317. *Extractives from Woods. Part VII.* Extractives from* Cephalosphaera usambarensis *Warb.*

By Wesley Cocker, T. B. H. McMurry, and M. S. Ntamila

Cephalosphaera usambarensis Warb. contains alkanes, saturated and unsaturated fatty acids, terpenoids, waxes, β-sitosterol, cycloeucalenol and 24-methylenecycloartanol. The latter has been synthesised from cycloeucalenol and from cycloartenone.

The hardwood, *Cephalosphaera usambarensis* warb. (family Myristicaceae) is imported to the British Isles as a timber of commerce. The dried fruit of the tree is reported [1] to contain a fat capable of causing dermatitis. The tree also yields [1] a kino-like resin, which is largely water-soluble, but no systematic examination of extractives from its heartwood has previously been reported.

A ligroin † extract of the heartwood has now been found to contain allo-ocimene, limonene, methylheptenone, α- and β-pinene, and terpinolene, the last being the main component. The hydrocarbons n-eicosane to n-tritriacontane inclusive are present and the wood contains waxes which on hydrolysis afford all the unbranched alkanoic acids from C_{13} to C_{25} inclusive, several monoethenoic acids, and linoleic and linolenic acids. The neutral part of the extractive contains β-sitosterol and a mixture of cycloeucalenol (I; R = H, R^1 = Me) and its 4-methyl homologue, 24-methylenecycloartanol (I; R = R^1 = Me).

The separation of cycloeucalenol and 24-methylenecycloartanol was readily effected by thin-layer chromatography (t.l.c.) on silica gel and by gas–liquid chromatography (g.l.c.), but we did not find conditions whereby they could be separated in quantity by column chromatography. The mixture of alcohols was therefore oxidised to the corresponding

* Part VI, *Perfumery Essent. Oil Record*, 1964, **55**, 442.
† "Ligroin" refers to light petroleum (b. p. 60—80°).

[1] Braun, *Arch. Pharm.*, 1925, **263**, 123.

ketones which were readily separated on neutral alumina giving cycloeucalenone (II; R = R^2 = H, R^1 = Me) and 24-methylenecycloartanone (II; R = R^1 = Me, R^2 = H). Reduction of the latter with sodium in propan-1-ol gave 24-methylenecycloartanol, m. p. 122°, $[\alpha]_D$ +42°, in good agreement with published data.[2,3]

24-Methylenecycloartanol was isolated [2] from rice-bran oil by Ohta and Shimizu and from *Tristania conferta* and *Angophora subvelutina* (Myrtaceae) by Australian workers.[3] The Japanese workers related the alcohol to cycloartanol by ozonolysis of its acetate to 24-oxocycloartanyl acetate (III; R = Ac) which was reduced (*a*) to cycloartanyl acetate and (*b*) to 24-hydroxycycloartanyl acetate which was dehydrated to cycloartenyl acetate (IV; R = OAc). We have now carried out partial syntheses of 24-methylenecycloartanol from (*a*) cycloeucalenol (I; R = H, R^1 = Me) by insertion of an additional methyl group at C-4 and (*b*) from cycloartenol (IV; R = OH). The synthetic alcohol and the extractive from *Cephalosphaera* were identical.

