**735.** *Synthesis in the Santonin Series.  Part II.**

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(−)-Dihydrocarvone (VI) has been converted *via* an epoxide (VII) into a (−)-α-(3-keto-4-methyl*cyclo*hexyl)propionic acid (IX) from which the keto-esters (XII) and (XIV) related to santonin have been obtained. The bromination and dehydrobromination of (XII) have been examined and the nature of the products is discussed.

(−)-Santonin (I) and the related lactones occurring in *Artemesia* species, and the alantolactones of *Inula Helenium*, represent in the sesquiterpene group the type of terpenoid substance in which one carbon atom of the terminal isoprene unit occurs as a carboxyl group or its equivalent. These lactones possess the selinene–eudesmol molecular skeleton, and in the location of unsaturation and of the keto-group of santonin there is a striking formal resemblance between, for example, santonin (I) and α-cyperone (II), and



(I)          (II)          (III)          (IV)          (V)
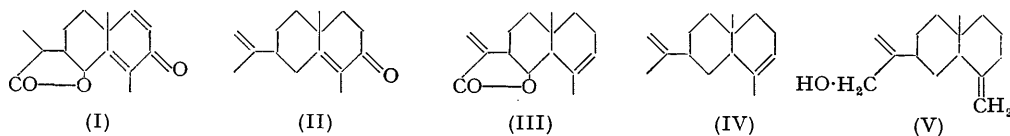
also between alantolactone (III) and α-selinene (IV). This resemblance is sufficiently close to suggest an underlying biogenetic relationship through a common precursor in which the carboxyl group of the lactones occurs as an alcohol group. A structure of this type is represented in Nature by the sesquiterpene alcohol sesquibenihiol (V), whilst a similar terminal alcohol group occurs also in the santalols and in lanceol. On this view it may be significant that costus root oil contains a series of sesquiterpene lactones, and a related primary alcohol, costol $C_{15}H_{24}O$, although the structures of these substances have not been fully elucidated (Semmler and Feldstein, *Ber.*, 1914, **47**, 2433; Naves, *Helv. Chim. Acta*, 1948, **31**, 1172).

These speculations suggested that in an approach to the synthesis of santonin it would be of interest to attempt the oxidation of the terminal isoprene unit of a simpler terpene. With this purpose (−)-dihydrocarvone (VI) has been oxidised at the terminal double bond by means of the sequence :



(VI)          (VII)          (VIII)          (IX)
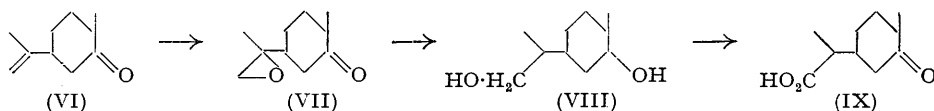
and in this way a keto-acid (IX) has been obtained which offers a convenient intermediate for the synthesis of substances related to santonin. (−)-Dihydrocarvone reacted rapidly and exothermally with perbenzoic acid in chloroform, to give a lævorotatory saturated neutral ketonic product, $C_{10}H_{16}O_2$, corresponding with the epoxide (VII). This was accompanied in smaller amount by a higher-boiling ketone, $C_{10}H_{18}O_3$, regarded as the corresponding glycol. The epoxide could be characterised by means of a semicarbazone. With 2 : 4-dinitrophenylhydrazine in alcoholic sulphuric acid, however, a bis-2 : 4-dinitrophenylhydrazone, $C_{22}H_{24}O_9N_8$, was obtained, which is most simply regarded as corresponding with the hydroxy-keto-aldehyde (X) formed by fission of the epoxide followed by

* Part I, preceding paper.

oxidation, as in a case recently reported by Braude and Forbes (*J.*, 1951, 1762). In the preparation of the epoxide no evidence was obtained of oxidative ring fission of the type noted by Bayer and Villiger (*Ber.*, 1900, **33**, 1569) and studied more recently by Friess (*J. Amer. Chem. Soc.*, 1949, **71**, 2571). The rate of reaction of perbenzoic acid with dihydrocarvone in moist chloroform at 0°, followed roughly by titration, indicated a bimolecular velocity constant of *ca.* $5 \times 10^{-4}$ l. mol.$^{-1}$ sec.$^{-1}$, in good agreement with a value of $5 \cdot 8 \times 10^{-4}$ found by Meerwein, Ogait, Prang, and Serini (*J. pr. chem.*, 1926, **113**, 9) for *p*-menth-8(9)-ene-1 : 2-diol under similar conditions. For the oxidative fission of *cyclo*hexanone Friess (*loc. cit.*) found a similar rate at 26·98° and it is clear that reaction at the olefinic centre occurs the more readily.

