A-60 n.m.r. spectrometer. Ultraviolet spectra were taken in 95% ethanol and rotations in ethanol unless otherwise stated. M. p.s were measured on a Kofler block ("Monoscope," Hans Bock Co., Frankfurt) and are corrected.

Isolation of Carabrone (I) from the Plant.—The dried and powdered fruits of the plant (1.19 kg.) were extracted with hot ether (4 × 4 l.) giving a dark green paste (62.2 g.). This extract was distilled to give a yellow oil (39.8 g., b. p. 140–156°/0.01 mm.). The distillate was dissolved in ether and extracted with 2*N*-sodium carbonate to separate the acid substance. The neutral fraction (34.8 g.) was treated with Girard's reagent r (9.5 g.) to afford a mixture of carbonyl compounds, a yellow oil (5.0 g.), which was crystallized from ether–light petroleum giving *carabrone* (I) (1.7 g., 0.14%). Recrystallization from the same solvent gave (I) as colourless needles, m. p. 90–91°, $[\alpha]_D^{24} + 116.9^\circ (\pm 2^\circ)$ (*c* 1.033); λ_{max} , 213 m μ (ϵ 8150); ν_{max} , (in $CHCl_3$) near 3100, 1758, 1712, 1665, and 1266 cm^{-1} ; ν_{max} , (KBr) 822 cm^{-1} , near-infrared (in CCl_4) 1.623 μ (Found: C, 72.5; H, 8.25%; *M*, 236.4. $C_{15}H_{20}O_3$ requires C, 72.55; H, 8.1%; *M*, 248.3); 2,4-dinitrophenylhydrazone, orange needles, m. p. 197–199° (Found: C, 59.2; H, 5.85; N, 13.2%; *M*, 424.2. $C_{21}H_{24}N_4O_6$ requires C, 58.85; H, 5.65; N, 13.1%; *M*, 426.4).

Hydrogenation of Carabrone (I).—(i) *Under neutral conditions.* 10% Palladized charcoal (100 mg.) was added to a solution of *carabrone* (I) (400 mg.) in ethanol (20 ml.). The mixture was hydrogenated at room temperature and atmospheric pressure. When 31 ml. (0.8 mol.) of hydrogen had been absorbed, the reaction stopped, and the catalyst and the solvent were removed. The residue was extracted with ether, and the extract washed with 2*N*-sodium carbonate, dried (Na_2SO_4) and evaporated, leaving a colourless oil (400 mg.). This oil was chromatographed on

⁶ E. P. Taylor and G. E. Watts, *J.*, 1952, 1123.

neutral alumina (12 g.). Elution with light petroleum-benzene (8:2) afforded *dihydrocarabrone* (II) (73 mg.) as colourless needles, m. p. 50—53° (from ether), $[\alpha]_D^{28} + 30.8^\circ (\pm 2^\circ)$ (c 1.031); ν_{\max} . (in CHCl_3) 1764 and 1714 cm^{-1} (Found: C, 71.95; H, 8.85. $\text{C}_{15}\text{H}_{22}\text{O}_3$ requires C, 71.95; H, 8.85%). Further elution with light petroleum-benzene (1:1) and benzene afforded the *product* (III) (185 mg.), a colourless oil, b. p. 135—140°/0.1 mm. (bath temp.); λ_{\max} . 221 μ (ϵ 10,260), ν_{\max} . (film) 1755, 1712, and 1687 cm^{-1} (Found: C, 72.55; H, 8.55. $\text{C}_{15}\text{H}_{20}\text{O}_3$ requires C, 72.55; H, 8.2%); 2,4-dinitrophenylhydrazone, yellow needles, m. p. 152—154° (Found: N, 13.2. $\text{C}_{21}\text{H}_{24}\text{N}_4\text{O}_8$ requires N, 13.1%).