The first synthesis was as follows. Cycloeucalenone (II; R = R^2 = H, R^1 = Me) was reacted with ethyl formate giving 2-hydroxymethylenecycloeucalenone (II; R = H, R^1 = Me, R^2 = CHOH), which was condensed with n-butanethiol thus affording 2-n-butylthiomethylenecycloeucalenone (II; R = H, R^1 = Me, R^2 = CH·S·C_4H_9). This compound was methylated [4] with methyl iodide and potassium t-butoxide giving 2-n-butylthiomethylene-24-methylenecycloartanone (II; R = R^1 = Me, R^2 = CH·S·C_4H_9). The butylthiomethylene group was removed [5] by hydrolysis with 25% sodium hydroxide in diethylene glycol giving 24-methylenecycloartanone, m. p. 102°, $[\alpha]_D$ +24°, undepressed by the ketone obtained by oxidation of the naturally occurring alcohol. It was indistinguishable from the latter spectroscopically and was not separated from it by t.l.c. or g.l.c. The nuclear magnetic resonance (n.m.r.) spectra of the two ketones (II; R = R^2 = H, R^1 = Me) and (II; R = R^1 = Me, R^2 = H) show a pair of doublets typical of a methylene group in a cyclopropane ring.[6] In (II; R = R^1 = Me, R^2 = H) the doublets occur at 9·42 and 9·12 τ (J = 4·0 c./sec.), and in (II; R = R^2 = H, R^1 = Me) at 9·61 and 9·35 τ (J = 3·6 c./sec.). The shift in the position of the peaks in going from the 4,4-dimethyl- to the 4-monomethylketone is no doubt due to the absence of the axial 4-methyl group in the latter compound.

The yield of 24-methylenecycloartanone was small and thus purification was not as rigorous as we wished. Since its melting point differed from that of the specimen obtained from the naturally occurring alcohol we turned our attention to the second synthetic route, which also required less vigorous experimental conditions.

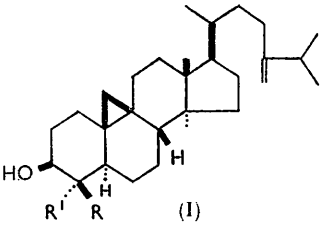
Cycloartenone (IV; R = O) isolated from the resin of the Jak tree (*Artocarpus integrifolia*) [7,8] was converted by standard methods into cycloartenyl acetate (IV; R = OAc), from which its epoxide (V) was obtained. The latter reacted with boron trifluoride to give 24-oxocycloartanyl acetate (III; R = Ac). That this was the correct ketone was shown by its n.m.r. and infrared (i.r.) spectra. The n.m.r. spectrum shows a peak at 7·4 τ with an intensity corresponding to the methyl group of the 3-acetoxyl. Had the product contained a methyl ketone as in (VI), the intensity of this band should correspond to six protons.

Comparison of the i.r. spectra of 24-methylenecycloartanyl acetate (acetate of I; R = R^1 = Me), the expected ketone (III; R = Ac), and cycloeucalenyl acetate (acetate of I; R = H, R^1 = Me) shows clearly the splitting of the 1380 cm.$^{-1}$ band in the first two spectra, due to the presence of the *gem*-dimethyl and isopropyl groups. Furthermore, the spectrum of (III; R = Ac) lacks the 1360 cm.$^{-1}$ band characteristic of a methyl ketone as in (VI).

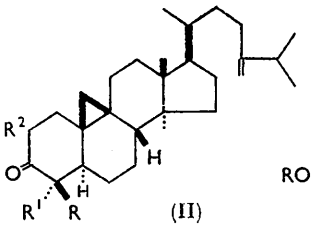
[2] Ohta and Shimizu, *Chem. and Pharm. Bull.* (*Japan*), 1958, **6**, 325.
[3] Ritchie, Snape, and Taylor, *Austral. J. Chem.*, 1961, **14**, 471, 473.
[4] Cf. Cox, King, and King, *J.*, 1959, 514.
[5] Cf. Ireland and Marshall, *J. Org. Chem.*, 1962, **27**, 1615.
[6] Djerassi and McCrindle, *J.*, 1962, 4034.
[7] Cocker, McMurry, and Start, unpublished information.
[8] Cf. Barton, *J.*, 1951, 1444, where isolation of cycloartenone from the fruit of *Artocarpus integrifolia* is described.

We stress these n.m.r. and i.r. spectra, for a mixture of C_{24} isomers of the less likely compound (VI) is known,[9] whose physical constants are similar to those of (III; R = Ac).