In the hydrogenolysis of 1 : 2-epoxydecane, Newman, Underhill, and Renoll (*J. Amer. Chem. Soc.*, 1949, **71**, 3362) have indicated that reduction to the primary alcohol is favoured by the use of Raney nickel catalyst under neutral conditions. With Raney nickel in alcohol the epoxide (VI) was converted into a glycol, $C_{10}H_{16}O_2$ which could be oxidised in moderate yield to a lævorotatory keto-acid, $C_{10}H_{16}O_3$. The derived methyl ester of this keto-acid was readily dehydrogenated with palladised charcoal to a phenolic carboxylic acid, $C_{10}H_{12}O_3$, characterised as a hydrate and a monophenylazo-derivative. These results clearly indicate that the glycol formed on hydrogenation of the epoxide consists largely of the 2 : 9-diol (VIII), leading to the keto-acid (IX) and to a dehydrogenated phenolic acid (XI).



(X)                                                            (XI)

By condensation of the methyl ester of (IX) with the methiodide of diethylamino-pentan-3-one (cf. du Feu, McQuillin, and Robinson, *J.*, 1937, 53; Adamson, McQuillin, Robinson, and Simonsen, *J.*, 1937, 1576) a bicyclic keto-ester, $C_{16}H_{26}O_3$, was obtained, showing the characteristic absorption of an αβ-unsaturated ketone [$\lambda_{max.}$ 245 mμ (log ε 4·05)]. This condensation was conveniently effected by means of sodiotri-phenylmethane in ether and the products were separated from triphenylmethane by alkaline hydrolysis which served also to complete the ring closure of the intermediate diketo-ester.

The bicyclic keto-ester in the presence of palladised charcoal absorbed one molecular proportion of hydrogen and in the presence of Adams's platinum oxide in acetic acid two molecular equivalents. The product of the latter reaction, after hydrolysis and dehydrogenation with selenium, gave 7-ethyl-1-methylnaphthalene; the picrate of this was readily purified and no significant amount of a second hydrocarbon was formed. The keto-ester is therefore regarded as being (XII). It was found to be dextrorotatory, in agreement with the formation of (+)-α-cyperone in the analogous condensation of diethyl-aminopentan-3-one methiodide with (−)-dihydrocarvone (Adamson, McQuillin, Robinson, and Simonsen, *loc. cit.*).



(XII)                                (XIII)                            (XIV)                          (XV)
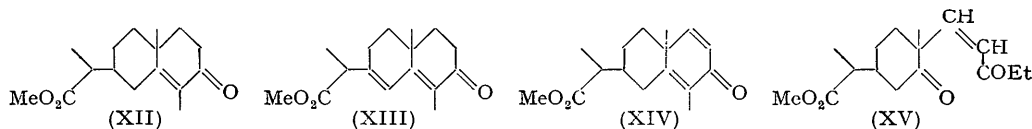
With the object of obtaining the diunsaturated keto-ester (XIV) more closely related to santonin, methyl α-(3-keto-4-methyl*cyclo*hexyl)propionate was condensed with ethyl ethynyl ketone in the presence of sodiotriphenylmethane in ether (cf. Woodward and Singh, *J. Amer. Chem. Soc.*, 1950, **72**, 494). This gave a product $C_{16}H_{22}O_3$ showing $\lambda_{max.}$ 240 mμ (log ε 3·96), which is in general agreement with a structure (XIV), but the yield was inconveniently small. There is more side reaction than in the Mannich-base condensation, and also if a Michael addition to the ethynyl group is regarded as the first step in the condensation it is clear that only a *cis*-form of an intermediate (XV) is likely to undergo cyclodehydration. In an analogous condensation between 2-methyl*cyclo*hexanone and

methyl propiolate Bachmann and Raunio (*ibid.*, p. 2530, 2533) observed predominantly anionoid attack by the ethynyl group on the keto-group rather than Michael addition, and this type of reaction may compete in the present case.