(ii) *Under alkaline conditions.* 10% Palladized charcoal (200 mg.) was added to a solution of carabrone (I) (814 mg.) in ethanol (20 ml.) containing 0.2 ml. of 50% aqueous sodium hydroxide. The mixture was hydrogenated at room temperature and atmospheric pressure. When 87 ml. (1.08 mol.) of hydrogen had been absorbed, the mixture was worked up as described above, leaving dihydrocarabrone (II) (689 mg.).

(iii) *Reduction with sodium borohydride.* A solution of carabrone (I) (500 mg.) and sodium borohydride (80 mg.) in methanol (5 ml.) was left for 2 hr. at room temperature. To this solution was added 2N-sulphuric acid (1 ml.). An ether extract of the mixture was washed with 2N-sodium carbonate and water, dried (Na_2SO_4), and evaporated, leaving the dihydrohydroxy-compound (IV) (500 mg.). To a solution of compound (IV) (500 mg.) in dimethylformamide (40 ml.) were added chromium trioxide (700 mg.) and then concentrated sulphuric acid (8 drops.); and the solution was left overnight, poured into ice-water, and extracted with ether. The extract was washed with aqueous sodium bisulphite, 2N-sodium carbonate, and water, dried (Na_2SO_4), and evaporated, leaving dihydrocarabrone (II) (395 mg.).

Conversion of the $\alpha\beta$ -Unsaturated Lactone (III) into the Keto-ester (VI).—A mixture of $\alpha\beta$ -unsaturated lactone (III) (114 mg.) and sodium borohydride (200 mg.) in methanol (2 ml.) was stirred for 1 hr. at room temperature. To this solution was added 2N-sulphuric acid (0.6 ml.), and this mixture was extracted with ether, the extract washed with potassium hydrogen carbonate solution, dried (Na_2SO_4), and evaporated, leaving the product (V), a light-yellow oil (110 mg.). The product was dissolved in 2.5 ml. of 10% potassium hydroxide in methanol and refluxed for 3 hr. The solution was evaporated, and the residue was dissolved in water (5 ml.). The aqueous solution was extracted with ether, and the aqueous layer was acidified with 2N-sulphuric acid, extracted with ether, and the extract washed with water, dried (Na_2SO_4), and evaporated, leaving a yellow oil (90 mg.), which was methylated with diazomethane, giving the *keto-ester* (VI) (80 mg.), a light-yellow oil, b. p. 155—160°/0.4 mm. (bath temp.), $[\alpha]_D^{23} + 24.8^\circ (\pm 2^\circ)$ (c 1.092); λ_{\max} . 283 μ (ϵ 65); ν_{\max} . (film) 1736 and 1708 cm^{-1} (Found: C, 67.7; H, 9.5. $\text{C}_{16}\text{H}_{26}\text{O}_4$ requires C, 68.05, 9.3%).

Conversion of Dihydrocarabrone (II) into the Aldehyde (VIII).—Toluene-*p*-sulphonic acid (55 mg.) was added to a solution of dihydrocarabrone (377 mg.) in acetic anhydride (5 ml.) and heated for 6 hr. at 100° in an oil-bath. To this solution was added sodium acetate (50 mg.), and then the mixture was evaporated *in vacuo*, extracted with ether, and the extract washed with saturated potassium hydrogen carbonate solution, dried (Na_2SO_4), and evaporated, leaving a brown oil (400 mg.). The residue was chromatographed on neutral alumina (12 g.) to give the enol acetate (VII) (120 mg.), ν_{\max} . (film) 1753 cm^{-1} , and the starting material (II) (230 mg.). The enol acetate was dissolved in ethyl acetate (5 ml.) and ozonized under usual conditions to give the aldehyde (VIII) (63 mg.), b. p. 135—140°/0.4 mm. (bath temp.); ν_{\max} . (film) 2740 (aldehyde), 1755 (lactone) and 1723 cm^{-1} (aldehyde); 2,4-dinitrophenylhydrazone, yellowish orange needles, m. p. 176—179°; λ_{\max} . 359 μ (ϵ 27,000) (Found: C, 56.65; H, 5.6; N, 13.55. $\text{C}_{19}\text{H}_{22}\text{N}_4\text{O}_6$ requires C, 56.7; H, 5.5; N, 13.9%).