The ketone (III; R = Ac) reacted with methyltriphenylphosphonium bromide [10] and base giving 24-methylenecycloartanyl acetate which, on hydrolysis, afforded 24-methylenecycloartanol (I; R = R^1 = Me), with melting point undepressed by the alcohol from *Cephalosphaera* and by a specimen from *Tristania conferta*.[3]



(I)



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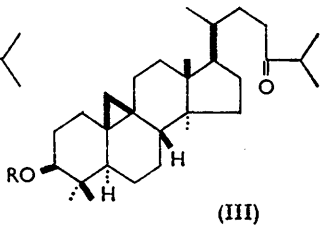
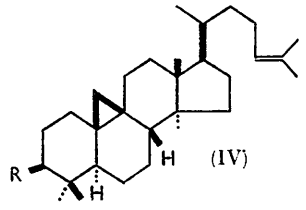
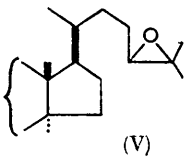


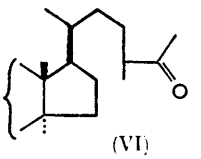
(III)



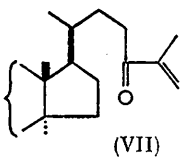
(IV)



(V)



(VI)



(VII)

In addition to compound (III; R = Ac), an unsaturated ketone and an alcohol were also isolated from the reaction products of (V) with boron trifluoride. The unsaturated ketone showed $\lambda_{max.}$ 2180 and 3150 Å, and $\nu_{max.}$ 1736 (ester), 1678 (α,β-unsaturated ketone), 1623 (C=C), 996 (cyclopropane), and 980 cm.$^{-1}$ (C=CH_2). The last-mentioned peak was of lower intensity than we have previously experienced with terminal methylene groups. Nevertheless, a tentative structure for this ketone is (VII). It could be derived from the corresponding alcohol, which is a possible reaction product of the epoxide with boron trifluoride.

In the acidic and phenolic fractions of the ligroin extract of *Cephalosphaera* we found pentachlorophenol. We were later informed that this was used as an antifungal substance by the East African suppliers of the wood.

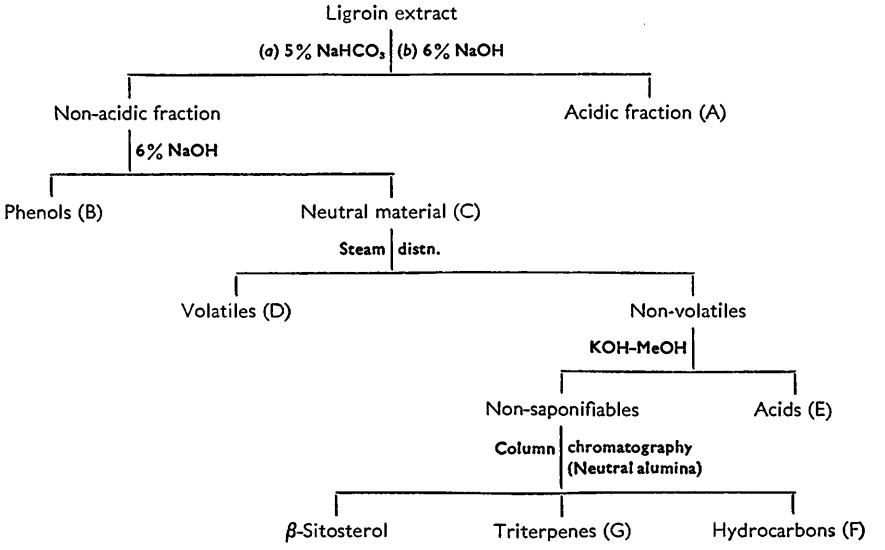
Experimental

Ultraviolet spectra were measured for ethanol solutions and infrared spectra for Nujol suspensions unless otherwise stated. Optical rotations refer to $CHCl_3$ solutions unless otherwise stated. Gas–liquid chromatography was performed with an Aerograph, Hy Fi 600 instrument. M. p.s are uncorrected.

Extraction of C. usambarensis.—The heartwood (15·7 kg.) was milled, extracted for 48 hr. with boiling ligroin, and the extraction was repeated with fresh solvent. The combined extracts were concentrated to 150 c.c. *in vacuo* and the product was fractionated as shown in the scheme.

