

678. *Studies in the Vitamin D Field. Part IV.<sup>1</sup> The Synthesis of Some Ring A Derivatives.*

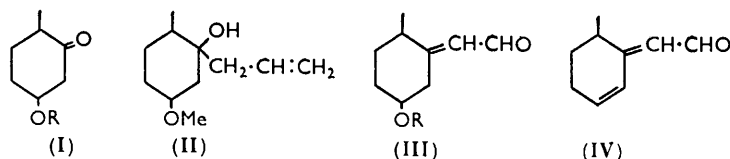
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Syntheses of 5-methoxy-2-methylcyclohexylideneacetaldehyde (III; R = Me) from 5-methoxy-2-methylcyclohexanone, and of 3-ethynyl-4-methylcyclohex-2-enol (VI; R = H) from 6-methylcyclohex-2-enone, are described; these compounds are of potential use for the synthesis of 9:10-*seco*-steroids and related substances. Some pilot experiments involving the synthesis of 6-methyl-1-phenylcyclohex-2-enol and some transformation products are recorded.

The *cd*-ketone derived from ergocalciferol has been converted into 4-chloro-6:7:8:9-tetrahydro-8-methyl-1-(1:4:5-trimethylhex-2-enyl)indane (XII; R = Cl).

In Part I,<sup>2</sup> some simple analogues of tachysterol were synthesised by condensation of cyclohexenyl-lithium with cyclohexylidene- and 2'-methylcyclohexylidene-acetaldehyde. For a synthesis of tachysterol itself along these lines an aldehyde of type (III) is required. Efforts to achieve simpler syntheses of the necessary ketone (I) having proved impracticable,<sup>1</sup> the methoxy-compound (I; R = Me) was prepared by the recorded method<sup>3</sup> from *p*-cresol. Details of the later stages of this preparation are given on p. 3338 since the conditions for satisfactory yields are important.

Reaction of 5-methoxy-2-methylcyclohexanone (I; R = Me) with allylmagnesium chloride gave 1-allyl-2-methyl-5-methoxycyclohexanol (II) which on ozonolysis, followed by distillation of the product over potassium hydrogen sulphate, furnished an unsaturated



aldehyde; from its light absorption ( $\lambda_{\text{max}}$ , 2370 Å,  $\epsilon$  9500 in EtOH) this consisted largely of the required 5-methoxy-2-methylcyclohexylideneacetaldehyde (III; R = Me). As was observed<sup>2</sup> with the analogous compound lacking the methoxy-group, the free aldehyde was unstable and gave unsatisfactory analytical results, but it readily yielded a pure semicarbazone and a pure 2:4-dinitrophenylhydrazone, the spectral characteristics of which agreed with the  $\alpha\beta$ -unsaturated structure. Prolonged treatment of the aldehyde (III; R = Me) with potassium hydrogen sulphate gave a product which showed an additional absorption maximum at 2800 Å, indicating that elimination had occurred to

<sup>1</sup> Part III, preceding paper.

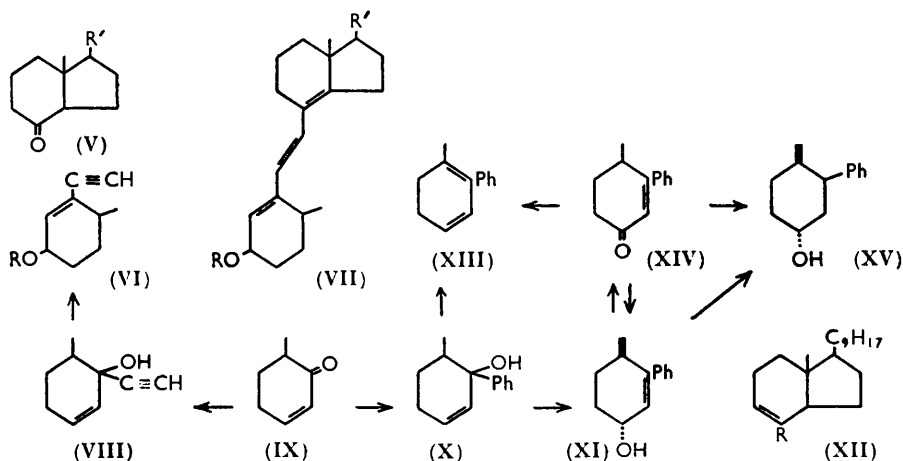
<sup>2</sup> Braude and Wheeler, *J.*, 1955, 320.