Bromination of (XII) was therefore examined with a view to introducing the required second double bond by dehydrobromination. In the analogous case of 3-keto-$\Delta^{4(5)}$-steroids Meystre and Wettstein (*Experientia*, 1946, **2**, 408) observed bromination in the conjugated 6-position by *N*-bromosuccinimide. La Forge and Soloway (*J. Amer. Chem. Soc.*, 1947, **69**, 979), Dauben and Wenkert (*ibid.*, p. 2074), and Crombie, Elliott, and Harper (*J.*, 1950, 971) reported similar preferential bromination in the conjugated position of substituted *cyclo*pentenones. Examination of the model, however, shows that in (XII) the 8-position is to some extent sterically hindered, thus possibly favouring bromination in position 3. Treatment of (XII) with one molecular proportion of *N*-bromosuccinimide in carbon tetrachloride in the presence of benzoyl peroxide and dehydrobromination of the product by means of boiling collidine gave a product showing double absorption maxima in the ultra-violet [$\lambda_{max.}$ 245 (log $\varepsilon$ 3·82) and 294 m$\mu$ (log $\varepsilon$ 3·65)], the second corresponding
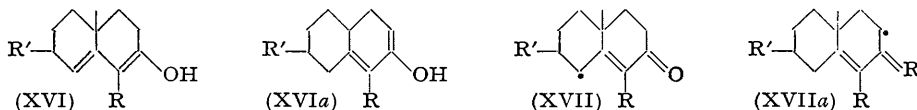


*Desmotroposantonin in alcohol.*
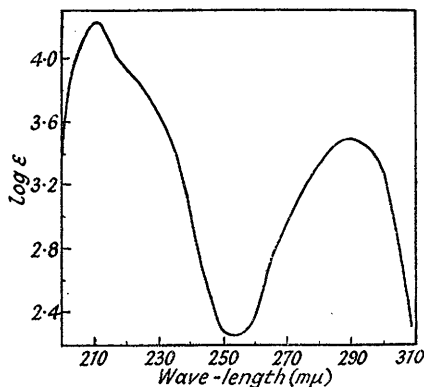
clearly with the conjugated diunsaturated keto-ester (XIII), and the former with the isomer (XIV) or with the keto-ester (XII) which cannot be very different in their light absorption. Chromatography on alumina gave a first fraction showing $\lambda_{max.}$ 247 m$\mu$ (log $\varepsilon$ 4·13) and absorbing almost exactly one molecular equivalent of hydrogen in the presence of palladised charcoal; later fractions showed increasing intensity of absorption at 294 m$\mu$ and increased uptake of hydrogen and corresponded with the starting material (XII) plus increasing proportions of the diunsaturated keto-ester (XIII). A more strongly absorbed still later fraction, however, showed again a single strong absorption maximum [$\lambda$ 242 m$\mu$ (log $\varepsilon$ 3·89)], and took up almost two equivalents of hydrogen in the presence of palladised charcoal, giving a ketonic product. These properties correspond with a dienone structure (XIV), and after digestion with fuming hydrochloric acid at 35° this material had absorption maxima at 212 (log $\varepsilon$ 3·98) and 290 m$\mu$ (log $\varepsilon$ 3·32), corresponding with the maxima shown by ($\pm$)-desmotroposantonin [$\lambda$ 212 (log $\varepsilon$ 4·2) and 290 m$\mu$ (log $\varepsilon_{max.}$ 3·47) (cf. Figure). This evidence of a desmotropic rearrangement clearly established the presence of material of structure (XIV) (cf. Clemo, Haworth, and Walton, *J.*, 1929, 2368) and on careful distillation a fraction could be isolated, and characterised by means of a semicarbazone, corresponding with (XIV) and showing a single absorption maximum at 272 m$\mu$ (log $\varepsilon$ 4·17) in agreement with this structure.