Acidic Fraction (A).—The extract, diluted to 800 c.c. with ether and extracted with 5% sodium hydrogen carbonate (5 × 200 c.c.), gave a mixture of chlorine-containing acidic compounds (0·3 g.), $\nu_{max.}$ 3550 (OH), 1700 (CO_2H), 1600, 1500 (Ar), and 765 cm.$^{-1}$ (Cl), from which pentachlorophenol was obtained, m. p. 176·5—177·5° (from aqueous methanol), $\lambda_{max.}$ 3050 Å (log ε 3·5). By g.l.c., using a sucrose diacetate hexaisobutyrate (SAIB) (on 60—100 mesh Embacel) column at 185—186°, (N_2 flow 26 c.c./min.; H_2 flow 27 c.c./min.; chart speed 20 in./hr.), pentachlorophenol was eluted in 23·4 min. in contrast to ferulic acid,[2] 3 min., cinnamic acid, 14·2 min., and veratric acid, 44 min.

[9] Henry, Irvine, and Spring, *J.*, 1955, 1607.
[10] Cf. Wittig, *Experienta*, 1956, **12**, 41; Idler and Fagerlund, *J. Amer. Chem. Soc.*, 1957, **79**, 1988.



Phenols (B).—The ether phase from which (A) was extracted, concentrated to 450 c.c. and washed with 6% sodium hydroxide (4 × 125 c.c.), gave a semi-solid (5·4 g.), $\nu_{max.}$ 3400, 2600, 1700, 1600, 1500, and 765 cm.$^{-1}$. By g.l.c. using a SAIB column (184—186°; chart speed 20 in./hr.; N_2 flow 26 c.c./min.; H_2 flow 27 c.c./min.) it gave four main peaks, retention times 10·8 min. (3·2%), 24·1 min. (43·2%), 52·5 min. (27·7%), and 126·6 min. (21·1%). The largest fraction corresponded to (A).

Neutral Fraction (C).—This fraction consisted of a brown semi-solid (27·5 g.) which was distilled in steam. The distillate (300 c.c.) was extracted with ether (3 × 50 c.c.) giving a terpenaceous oil (2 g.), b. p. 53—58°/2·5 mm., $\nu_{max.}$ 3400 (OH), 1715 (ketone), and 1605 cm.$^{-1}$ (conj. C=C). This oil was submitted to g.l.c. on SAIB and Apiezon L columns; we give the data obtained from the former column (Table 1), but this was confirmed by the latter.

There were sixteen other unidentified components. The non-steam-volatile fraction was collected in ether (3 × 50 c.c.) from which a yellow solid (18·5 g.) was recovered. This was refluxed for 7·5 hr. with potassium hydroxide (10 g.) in methanol (150 c.c.), and benzene (80 c.c.). The olvents were removed, the residue was dissolved in water (1 l.) and extracted with ether

TABLE 1

G.l.c.* data of the steam-volatile terpenoid mixture (D)

Peak no.	Rel. retention time	Substance	Approx. quantity (%)	Peak no.	Rel. retention time	Substance	Approx. quantity (%)
8	1	α-Pinene	3·23	13	2·00	Limonene	11·06
9	1·06	Methylheptenone	1·67	14	2·06	Allo-ocimene	12·74
10	1·33	β-Pinene	9·05	15	2·79	Terpinolene	19·61

* 20% SAIB on 60—100 mesh Embacel, 10 ft. × ⅛ in.; 104—105°, chart speed 15 in./hr., N_2 flow 26 c.c./min., H_2 flow 25 c.c./min.

(3 × 250 c.c.), and the aqueous solution was acidified and extracted with ether from which free acids (E) (6·9 g.), $\nu_{max.}$ 1700 cm.$^{-1}$ (CO_2H) were obtained as an oil.