<sup>3</sup> U.S.P. 2,511,815.

some extent to give the conjugated dienal (IV); the 2:4-dinitrophenylhydrazone prepared from such a product showed light absorption and analytical figures compatible with a parent compound having this structure.

An acetylenic compound (VI) is clearly of potential synthetical use in this field; for example, condensation with the  $\alpha$ -ketone (V), followed by partial reduction and dehydration, could give the  $\mu$ -tachysterol<sup>4</sup> derivative (VII). A pilot investigation was carried out on the reaction of 6-methylcyclohex-2-enone (IX) with phenylmagnesium bromide, which gave 6-methyl-1-phenylcyclohex-2-enol (X) in good yield. This rearranged in acidified aqueous acetone to the conjugated alcohol (XI); a small amount of a solid hydrocarbon, probably 1-methyl-2-phenylcyclohexa-1:3-diene (XIII), was also formed. Oxidation of the alcohol (XI) with chromium trioxide in pyridine gave 4-methyl-3-phenylcyclohex-2-enone (XIV), and when this was reduced with lithium aluminium hydride the original alcohol (XI), together with a large amount of hydrocarbon, was formed. Since reduction of unhindered ketones with lithium aluminium hydride normally<sup>5</sup> gives the equatorial epimer the alcohol can be allocated the *trans*-configuration shown (formulae refer to optically inactive materials), in which the methyl and the hydroxyl group are both in quasi-equatorial<sup>5</sup> positions. Catalytic hydrogenation of this alcohol, and also reduction of the ketone (XIV) with sodium in propan-2-ol, gave the same saturated alcohol, 4-methyl-3-phenylcyclohexanol (XV).

3-Ethynyl-4-methylcyclohex-2-enol (VI; R = H) was then prepared by a similar sequence of reactions. Conjugated unsaturated ketones do not readily react with metal acetylides in liquid ammonia (*isophorone* is notoriously inactive<sup>6</sup>), and 6-methylcyclohex-2-enone (IX) with lithium acetylide gave only an impure alcohol containing much unchanged ketone. Pure 1-ethynyl-6-methylcyclohex-2-enol (VIII) was obtained, however, by reaction of the ketone with acetylene monomagnesium bromide in tetrahydrofuran



under the conditions recently described<sup>7</sup> for the preparation of this reagent.\* Rearrangement in acidified aqueous acetone proceeded smoothly to give the desired product (VI; R = H), which readily gave the tetrahydropyranyl ether (VI; R = C<sub>5</sub>H<sub>9</sub>O).

A possible partial synthesis of the tachysterol system would involve condensation of an aldehyde (III) with the alkenyl-lithium (XII; R = Li) according to the general method suggested in Part I,<sup>2</sup> and an investigation was therefore made of the conversion of the

\* We are much indebted to Professor E. R. H. Jones, F.R.S., for informing us about this method before its publication.

<sup>4</sup> Inhoffen, Brückner, Irmscher, and Quinkert, *Chem. Ber.*, 1955, **88**, 1424.

<sup>5</sup> Barton and Cookson, *Quart. Rev.*, 1956, **10**, 44.

<sup>6</sup> Oroshnik and Mebane, *J. Amer. Chem. Soc.*, 1949, **71**, 2062.

<sup>7</sup> Jones, Skattebøl, and Whiting, *J.*, 1956, 4765.