In the bromination of (XII) by means of *N*-bromosuccinimide free bromine was observed from an early stage. The solution remained yellow-orange until the whole of the imide had reacted and then began to darken. At this stage hydrogen bromide could be detected. Bromine, liberated through the release of hydrogen bromide from an intermediate bromo-ketone, may therefore be the principal reagent in this case, the solution being buffered to low acidity so long as *N*-bromosuccinimide remains. The reaction appeared to be catalysed by benzoyl peroxide, but this may also be effective in part through the formation of acidic products. There is evidence for similar intervention of bromine

11 N

and the formation of addition products as a concomitant to allylic bromination of an olefin (Wieland and Miescher, *Helv. Chim. Acta*, 1947, **30**, 1876). In the monobromination of 3-keto-$\Delta^{4(5)}$-steroids by bromine or *N*-bromosuccinimide, substitution takes place primarily in the 6-position (cf. Djerassi *et al.*, *J. Amer. Chem. Soc.*, 1950, **72**, 4534), and it is to be expected that the factors stabilising an enol (XVI; R = R' = H) in comparison with (XVI*a*; R = R' = H) will be effective in a similar stabilisation of an intermediate

$$R'—\overset{}{\underset{\text{(XVI)} \quad R}{\bigcirc\!\!\bigcirc}}\!\!\text{OH} \qquad R'—\overset{}{\underset{\text{(XVI}a) \quad R}{\bigcirc\!\!\bigcirc}}\!\!\text{OH} \qquad R'—\overset{}{\underset{\text{(XVII)} \quad R}{\bigcirc\!\!\bigcirc}}\!\!\text{O} \qquad R'—\overset{}{\underset{\text{(XVII}a) \quad R}{\bigcirc\!\!\bigcirc}}\!\!\text{R}$$

radical (XVII; R = R' = H) in comparison with (XVII*a*; R = R' = H). In (XII), however, where R = Me and R' = CHMe·CO$_2$Me, removal of a hydrogen atom or a proton which is the rate-determining step is hindered at position 8 whereas at position 3 one hydrogen atom lies " equatorially " away from the substituent at C$_{(10)}$ and is unhindered. The effect, however, is apparently insufficient to prevent considerable bromination at C$_{(8)}$.

## EXPERIMENTAL

(−)-2-*Keto*-8 : 9-*epoxy*-p-*menthane.*—(−)-Dihydrocarvone (24 g.) in chloroform (50 c.c.) was added gradually to a solution of perbenzoic acid (22·25 g., 1·02 equivs.) in chloroform (550 c.c.) cooled in ice, and the solution kept at 0° for 24 hours. The liquid was thoroughly washed with cold aqueous sodium hydrogen carbonate (to remove benzoic acid) and then with water and dried (MgSO$_4$). Removal of solvent and distillation gave material (18·3 g.), b. p. 135—145°/9 mm., and a small fraction, b. p. 120—125°/0·1 mm. Redistillation of the main fraction gave 2-*keto*-8 : 9-*epoxy*-p-*menthane* as a colourless liquid, b. p. 65°/0·1 mm., $n_D^{20}$ 1·4751, $[\alpha]_D$ −13·2° (*c*, 1·27 in chloroform) (Found : C, 71·1; H, 9·8. C$_{10}$H$_{16}$O$_2$ requires C, 71·4; H, 9·5%). The higher-boiling fraction on redistillation afforded a colourless viscous oil, b. p. 120—125°/0·1 mm., $n_D^{20}$ 1·4841 (Found : C, 64·9; H, 9·2. C$_{10}$H$_8$O$_3$ requires C, 64·5; H, 9·5%), corresponding to a 2-keto-*p*-menthane-8 : 9-diol (cf. Wallach, *Ber.*, 1895, **28**, 2706).

The epoxide gave a *semicarbazone*, m. p. 187°, colourless prisms from methyl alcohol (Found : C, 58·3; H, 8·5. C$_{11}$H$_{19}$O$_2$N$_3$ requires C, 58·6; H, 8·4%). 2 : 4-Dinitrophenylhydrazine in alcoholic sulphuric acid gave orange-yellow prisms, m. p. 205°, from ethyl alcohol–ethyl acetate, corresponding with 2-(3-*keto*-4-*methyl*cyclo*hexyl*)*lactaldehyde bis*-2 : 4-*dinitrophenylhydrazone* (Found : C, 48·7; H, 4·3. C$_{22}$H$_{24}$O$_9$N$_8$ requires C, 48·6; H, 4·4%).