Acids (E).—These acids (0·93 g.) were refluxed for 2 min. with 15 c.c. of a mixture of boron trifluoride–ether complex (124 g.) in methanol (500 c.c.) giving esters, $\nu_{max.}$ 1740 cm.$^{-1}$, which, like the acids, were unsaturated to bromine in chloroform. The mixture was separated into saturated, and mono-, di-, and tri-unsaturated esters through their acetoxymercurimethoxy-complexes.[11] Each fraction was submitted to g.l.c. on (*a*) diethylene glycol succinate (DEGS),

[11] Cocker, Dahl, and McMurry, *J.*, 1963, 1654; cf. Jantzen and Andreas, *Chem. Ber.*, 1959, **92**, 1427; Mangold and Kammereck, *Chem. and Ind.*, 1961, 1032.

(*b*) Apiezon L, and (*c*) Silicone S.E. columns. Data obtained from the first column only are given (Tables 2 and 3).

TABLE 2

G.l.c.* of saturated esters

Peak no.	Rel. retention time	Carbon number of acid	Approx. quantity (%)	Peak no.	Rel. retention time	Carbon number of acid	Approx. quantity (%)
1	0·308	13	1·64	8	1·731	20	6·10
2	0·435	14	5·05	9	2·270	21	2·58
3	0·519	15	2·58	10	2·922	22	7·74 A
4	0·692	16	35·68	11	3·868	23	4·92
5	0·840	17	Trace	12	5·116	24	11·27
6	1·000	18	13·61 A	13	7·000	25	7·28
7	1·308	19	1·76				

A = authentic specimen

* 20% DEGS on 60—100 mesh Embacel, 5 ft. × ⅛ in., 226°; chart speed 30 in./hr., N_2 flow 27 c.c./min., H_2 flow 24 c.c./min.; T_R of methyl octadecanoate = 1.

TABLE 3

G.l.c.* of mono-unsaturated esters

Peak no.	Rel. retention time	Carbon number of acid	Approx. quantity (%)	Peak no.	Rel. retention time	Carbon number of acid	Approx. quantity (%)
1	0·199	8	1·07	8	0·760	16	3·02
2	0·264	10	1·78	9	1·000	18	51·07 A
3	0·312	11	0·54	10	1·160	19	17·08
4	0·352	12	1·07	11	1·640	21	4·45
5	0·432	13	2·68	12	1·938	22	1·25
6	0·528	14	2·49	13	2·272	23	3·56
7	0·584	15	7·47	14	2·608	24	2·49

* Column as Table 2, 199—200°; chart speed 30 in./hr., N_2 flow 27 c.c./min., H_2 flow 25 c.c./min.; T_R of methyl oleate = 1.

Di-unsaturated esters. Column and conditions as for mono-unsaturated esters. Methyl linoleate was eluted from the column, retention time, 5·4 min.

Tri-unsaturated esters. Column and conditions as for mono-unsaturated esters. Methyl linolenate was eluted from the column, retention time, 5·7 min.

Non-saponifiable Fraction.—This fraction (11·6 g.) had $\nu_{max.}$ 3400 (OH), 1640 (C=C), and 886 cm.$^{-1}$ (C=CH_2). It rapidly decolourised bromine in chloroform, gave an intense yellow colour with tetranitromethane, and a green colour with the Liebermann–Burchardt reagent. This fraction (8·4 g.), in ligroin, was chromatographed on neutral alumina and eluted in 100 c.c. fractions with (a) ligroin (fractions 1—10), (b) ligroin–benzene in varying proportions from 90/10 to 10/90 (fractions 11—28), benzene (fractions 29—50), benzene–ether in varying proportions as for (*b*) (fractions 51—66), and ether.

Hydrocarbons (F).—Fractions (1—10) when combined yielded a solid which crystallised from chloroform–methanol as plates (1·3 g.), m. p. 53—58°, $[\alpha]_D$ 0°, $\nu_{max.}$ 725 and 715 cm.$^{-1}$ (chain of CH_2), consisting of a mixture of alkanes. It was analysed by g.l.c. on DEGS and silicone elastomer columns. Data for the latter column are given (Table 4), but similar data were obtained from the other column.