C<sub>19</sub> ketone (V; R' = C<sub>9</sub>H<sub>17</sub>), derived<sup>8,9</sup> from ergocalciferol, into the chloro-compound (XII; R = Cl) by reaction with phosphorus pentachloride. The product was analytically pure, but could, of course, be a mixture of (XII; R = Cl) and the isomer with the double bond in the bridgehead position. The far-ultraviolet absorption spectrum was kindly measured with a double-beam photoelectric recording vacuum spectrophotometer<sup>10</sup> by Dr. D. W. Turner, who reported that "it shows (in hexane) only one broad band ( $\lambda_{\max}$ . 1900 Å,  $\epsilon$  17,500), which is consistent with a summation of the absorptions due to the olefinic side chain and the 4:5-double bond, as in (XII; R = Cl) (cf. ergost-22-enyl acetate,  $\lambda_{\max}$ . 1850 Å,  $\epsilon$  11,600; and 1-chlorocyclohexene,  $\lambda_{\max}$ . 1950 Å,  $\epsilon$  6,400). The 4:9-isomer would probably show a separate maximum above 2100 Å [cf. ergost-8(14)-enol,  $\lambda_{\max}$ . 2080 Å,  $\epsilon$  11,200]." Thus it seems unlikely that the product contained any significant proportion of the 4:9-isomer, and we accordingly regard it as the required 4-chloro-6:7:8:9-tetrahydro-8-methyl-1-(1:4:5-trimethylhex-2-enyl)indane (XII; R = Cl).

#### EXPERIMENTAL

**5-Methoxy-2-methylphenol.**—Sodium nitrite (34.5 g.) in water (135 ml.) was added at 0–5° to a mixture of 5-methoxy-2-methylaniline<sup>11</sup> (69 g.), sulphuric acid (55 ml.), and water (1 l.). This solution was then slowly added (20 min.) to a boiling mixture of benzene (1030 ml.), water (710 ml.), and sulphuric acid (355 ml.); boiling was continued for a further 15 min. and the mixture was then cooled. The benzene layer was removed, the aqueous portion was extracted with benzene, and the combined benzene solutions were dried (Na<sub>2</sub>SO<sub>4</sub>) and evaporated to a semi-solid residue (69 g.). The combined products (251 g.) from four such experiments were steam-distilled, and the 5-methoxy-2-methylphenol (176 g., 63%), m. p. 42–43°, isolated by extraction of the distillate with benzene (lit.,<sup>12</sup> m. p. 47°).

**5-Methoxy-2-methylcyclohexanol.**—The above phenol (137 g.) in methanol (500 ml.) was hydrogenated over Raney nickel W7 at 120–130°/130 atm. for 60 hr. The crude product was washed with alkali, and the residual neutral material distilled to give 5-methoxy-2-methylcyclohexanol (111 g.), b. p. 84–110°/14 mm.,  $n_D^{25}$  1.4608–1.4656. Redistillation of a portion gave a main fraction, b. p. 86–93°/14 mm.,  $n_D^{25}$  1.4609 (Found: C, 67.2; H, 11.4. Calc. for C<sub>8</sub>H<sub>16</sub>O<sub>2</sub>: C, 66.6; H, 11.2%) (lit.,<sup>3</sup> b. p. 74–93°/8 mm.).

**5-Methoxy-2-methylcyclohexanone.**—A solution of chromic acid (35 g.) in acetic acid (53.5 ml.) and water (53.5 ml.) was added dropwise (50 min.) to 5-methoxy-2-methylcyclohexanol (61 g.) in benzene (650 ml.), with vigorous stirring, at ca. 50°. Stirring at this temperature was maintained for a further 3 hr., and the mixture was then cooled. The benzene layer was combined with benzene extracts of the aqueous portion, washed with aqueous sodium hydrogen carbonate and with water, dried, and evaporated to an oil (57.5 g.). The combined product (129 g.) from such oxidation of 134 g. of the alcohol on fractional distillation through a Fenske column gave: (i) 2-methylcyclohexanone (17 g.), b. p. 55–56°/16 mm.,  $n_D^{25}$  1.4490 (semicarbazone, m. p. 191°) (lit.,<sup>13</sup>  $n_D^{25}$  1.4483, semicarbazone, m. p. 191°), derived from 2-methylcyclohexanol present in the crude alcohol; (ii) 5-methoxy-2-methylcyclohexanone (81 g., 60%), b. p. 94°/16 mm.,  $n_D^{25}$  1.4559,  $\nu_{\max}$ . (liquid film) 1707 (C=O) cm.<sup>-1</sup> (Found: C, 67.5; H, 10.3. Calc. for C<sub>8</sub>H<sub>14</sub>O<sub>2</sub>: C, 67.6; H, 9.9%) (lit.,<sup>3</sup> b. p. 83–87°/8 mm.) [semicarbazone, m. p. 167–168° (lit.,<sup>14,15</sup> m. p. 167°, 158–159°) (Found: C, 54.4; H, 8.6; N, 21.15. Calc. for C<sub>9</sub>H<sub>17</sub>O<sub>2</sub>N<sub>3</sub>: C, 54.3; H, 8.6; N, 21.1%)].