p-*Menthane*-2 : 9-*diol.*—Dihydrocarvone epoxide (18 g.) in ethyl alcohol (120 c.c.) with Raney nickel (*ca.* 10 g.) was hydrogenated at 100°/90 atm. for 3 hours. Recovery of the material and distillation gave material (4·3 g.), b. p. 75—80°/0·5 mm., and (10·2 g.) b. p. 115—125°/0·4 mm. The first fraction was redistilled and *p*-menthol obtained as a mobile oil, b. p. 45°/0·2 mm., $n_D^{22}$ 1·4677 (Found : C, 76·8; H, 12·7. Calc. for C$_{10}$H$_{20}$O : C, 76·9; H, 12·8%). The main fraction was redistilled and afforded p-*menthane*-2 : 9-*diol* as a viscous oil, b. p. 115—117°/0·4 mm., $n_D^{19}$ 1·4922, $[\alpha]_D$ −14·1° (*c*, 1·2 in chloroform) (Found : C, 69·8; H, 11·9. C$_{10}$H$_{20}$O$_2$ requires C, 69·8; H, 11·6%).

α-(3-*Keto*-4-*methyl*cyclo*hexyl*)*propionic Acid.*—*p*-Menthane-2 : 9-diol (9 g.) in acetone (100 c.c) was treated gradually, with stirring, with chromic acid (11 g.) in water (50 c.c.) and concentrated sulphuric acid (5 c.c.), the temperature being kept at 25—30°. After 8 hours at room temperature, the mixture was somewhat diluted with water and thoroughly extracted with ether, ammonium sulphate being added to assist separation. α-(3-*Keto*-4-*methyl*cyclo*hexyl*)-*propionic acid*, separated by means of sodium hydrogen carbonate solution, was a viscous oil, b. p. 125—130°/0·05 mm. (Found : C, 65·2; H, 9·1. C$_{10}$H$_{16}$O$_3$ requires C, 65·2; H, 8·7%). The 2 : 4-*dinitrophenylhydrazone* formed orange prisms, m. p. 168°, from benzene–light petroleum (Found : C, 53·0; H, 5·7. C$_{16}$H$_{20}$O$_6$N$_4$ requires C, 52·75; H, 5·5%). The *methyl* ester, obtained by methyl-alcoholic sulphuric acid, had b. p. 73°/0·1 mm., $n_D^{19}$ 1·4664, $[\alpha]_D$ −10·3° (*c*, 2·8 in chloroform) (Found : C, 66·7; H, 9·5. C$_{11}$H$_{18}$O$_3$ requires C, 66·6; H, 9·1%).

The neutral fraction from this oxidation on distillation gave some recovered menthanediol and a fraction, b. p. 75—80°/0·1 mm., $n_D^{20}$ 1·4709, reducing Schiff's and Fehling's reagents and yielding 2-(3-*keto*-4-*methyl*cyclo*hexyl*)*propaldehyde bis*-2 : 4-*dinitrophenylhydrazone*, m. p. 231°, as orange prisms from ethyl acetate (Found : C, 49·7; H, 4·7%. C$_{22}$H$_{24}$O$_8$N$_8$ requires C, 50·0; H, 4·6%).

*Dehydrogenation of Methyl* α-(3-*Keto*-4-*methyl*cyclo*hexyl*)*propionate.*—Methyl α-(3-keto-4-

methyl*cyclo*hexyl)propionate (1 g.) was heated with palladised charcoal (0·4 g.) for 3 hours at 285°. α-(3-*Hydroxy-4-methylphenyl)propionic acid*, isolated by aqueous sodium hydrogen carbonate, was distilled and obtained as a colourless glass, b. p. 150°/0·1 mm., which crystallised in air. This *hydrate* crystallised from benzene–light petroleum (b. p. 60—80°) as colourless prisms, m. p. 47° (Found : C, 60·6; H, 7·4. $C_{10}H_{12}O_3,H_2O$ requires C, 60·6; H, 7·1%). When kept over phosphoric oxide it reverted to a colourless glass. Dehydration was completed *in vacuo* at 100° (Found : C, 66·3; H, 7·0. $C_{10}H_{12}O_3$ requires C, 66·6; H, 6·7%). The acid coupled with benzenediazonium chloride, giving a *phenylazo*-derivative, orange yellow prisms, m. p. 144°, from benzene–light petroleum (Found : C, 67·6; H, 6·0. $C_{16}H_{16}O_3N_2$ requires C, 67·6; H, 5·7%).