Oxidation of Dihydrocarabrone (II) with Trifluoroacetic Acid.—A solution of trifluoroacetic acid was prepared by dropwise addition of a solution of trifluoroacetic anhydride (2.5 g., 4.2 equiv.) in methylene dichloride (3 ml.) to a suspension of 80% hydrogen peroxide (420 mg., 3.5 equiv.) in methylene dichloride (2 ml.) with stirring in an ice bath. This solution was added dropwise to a stirred suspension of dry, finely ground disodium hydrogen phosphate (4.2 g.) in a solution of dihydrocarabrone (II) (700 mg.) in methylene dichloride (10 ml.) over a 15-min. period. The mixture was then stirred for 1 hr., left for 38 hr. at room temperature, and refluxed for an additional 3.5 hr. The insoluble salts were collected and washed with methylene dichloride. The combined filtrate was washed with sodium hydrogen sulphite solution, water, potassium hydrogen carbonate solution, and water, dried (Na_2SO_4), and evaporated, leaving the product (IX) (727 mg.) as a yellow oil, ν_{\max} . (film) 1760 and 1735 cm^{-1} .

Hydrolysis of the Acetate (IX).—A mixture of compound (IX) (727 mg.) in methanol (20 ml.) and potassium carbonate (1.5 g.) in water (8 ml.) was refluxed for 2 hr. on a steam-bath and evaporated. The residue was dissolved in water and extracted with ether. The aqueous layer was acidified to Congo Red with 2*N*-sulphuric acid, extracted with ether, and the extract washed with potassium hydrogen carbonate solution, dried (Na_2SO_4), and evaporated, leaving the alcohol (X) (550 mg.) as a colourless oil, b. p. 155–160°/0.2 mm. (bath temp.), $[\alpha]_D^{22} + 67.7^\circ (\pm 3^\circ)$ (*c* 0.651) (Found: C, 68.9; H, 9.2. $\text{C}_{13}\text{H}_{20}\text{O}_3$ requires C, 69.6; H, 9.0%).

Dimethylamino-derivative (XII).—The tosylate of the alcohol (X) (460 mg.) was dissolved in 20% dimethylamine in ethanol (5 ml.) and heated in a sealed tube at 90–105° for 3 hr. The solution was evaporated, and then the residue was dissolved in 2*N*-hydrochloric acid and extracted with ether. The aqueous layer was made alkaline with 2*N*-sodium carbonate, extracted with ether, and the extract washed with water, dried (Na_2SO_4), and evaporated, leaving a crystalline substance (280 mg.). Recrystallization from light petroleum gave the amine (XII) as colourless needles, m. p. 51–54°, $[\alpha]_D^{23.5} + 42.5^\circ (\pm 2^\circ)$ (*c* 0.954) (Found: C, 71.9; H, 10.15; N, 5.45. $\text{C}_{15}\text{H}_{25}\text{NO}_2$ requires C, 71.7; H, 10.05; N, 5.55%). The hydrochloride formed colourless needles, m. p. 209–212°.

Pyrolysis of the N-Oxide of the Amine (XII).—30% Hydrogen peroxide (1.2 ml.) was added to a solution of the amine (XII) (664 mg.) in methanol (3 ml.) with stirring in an ice-bath and left for 16 hr. at room temperature. The excess of hydrogen peroxide was decomposed by stirring the solution with platinum-black (100 mg.) for 4 hr., at which time the solution is negative to hydrogen peroxide test with lead sulphide paper. The platinum black was separated, and the filtrate was evaporated *in vacuo*, leaving a colourless syrup (700 mg.), which was crystallized from acetone to give the *N*-oxide (XIII) as needles, m. p. 55–58°. The crude amine oxide (680 mg.) was heated in nitrogen at 10 mm. in an oil-bath; and decomposition of the amine oxide began at 100° and was completed at 120° after 35 min., at which time a mobile oil was left in the flask. The residue was dissolved in ether and extracted with 2*N*-hydrochloric acid. The ether layer was washed with 2*N*-sodium carbonate, dried (Na_2SO_4), and evaporated, giving the product (XIV) as a colourless oil (455 mg.), b. p. 130–140°/1 mm. (bath temp.); λ_{max} . 207.5 μ (ϵ 8750); ν_{max} . (film) 3150, 1758, 1630, 990, 962, and 895 cm^{-1} (Found: C, 75.65; H, 8.85. $\text{C}_{13}\text{H}_{18}\text{O}_2$ requires C, 75.7; H, 8.8%). The aqueous layer was made alkaline with 2*N*-sodium carbonate, extracted with ether, and the extract washed with water, dried (Na_2SO_4), and evaporated, leaving the starting material (XII) (42 mg.).