**1-Allyl-5-methoxy-2-methylcyclohexanol.**—A mixture of 5-methoxy-2-methylcyclohexanone (21.3 g.), allyl chloride (14.4 g.), benzene (30 ml.), and dry ether (75 ml.) was added dropwise (3.5 hr.) to a stirred mixture of magnesium (4.0 g.), ether (40 ml.), and iodine (trace), the bath-temperature being maintained at 35–40° during the first 2.5 hr. and gradually raised to 50° during the final hour. The cooled mixture was then treated at 0° with ammonium chloride

<sup>8</sup> Windaus and Grundmann, *Annalen*, 1936, **524**, 295.

<sup>9</sup> Dimroth and Jonsson, *Ber.*, 1941, **74**, 520.

<sup>10</sup> D. W. Turner, *J.*, 1957, 4555.

<sup>11</sup> Beaven, Bird, Hall, Leslie, and E. E. Turner, *J.*, 1954, 131.

<sup>12</sup> Limpach, *Ber.*, 1891, **24**, 4139.

<sup>13</sup> Skita, *Ber.*, 1923, **56**, 1014.

<sup>14</sup> Inhoffen, Weissermel, and Quinkert, *Chem. Ber.*, 1955, **88**, 1313.

<sup>15</sup> Corsano and Capitto, *Gazzetta*, 1955, **85**, 1590.

(60 g.) in water (100 ml.), and filtered. The aqueous portion of the filtrate was extracted with ether, and the combined organic layers were dried and distilled to give 1-allyl-5-methoxy-2-methylcyclohexanol (14 g., 50%), b. p. 91—94°/0.9 mm.,  $n_D^{24}$  1.4710,  $\nu_{\max}$ . (liquid film) 3454 (O-H), 1635 (C=O)  $\text{cm}^{-1}$  (Found: C, 71.5; H, 11.0.  $\text{C}_{11}\text{H}_{20}\text{O}_2$  requires C, 71.7; H, 10.9%).

*5-Methoxy-2-methylcyclohexylideneacetaldehyde*.—The preceding compound (10.0 g.) in acetic acid (50 ml.) was ozonised at 0° for 14 hr. Zinc dust (10 g.) was then added, and the mixture was heated on the steam-bath for 20 min., then poured on ice and extracted with ether to give a product (2.7 g.), b. p. 80—100°/0.3 mm.,  $n_D^{24}$  1.4779,  $\lambda_{\max}$ . (in  $\text{C}_6\text{H}_{14}$ ) 2370 Å ( $\epsilon$  8400). It was redistilled over fused potassium hydrogen sulphate (0.3 g.) to give *5-methoxy-2-methylcyclohexylideneacetaldehyde*, b. p. 91—92°/0.2 mm.,  $n_D^{22}$  1.4910,  $\lambda_{\max}$ . (in  $\text{C}_6\text{H}_{14}$ ) 2370 Å ( $\epsilon$  9400),  $\nu_{\max}$ . (liquid film) 3430 (weak; trace of hydroxy-compound), 2720 (C-H in CHO), 1715 and 1667 (C=O), 1627 (C=O)  $\text{cm}^{-1}$  (Found: C, 67.1, 68.3; H, 9.6, 9.6.  $\text{C}_{10}\text{H}_{16}\text{O}_2$  requires C, 71.4; H, 9.6%). It gave a *semicarbazone* (from aqueous ethanol), m. p. 172—174°,  $\lambda_{\max}$ . (in EtOH) 2740 ( $\epsilon$  37,400) (Found: C, 59.05; H, 8.3; N, 19.0.  $\text{C}_{11}\text{H}_{19}\text{O}_2\text{N}_3$  requires C, 58.6; H, 8.5; N, 18.65%), and a 2:4-dinitrophenylhydrazone, orange rosettes (from benzene), m. p. 183°,  $\lambda_{\max}$ . (in  $\text{CHCl}_3$ ) 3850 Å ( $\epsilon$  31,000) (Found: C, 55.7; H, 5.9; N, 15.6.  $\text{C}_{16}\text{H}_{20}\text{O}_6\text{N}_4$  requires C, 55.15; H, 5.8; N, 16.1%).