*Methyl* α-(1 : 2 : 3 : 4 : 5 : 6 : 7 : 10-*Octahydro-7-keto-8 : 10-dimethyl-2-naphthyl)propionate.*— 1-Diethylaminopentan-3-one (Adamson, McQuillin, Simonsen, and Robinson, *J.*, 1937, 1576) gave a *methiodide*, m. p. 70—71°, as prisms from acetone (Found : C, 40·5; H, 7·4. $C_{10}H_{22}ONI$ requires C, 40·2; H, 7·4%).

1-Diethylaminopentan-3-one (6·8 g.) was treated gradually with cooling with methyl iodide (6·2 g.) so that the crystalline methiodide was deposited over the walls of the flask (cf. Cornforth and Robinson, *J.*, 1949, 1855), and a solution of methyl α-(3-keto-4-methyl-*cyclo*hexyl)propionate (8·5 g.) in dry ether (85 c.c.) was added. A solution of sodiotriphenyl-methane (from triphenylmethyl chloride, 16 g., in ether, 370 c.c.) was then run in under nitrogen, the red colour being almost instantly discharged. After 3 hours at 0° and 36 hours at room temperature under nitrogen the mixture was refluxed with stirring for 4 hours. The cooled mixture was then treated with water and rendered just acid with a little dilute acetic acid. The ether-soluble material was isolated and the ethereal solution washed with water and dried ($MgSO_4$). The residue, after removal of solvent, was hydrolysed by 3 hours' refluxing with potassium hydroxide (7·5 g.) in aqueous ethanol (40 c.c.). The alkali-soluble material, isolated after dilution and removal of triphenylmethane in ether–benzene, gave an oil which was esterified by 3 hours' refluxing with methanol (80 c.c.) and a little concentrated sulphuric acid. Isolation gave unchanged methyl α-(3-keto-4-methyl*cyclo*hexyl)propionate (4·1 g.), b. p. 73— 83°/0·1 mm., $n_D^{20}$ 1·4654, and a fraction (2·5 g.), b. p. 125—135°/0·1 mm., $n_D^{20}$ 1·5175, which was redistilled and gave *methyl* α-(1 : 2 : 3 : 4 : 5 : 6 : 7 : 10-*octahydro-7-keto-8 : 10-dimethyl-2-naphthyl)-propionate* as a pale yellow oil, b. p. 125—127°/0·1 mm., $n_D^{20}$ 1·5188, $[α]_D$ +21·2° (*c*, 3·9 in chloroform), $λ_{max.}$ 245 mμ (log ε 4·05) (Found : C, 72·6; H, 9·2. $C_{16}H_{24}O_3$ requires C, 72·6; H, 9·1%). The 2 : 4-*dinitrophenylhydrazone* formed scarlet prisms, m. p. 166°, from alcohol–ethyl acetate (Found : C, 59·5; H, 6·5. $C_{22}H_{26}O_6N_4$ requires C, 59·4; H, 6·3%).

*Dehydrogenation.* The foregoing ester (0·9 g.) was hydrogenated (2 mols. absorbed) in acetic acid (20 c.c.) with Adams's platinum oxide, and the product hydrolysed by aqueous-alcoholic potassium hydroxide. The acid, a yellow gum, was treated with selenium (4 g.) at 320—340° for 18 hours. The neutral product recovered from this treatment was distilled from sodium and converted directly into the picrate which formed golden-yellow needles from alcohol and after one recrystallisation from alcohol had m. p. 95°, undepressed on admixture with 7-ethyl-1-methylnaphthalene picrate.

*Bromination and Dehydrobromination of Methyl* α-(1 : 2 : 3 : 4 : 5 : 6 : 7 : 10-*Octahydro-7-keto-8 : 10-dimethyl-2-naphthyl)propionate.*—The ester (6·5 g.) in carbon tetrachloride (85 c.c.) was heated under reflux for 4 hours with *N*-bromosuccinimide (4·5 g.) and a little benzoyl peroxide. After cooling in ice, succinimide (2·3 g.) was filtered off and the filtrate evaporated *in vacuo*, to give a brown oil which evolved a little hydrogen bromide.