Ozonolysis of (XIV).—A solution of compound (XIV) (400 mg.) in ethyl acetate (10 ml.) was ozonized under usual conditions to give the aldehyde (XV) (260 mg.), a light-yellow oil, b. p. 160–170°/2 mm. (bath temp.); λ_{max} . 209 μ (ϵ 4470), ν_{max} . (film) 2750, 1770, and 1694 cm^{-1} ; and the acid (XVI) (54 mg.), colourless needles, m. p. 175–177°; ν_{max} . (Nujol) 1779 and 1689 cm^{-1} (Found: C, 64.05; H, 7.35. $\text{C}_{12}\text{H}_{16}\text{O}_4$ requires C, 64.25; H, 7.2%). The 2,4-dinitrophenylhydrazone of the aldehyde (XV) was a mixture of two hydrazones, † which afforded orange prisms, m. p. 173–175°, R_F 0.50, λ_{max} . 369 μ (ϵ 26,300) (Found: C, 55.6; H, 5.35; N, 14.25. $\text{C}_{18}\text{H}_{20}\text{N}_4\text{O}_6$ requires C, 55.65; H, 5.2; N, 14.45%) and orange prisms, m. p. 216–217°, R_F 0.45 (Found: C, 55.3; H, 5.4%), by recrystallization (from ethanol) and preparative thin-layer chromatography (Kieselgel G “Merck,” ether).

Dehydrogenation of Dihydrocarabrone (II).—A mixture of dihydrocarabrone (II) (350 mg.) and 30% palladized charcoal (200 mg.) was heated at 300–360° (bath temp.) for 4.5 hr., during which 67 ml. (2.14 mol.) of hydrogen was generated. The residue was extracted with light petroleum and washed with Claisen’s solution. The light petroleum extract was washed with water and evaporated, leaving a light-yellow oil (141 mg.). This residue was dissolved in light petroleum and chromatographed on neutral alumina (5 g.), giving a colourless oil (95 mg.) on elution with light petroleum. This oil was distilled at 115–120°/0.1 mm. (bath temp.) giving the product (XXI) (75 mg.) as a colourless mobile oil; λ_{max} . 217 μ (ϵ 9700), 267 μ (ϵ 777), and 275.5 μ (ϵ 830); ν_{max} . (film) 1718, 1616, 1506, and 823 cm^{-1} ; retention time, § 7.8 min.; n.m.r. τ 7.77 (CH_3), 7.92 ($\text{CH}_3\text{-CO}$), 8.82 ($\text{CH}_3\text{-CH}_2$, triplet $J = 7.4$ c./sec.) (Found: C, 82.1; H, 10.1. $\text{C}_{14}\text{H}_{20}\text{O}$ requires C, 82.3; H, 9.85%).

Huang-Minlon Reduction of the Ketone (XXI).—A mixture of the ketone (XXI) (48 mg.),

† When these two hydrazones were melted, they gave, respectively, an equilibrium mixture (*ca.* 1:1) of each compound. They therefore may be geometrical isomers of phenylhydrazone.