In another experiment, the product was distilled twice over potassium hydrogen sulphate, and then had b. p. 87°/0.2 mm.,  $n_D^{24}$  1.4944,  $\lambda_{\max}$ . (in EtOH) 2400 and 2800 ( $\epsilon$  4200 and 760) (Found: C, 71.2; H, 9.8%). With 2:4-dinitrophenylhydrazine in phosphoric acid it gave, after chromatography, *2-methylcyclohex-5-enylideneacetaldehyde* 2:4-dinitrophenylhydrazone, dark red prisms [from benzene—light petroleum (b. p. 60—80°)], m. p. 164—166°,  $\lambda_{\max}$ . (in  $\text{CHCl}_3$ ) 3100 and 3960 Å ( $\epsilon$  12,000 and 35,700) (Found: C, 57.1; H, 5.4; N, 17.8.  $\text{C}_{15}\text{H}_{16}\text{O}_4\text{N}_4$  requires C, 57.0; H, 5.1; N, 17.7%).

*6-Methyl-1-phenylcyclohex-2-enol*.—A solution of 6-methylcyclohex-2-enone<sup>1</sup> (22.0 g.) in ether (50 ml.) was slowly added (30 min.) at 0° to a Grignard reagent prepared from magnesium (6 g.), bromobenzene (33 g.), and ether (100 ml.). Stirring was continued for 2.5 hr. at room temperature, and the complex was then decomposed by the addition of excess of aqueous ammonium chloride. The ether layer, and ethereal extracts of the aqueous layer, were combined, dried ( $\text{Na}_2\text{SO}_4 + \text{K}_2\text{CO}_3$ ), and distilled from a trace of potassium carbonate to give 6-methyl-1-phenylcyclohex-2-enol (28.3 g., 75%), b. p. 86—87°/10<sup>-3</sup> mm.,  $n_D^{23}$  1.5529,  $\lambda_{\max}$ . (in EtOH) 2520 Å ( $\epsilon$  1900),  $\nu_{\max}$ . (liquid film) 3367 (O-H)  $\text{cm}^{-1}$  (Found: C, 83.4, 83.6; H, 8.7, 8.6.  $\text{C}_{13}\text{H}_{18}\text{O}$  requires C, 82.9; H, 8.6%).

*4-Methyl-3-phenylcyclohex-2-enol*.—A mixture of 6-methyl-1-phenylcyclohex-2-enol (20.6 g.), acetone (600 ml.), water (400 ml.), and 2N-hydrochloric acid (5 ml.) was set aside for 24 hr., then neutralised with sodium hydrogen carbonate. The acetone was distilled off through a short column, and the residual aqueous solution was extracted with chloroform to give, on distillation: (i) a white solid (1 g.), probably 1-methyl-2-phenylcyclohexa-1:3-diene, b. p. 120—130° (bath)/10<sup>-3</sup> mm., which crystallised from aqueous methanol in plates, m. p. 69—70°,  $\lambda_{\max}$ . (in EtOH) 2480 Å ( $\epsilon$  17,700) (Found: C, 91.6, 91.3; H, 6.6, 6.55; O, nil.  $\text{C}_{13}\text{H}_{14}$  requires C, 91.7; H, 8.3%); and (ii) 4-methyl-3-phenylcyclohex-2-enol (17.4 g., 84%), b. p. 105—107°/10<sup>-3</sup> mm.,  $n_D^{23}$  1.5672,  $\lambda_{\max}$ . 2410 Å ( $\epsilon$  12,800),  $\nu_{\max}$ . (liquid film) 3311 (O-H), 1642 (C=C)  $\text{cm}^{-1}$  (Found: C, 82.85; H, 8.8.  $\text{C}_{13}\text{H}_{18}\text{O}$  requires C, 82.9; H, 8.6%). Like the unconjugated isomer, it gave an intense green colour with concentrated sulphuric acid. The 3:5-dinitrobenzoate formed needles (from aqueous acetone), m. p. 128° (Found: C, 62.55; H, 5.0; N, 7.3.  $\text{C}_{20}\text{H}_{18}\text{O}_6\text{N}_2$  requires C, 62.8; H, 4.75; N, 7.3%).