Alcohols (G).—Fractions (28—50) when combined afforded a solid (3·8 g.), m. p. 99—116°, $\nu_{max.}$ 3300—3400 (OH), 1640 (C=C), 1040 (OH), 1000 (cyclopropane), and 886 cm.$^{-1}$ (C=CH_2). It gave a yellow Liebermann–Burchardt reaction and it rapidly decolourised bromine in chloroform. Attempts to resolve this mixture by chromatography were unsuccessful. It was therefore oxidised as follows. The mixture (1·027 g.) in acetone (100 c.c.) was slowly treated with chromium trioxide (2·6 g.) in water (10 c.c.) containing sulphuric acid (1·25 c.c.) and set aside for 12 hr. It was poured into water (300 c.c.) and extracted with ether (3 × 100 c.c.) from which a mixture of ketones (0·99 g.), m. p. 59—64°, $\nu_{max.}$ 1715 cm.$^{-1}$ (cyclohexanone), was obtained. The mixture, in ligroin (50 c.c.), was eluted from a column of neutral alumina with ligroin. Two substances were isolated.

TABLE 4

G.l.c.* of hydrocarbon fraction (F)

Peak no.	T_R	Carbon number	Approx. quantity (%)	Peak no.	T_R	Carbon number	Approx. quantity (%)
1	0·156	20	0·1	8	1·347	27	13·7
2	0·216	21	0·1	9	1·801	28	12·7
3	0·298	22	0·3	10	2·44	29	12·3
4	0·397	23	1·3 A	11	3·27	30	9·8 A
5	0·539	24	4·8	12	4·41	31	9·8
6	0·738	25	10·4	13	6·00	32	5·4
7	1·000	26	13·0 A	14	7·94	33	6·4

* 5% S.E. 30 on 60—80 mesh Chromosorb W, 235°, chart speed 15 in./hr., N_2 flow 25 c.c./min., H_2 flow 27 c.c./min.; T_R of hexacosanoic acid = 1, Fractions 11—27 yielded only traces of extractive.

(*a*) 24-Methylenecycloartanone (0·13 g.) formed plates, m. p. 111—112° (from methanol), $[\alpha]_D$ +20° (*c* 0·21), $\lambda_{max.}$ 2800 Å (log ε 1·58), $\nu_{max.}$ 1715 (C=O), 1645 (C=C), 1001 (cyclopropane), and 886 cm.$^{-1}$ (C=CH_2) (Found: C, 84·8; H, 11·6. Calc. for $C_{31}H_{50}O$: C, 84·9; H, 11·5%). It gave a 2,4-*dinitrophenylhydrazone*, needles, m. p. 230—232° (from methanol–chloroform), $[\alpha]_D^{19}$ −49° (*c* 0·16), $\lambda_{max.}$ 3700 Å (log ε 4·38) (Found: C, 71·5; H, 9·0. $C_{37}H_{54}N_4O_4$ requires C, 71·8; H, 8·8%). Reduction of the ketone (39 mg.) by refluxing for 1·5 hr. with sodium (1 g.) in propan-1-ol (20 c.c.) gave 24-methylenecycloartanol (30 mg.) as plates (from methanol), m. p. and mixed m. p. with a specimen from *Tristania* [3] 122—122·5°, $[\alpha]_D^{20}$ +42° (*c* 0·18) (lit.,[2] m. p. 121—122°, $[\alpha]_D$ +43°), $\nu_{max.}$ 3400 (OH), 1639 (C=C), 1010 (cyclopropane), and 885 cm.$^{-1}$ (C=CH_2) (Found: C, 83·5; H, 11·7. Calc. for $C_{31}H_{52}O,\frac{1}{2}$MeOH: C, 83·0; H, 11·8%). T.l.c. in two directions on silica gel using (i) benzene(75)–ether(25), and (ii) cyclohexane(85)–ethyl acetate(15) showed it to be homogeneous.