§ For the analysis of this product, a column, 3 m. long, i. d. 6 mm., consisting of Silicone oil KF-54 (Shinetsu Co.) on Chromosorb W (30 to 60 mesh) was operated at 160° with a flow rate of 200 ml./min. of hydrogen.

ground potassium hydroxide (200 mg), and 80% hydrazine hydrate (0.2 ml.) in triethylene glycol (2 ml.) was heated at 130—140° for 30 min., and the temperature was gradually elevated and retained at 190—200° for 2 hr. The mixture was poured into ice-water, extracted with ether, and the extract washed with water, dried (Na_2SO_4), and evaporated, leaving a light-yellow oil (30 mg.). This oil was distilled at 164—170°/30 mm. (bath temp.) giving the *product* (XXIII) as a colourless mobile oil; λ_{max} . 260.5 (678), 267 (736), and 275.5 $\text{m}\mu$ (ϵ 620); λ_{min} . 264 (664) and 273.5 $\text{m}\mu$ (ϵ 523); ν_{max} . (in CS_2) 1377, 1159, 1060, 887, and 818 cm^{-1} ; retention time, || 30.5 min.; a mixed sample of the product (XXIII) and synthesized 4-ethyl-2-n-pentyltoluene: retention time, 30.4 min. (Found: C, 88.0; H, 11.65. $\text{C}_{14}\text{H}_{22}$ requires C, 88.35; H, 11.65%). Compound (XXIII) was shown to be identical with 4-ethyl-2-n-pentyltoluene by comparisons of infrared and ultraviolet spectra and gas chromatograms.

Synthesis of 4-Ethyl-2-n-pentyltoluene (XXIII).—A mixture of *p*-ethyltoluene (1.88 g.) and *n*-pentanoyl chloride (2.02 g.) was added dropwise to a suspension of powdered anhydrous aluminium chloride (2.2 g) in carbon disulphide (5 ml.) with stirring at -5° to -6° for 20 min. The mixture was stirred at -5 — 0° for 2 hr. and left overnight at room temperature. This mixture was poured into a mixture of ice (10 g.) and concentrated hydrochloric acid (2 ml.) and extracted with ether. The ether extract was washed with 2*N*-sodium carbonate and water, dried (Na_2SO_4), and evaporated, leaving a yellow mobile oil (3.0 g.). This oil was distilled at 120—123°/10 mm. giving the *product* (XXIV) as a colourless mobile oil (2.2 g., 69%); ν_{max} . (in CHCl_3) 1680 and 1608 cm^{-1} (Found: C, 82.15; H, 9.9. $\text{C}_{14}\text{H}_{20}\text{O}$ requires C, 82.3; H, 9.85%). Granulated zinc (15 g.) was covered with 5% mercuric chloride solution (80 ml.) for 24 hr. giving amalgamated zinc. A mixture of this and compound (XXIV) (2.18 g.) in 30% hydrochloric acid (15 ml.) was refluxed for 6.5 hr., during which time 30% hydrochloric acid (45 ml.) was added in five portions. The whole was boiled for a further 6 hr., then diluted with water (20 ml.) and extracted with ether. The ether extract was washed with 2*N*-sodium carbonate and water, dried (Na_2SO_4), and evaporated, leaving a light-yellow mobile oil (1.9 g.). This oil was distilled at 146—147°/30 mm. giving 4-ethyl-2-n-pentyltoluene (XXIII) as a colourless mobile oil (1.64 g., 81%), n_{D}^{20} 1.4950; λ_{max} . 260.5 (665), 267 (714), and 275.5 $\text{m}\mu$ (ϵ 600); λ_{min} . 264 (650) and 273.5 $\text{m}\mu$ (ϵ 502); ν_{max} . (in CS_2) 1377, 1160, 1060, 887, and 818 cm^{-1} ; retention time, || 30.4 min. (Found: C, 88.1; H, 11.65. $\text{C}_{14}\text{H}_{22}$ requires C, 88.35; H, 11.65%).

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|| For the analysis of products, a column, 3 m. long, i. d. 6 mm., consisting of Silicone 550 on Chromosorb (30 to 60 mesh) was operated at 170° with a flow rate of 200 ml./min. of hydrogen.