This material was heated under reflux for 2½ hours with dry technical collidine (45 c.c.), and the base hydrobromide (3·9 g.) filtered off after cooling and dilution with ether. The ethereal solution was freed from excess of collidine by washing it with aqueous hydrochloric acid and finally with water. The dried ethereal solution gave on distillation a viscous yellow oil (3·7 g.), b. p. 140—150°/0·4 mm., $n_D^{20}$ 1·5288. This was chromatographed in light petroleum (50 c.c.; b. p. 60—80°) on alumina (100 g.), and the following main fractions were collected, fractions 3 and 4 forming the bulk of the material recovered.

| | Eluant | $n_D^{20}$ | $λ_{max.}$ (mμ) & log ε | Double bonds | Found, % C | H |
|---|---|---|---|---|---|---|
| (1) | Light petroleum–benzene (19 : 1) ......... | 1·5220 | 247 (4·13) | 0·9 | 72·4 | 9·2 |
| (2) | ,, ,, (9 : 1) ......... | 1·5224 | 247 (4·08) 294 (3·51) | — | 72·0 | 9·2 |
| (3) | ,, ,, (1 : 1) ......... | 1·5235 | 247 (4·04) 294 (3·96) | 1·54 | 72·4 | 9·1 |
| (4) | Benzene–ether (1 : 1) ....................... | 1·5338 | 242 (3·85) | 1·98 | 72·0 | 8·4 |

Fraction 4 afforded *methyl* α-(1 : 2 : 3 : 4 : 7 : 10-*hexahydro*-7-*keto*-8 : 10-*dimethyl*-2-*naphthyl*)-*propionate semicarbazone*, m. p. 75°, as a somewhat yellow powder from aqueous methanol, $\lambda_{max.}$ 272 mμ (log ε 4·17) (Found : C, 63·9; H, 7·8. $C_{17}H_{25}O_3N_3$ requires C, 63·95; H, 7·9%).

A small amount of fraction 4 with fuming hydrochloric acid was kept at 35° in a sealed tube for 24 hours. The recovered material, purified by chromatography on alumina followed by distillation in the molecular still gave a resinous solid showing absorption at 212 mμ and 290 mμ (log ε 3·97 and 3·32 respectively).

*Pent-*1-*yn-*3-*one*.—Pent-1-yn-3-ol (Adams and McGrew, *J. Amer. Chem. Soc.*, 1937, **59**, 1497) was oxidised by chromic acid in acetone (Bowden, Heilbron, Jones, and Weedon, *J.*, 1946, 39) to *pent*-1-*yn*-3-*one* (45%), b. p. 106°, $n_D^{20}$ 1·4813 (Found : C, 73·1; H, 7·7. $C_5H_6O$ required C, 73·0; H, 7·3%). The 2 : 4-*dinitrophenylhydrazone* formed golden-yellow plates, m. p. 151°, from alcohol–ethyl acetate (Found : C, 50·5; H, 3·9. $C_{11}H_{10}O_4N_4$ requires C, 50·4; H, 3·8%).

*Condensation of Methyl* α-(3-*Keto*-4-*methyl*cyclo*hexyl*)*propionate with Pent-*1-*yn-*3-*one*.—The ester (6·5 g.) in dry ether (50 c.c.), cooled in ice, was treated with sodiotriphenylmethane (from triphenylmethyl chloride, 11 g., in ether, 250 c.c.) under nitrogen. Pent-1-yn-3-one (2·7 g.) in ether (50 c.c.) was then added with stirring and the mixture kept under nitrogen at 0° for 4 hours and at room temperature overnight. Water was then added and dilute hydrochloric acid to neutrality. The recovered ether-soluble material was hydrolysed by 2 hours' refluxing with potassium hydroxide (2·5 g.) in water (25 c.c.) and alcohol (25 c.c.). From the alkali-soluble material, α-(3-keto-4-methyl*cyclo*hexyl)propionic acid (3·1 g.) was recovered by distillation, and the residue purified by means of sodium hydrogen carbonate and re-esterified by diazomethane. Distillation of the ester gave *methyl* α-(1 : 2 : 3 : 4 : 7 : 10-*hexahydro*-7-*keto*-8 : 10-*dimethyl*-2-*naphthyl*)*propionate*, in small amount, as a viscous yellow oil, b. p. 125°/0·05 mm. (Found : C, 73·1; H, 8·9. $C_{16}H_{22}O_3$ requires C, 73·2; H, 8·4%).

KING'S COLLEGE, NEWCASTLE-ON-TYNE, 1.