*4-Methyl-3-phenylcyclohex-2-enone*.—Chromium trioxide (15 g.) was added in small portions to stirred pyridine (200 ml.) below 20°. The mixture was then cooled to 0°, a solution of 4-methyl-3-phenylcyclohex-2-enol (11 g.) in pyridine (100 ml.) was gradually added, and the whole was kept at 5—10° for 3 days. The pyridine was then removed under reduced pressure at 20°, and the residue was treated with ether and water. Distillation of the dried ethereal solution afforded the *ketone* (10.3 g., 95%), b. p. 92—94°/0.01 mm.,  $n_D^{23}$  1.5893,  $\lambda_{\max}$ . (in EtOH) 2800 Å ( $\epsilon$  18,000),  $\nu_{\max}$ . (liquid film) 1672 (C=O) (Found: C, 83.9; H, 7.7.  $\text{C}_{13}\text{H}_{14}\text{O}$  requires C, 83.8; H, 7.6%). The 2:4-dinitrophenylhydrazone formed crimson needles (from ethyl acetate—methanol), m. p. 190°,  $\lambda_{\max}$ . (in  $\text{CHCl}_3$ ) 4000 Å ( $\epsilon$  33,000) (Found: C, 62.3; H, 5.0; N, 15.9.  $\text{C}_{18}\text{H}_{18}\text{O}_4\text{N}_4$  requires C, 62.3; H, 4.95; N, 15.3%).

*Reduction of 4-Methyl-3-phenylcyclohex-2-enone*.—(i) *With lithium aluminium hydride*. The *ketone* (2.5 g.) in ether (25 ml.) was added to a solution of lithium aluminium hydride (0.5 g.)

in ether (75 ml.) and the mixture was stirred for 30 min. and then cooled to 0° and acidified with hydrochloric acid. Isolation with ether afforded a pale yellow viscous liquid (1.8 g.), b. p. 130—150° (bath)/10<sup>-4</sup> mm.,  $n_D^{25}$  1.5818—1.5840,  $\lambda_{\max.}$  (in EtOH) 2280, 2340, and 3050 Å ( $\epsilon$  10,000, 10,000, and 10,000) (Found: C, 88.5; H, 8.65. Calc. for C<sub>13</sub>H<sub>14</sub>O: C, 82.9; H, 8.6. Calc. for C<sub>13</sub>H<sub>14</sub>: C, 91.7; H, 8.3%); it gave 4-methyl-3-phenylcyclohex-2-enyl 3 : 5-dinitrobenzoate, m. p. and mixed m. p. 126—127°.

(ii) *With sodium and propanol.* Sodium (15 g.) was gradually added (30 min.) to a boiling solution of 4-methyl-3-phenylcyclohex-2-enone (3.0 g.) in propanol (100 ml.). Boiling was continued for a further 25 min., and the remaining sodium was decomposed by the addition of methanol (50 ml.) and water (15 ml.). The solvents were then removed under reduced pressure and the residue was treated with ether and water. Distillation of the dried ethereal solution gave 4-methyl-3-phenylcyclohexanol (2.9 g., 97%), b. p. 105—110°/10<sup>-2</sup> mm.,  $n_D^{25}$  1.5421,  $\lambda_{\max.}$  (in EtOH) 2420 Å ( $\epsilon$  380),  $\nu_{\max.}$  (liquid film) 3333 (O-H) (Found: C, 81.5; H, 9.6. C<sub>13</sub>H<sub>16</sub>O requires C, 82.1; H, 9.5%). It had an odour of limonene. The 3 : 5-dinitrobenzoate formed needles [from acetone—light petroleum (b. p. 40—60°)], m. p. 133—135°,  $\lambda_{\max.}$  (in EtOH) 2320 ( $\epsilon$  24,000) (Found: C, 62.6; H, 5.6. C<sub>20</sub>H<sub>20</sub>O<sub>6</sub>N<sub>2</sub> requires C, 62.5; H, 5.2%).

*Hydrogenation of 4-Methyl-3-phenylcyclohex-2-enol.*—The alcohol (1.5 g.) in methanol (25 ml.) absorbed 248 ml. (calc. 250 ml.) of hydrogen at 24°/752 mm. during 15 min. over 10% palladised charcoal (0.1 g.). Evaporation of the filtered solution gave 4-methyl-3-phenylcyclohexanol (1.4 g.), identified as the 3 : 5-dinitrobenzoate, m. p. and mixed m. p. 133—134°.

*1-Ethynyl-6-methylcyclohex-2-enol.*—A Grignard reagent was prepared from ethyl bromide (23 g.) and magnesium (5 g.) in boiling tetrahydrofuran (100 ml.), and added dropwise whilst still hot, during 25 min., to tetrahydrofuran (100 ml.) through which a rapid stream of acetylene was passed at room temperature. After 1 hr., the gas stream was reduced to a slow flow, and the solution was cooled to -10°. 6-Methylcyclohex-2-enone<sup>1</sup> (11.0 g.) in tetrahydrofuran (50 ml.) was added, and the mixture was stirred for 18 hr. at room temperature, the slow stream of acetylene being maintained. An excess of saturated aqueous ammonium chloride was then added at 0°, and the organic layer was removed and combined with ethereal extracts of the aqueous layer (on a larger scale it is preferable to distill off the tetrahydrofuran through a column, dilute the residue with water, and extract it with chloroform). Removal of solvent from the dried (Na<sub>2</sub>SO<sub>4</sub> + K<sub>2</sub>CO<sub>3</sub>) extract, and distillation of the residue, gave 1-ethynyl-6-methylcyclohex-2-enol (7.3 g., 54%), b. p. 44—45°/10<sup>-4</sup> mm.,  $n_D^{25}$  1.4990, no strong absorption between 2000 and 4000 Å,  $\nu_{\max.}$  (in CCl<sub>4</sub>) 3623 and 3472 (O-H), 3300 ( $\equiv$ C-H), 3030 ( $=$ C-H), 2924 (C-H), 2123 (C=CH), 1656 (C=C) cm.<sup>-1</sup> (Found: C, 79.5; H, 9.0. C<sub>9</sub>H<sub>12</sub>O requires C, 79.4; H, 8.9%).

An identical experiment, but with the ethylmagnesium bromide prepared in ether, gave a yield of only 39%.

*3-Ethynyl-4-methylcyclohex-2-enol.*—A mixture of 1-ethynyl-6-methylcyclohex-2-enol (44 g.), acetone (400 ml.), water (350 ml.), and 2N-hydrochloric acid (50 ml.) was set aside for 24 hr., then neutralised with sodium hydrogen carbonate, concentrated to remove acetone, and extracted with ether to give 3-ethynyl-4-methylcyclohex-2-enol (40 g., 90%), b. p. 60—61°/10<sup>-3</sup> mm.,  $n_D^{24}$  1.5109,  $\lambda_{\max.}$  (in EtOH) 2260 Å ( $\epsilon$  9,000),  $\nu_{\max.}$  (in CCl<sub>4</sub>) 3610 (O-H), 3279 ( $\equiv$ C-H), 3021 ( $=$ C-H), 2933 and 2865 (C-H), 2105 (C=CH), 1623 (C=C) cm.<sup>-1</sup> (Found: C, 79.6; H, 9.0. C<sub>9</sub>H<sub>12</sub>O requires C, 79.4; H, 8.9%). The compound was unstable in air, and became yellow in a few hours. The 3 : 5-dinitrobenzoate formed colourless prisms (from acetone—pentane), m. p. 94—95°,  $\lambda_{\max.}$  (in EtOH) 2270 Å ( $\epsilon$  43,000) (Found: C, 57.65; H, 4.5; N, 9.2. C<sub>16</sub>H<sub>14</sub>O<sub>6</sub>N<sub>2</sub> requires C, 58.2; H, 4.3; N, 8.5%).

*3-Ethynyl-4-methylcyclohex-2-enyl Tetrahydropyran-2-yl Ether.*—A mixture of 2 : 3-dihydro-4H-pyran (50 ml.), 3-ethynyl-4-methylcyclohex-2-enol (38 g.), and concentrated hydrochloric acid (0.2 c.c.) was set aside under nitrogen for 3 days, then neutralised with potassium carbonate (1 g.) and distilled through a Fenske column. The ether (48 g., 78%) had b. p. 82—83°/10<sup>-4</sup> mm.,  $n_D^{25}$  1.5022,  $\lambda_{\max.}$  (in EtOH) 2260 Å ( $\epsilon$  12,000),  $\nu_{\max.}$  3290 ( $\equiv$ C-H), 3021 ( $=$ C-H), 2933 and 2882 (C-H), 2110 (C=CH), 1626 (C=C) cm.<sup>-1</sup> (Found: C, 76.05; H, 9.3. C<sub>14</sub>H<sub>20</sub>O<sub>2</sub> requires C, 76.3; H, 9.15%).

*4-Chloro-6 : 7 : 8 : 9-tetrahydro-8-methyl-1-(1 : 4 : 5-trimethylhex-2-enyl)indane.*—Ergocalciferol (5 g.) was oxidised by Dimroth and Jonsson's method<sup>9</sup> to the C<sub>19</sub> ketone, b. p. 150—174° (bath)/10<sup>-4</sup> mm.,  $n_D^{25}$  1.4942 (Found: C, 81.4; H, 11.5. C<sub>19</sub>H<sub>32</sub>O requires C, 82.5; H, 11.7%) (no analysis or physical constants have previously been recorded). Another preparation,

purified by chromatography in benzene on alumina, had  $n_D^{25}$  1.4945 (Found: C, 82.8; H, 11.8%). It gave a 2 : 4-dinitrophenylhydrazone, orange needles (from aqueous methanol), m. p. 86—89°,  $\lambda_{\max.}$  (in  $\text{CHCl}_3$ ) 3680 Å ( $\epsilon$  21,000) (Found: 66.2; H, 8.2; N, 11.8.  $\text{C}_{25}\text{H}_{36}\text{O}_4\text{N}_4$  requires C, 65.8; H, 8.0; N, 12.3%).

The  $\text{C}_{19}$  ketone (1.8 g.) in dry ether (5 ml.) was added dropwise (3 hr.) to phosphorus pentachloride (1.8 g.) suspended in dry ether (5 ml.) at 0°. <sup>16</sup> After 16 hr. at room temperature, the mixture was poured on crushed ice, stirred for 2 hr., and extracted with ether. Concentration of the washed and dried extracts gave an oil (1.5 g.) which was transferred in benzene to an alumina column and eluted with light petroleum (b. p. 60—80°). The product (0.7 g.), isolated from the first 55 c.c. of eluate, was twice re-chromatographed in light petroleum (b. p. 60—80°) to give the *chloro-hydrocarbon* (0.4 g.),  $n_D^{24}$  1.5045 (Found: C, 77.2; H, 10.65; Cl, 12.2.  $\text{C}_{19}\text{H}_{31}\text{Cl}$  requires C, 77.4; H, 10.6; Cl, 12.0%),  $\lambda_{\max.}$  (in hexane) 1900 Å ( $\epsilon$  17,500).

Grateful acknowledgment is made to the Distillers' Company for a Studentship (A. A. W., 1954—56) and to the Salters' Company for a Scholarship (A. A. W., 1956—57). One of us (M. U. S. S.) thanks the Council of the University of Ceylon for a year's sabbatical leave.

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[Received, May 19th, 1958.]

<sup>16</sup> Cf. Braude and Coles, *J.*, 1950, 2014.

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