(*b*) The second substance was cycloeucalenone (0·35 g.), needles, m. p. and mixed m. p. 85—86° (from ethanol), $[\alpha]_D$ +54·4° (*c* 0·89) (lit.,[12] m. p. 84°, $[\alpha]_D$ +54°), $\nu_{max.}$ 1715, 1640, 1009, and 886 cm.$^{-1}$ (Found: C, 84·35; H, 11·4. Calc. for $C_{30}H_{48}O$: C, 84·8; H, 11·4%). Its 2,4-dinitrophenylhydrazone consisted of orange plates (from methanol–chloroform), m. p. and mixed m. p. with a sample from authentic cycloeucalenone, 244—246°, $[\alpha]_D$ −47·8°, $\lambda_{max.}$ 3740 Å (log ε 4·38), $\nu_{max.}$ 3333 (NH), 1639 (C=N), 1592 (Ar), 1538 (NO_2), 1504 (Ar), and 888 cm.$^{-1}$ (C=CH_2) (Found: C, 71·2; H, 8·6. Calc. for $C_{36}H_{52}N_4O_4$: C, 71·5; H, 8·7%). Reduction of the suspected cycloeucalenone (0·06 g.) by refluxing with sodium wire (1·5 g.) in propan-1-ol (20 c.c.) for 1·5 hr. gave the alcohol (0·06 g.), as needles (from acetone), m. p. and mixed m. p. with authentic cycloeucalenol, 142—142·5°, $[\alpha]_D$ +45·7° (*c* 0·47) (lit.,[12] m. p. 140°, $[\alpha]_D$ +45°) (Found: C, 84·2; H, 11·8. Calc. for $C_{30}H_{50}O$: C, 84·4; H, 11·8%).

β-*Sitosterol.*—Fractions (50—55) gave only traces of eluate. Fractions (55—65), eluted from the column with benzene–ether, when combined gave a solid (2·2 g.) which crystallised from methanol as needles, m. p. and mixed m. p. 142·5°, $[\alpha]_D^{20}$ −34° (*c* 0·32) (lit.,[13] m. p. 140°, $[\alpha]_D$ −37°). Its 3,5-dinitrobenzoate had m. p. and mixed m. p. 207° (lit.,[14] 202—203°) $[\alpha]_D^{20}$ −10·1° (*c* 0·61) (Found: C, 71·2; H, 8·8; N, 4·4. Calc. for $C_{36}H_{52}N_2O_6$: C, 71·0; H, 8·6; N, 4·6%).

Synthesis of 24-*Methylenecycloartanol.*—(*a*) *From cycloeucalenol.* Cycloeucalenyl acetate (10 g.; m. p. 103—105°, $[\alpha]_D$ +62°) was refluxed for 4·5 hr. with 5% methanolic potassium hydroxide (60 c.c.) giving cycloeucalenol (9·45 g.), m. p. 138—140°. The alcohol (8·9 g.) in acetone (400 c.c.) was slowly treated with 4·6 c.c. of a solution of chromium trioxide (2·54 g.) in water (10 c.c.) containing sulphuric acid (2·3 c.c.) and the mixture was heated on a water-bath for 5 min. The product was poured into water (700 c.c.) and extracted with ether, giving cycloeucalenone (6·43 g.), m. p. 84—85°.

2-*Hydroxymethylenecycloeucalenone.* Cycloeucalenone (4·0 g.) in ether (50 c.c.) was slowly treated with a solution of sodium (3 g.) in methanol (30 c.c.), followed by ethyl formate (4·8 c.c.), and the mixture was set aside overnight. It was then neutralised with a phosphate buffer (pH 8), the ether phase was washed with water giving 2-*hydroxymethylenecycloeucalenone* (4·1 g.) which crystallised from methanol–chloroform as pale yellow needles, m. p. 125—126°, $[\alpha]_D^{20}$

[12] Cox, King, and King, *J.*, 1956, 1384.
[13] Anderson, Shriner, and Burr, *J. Amer. Chem. Soc.*, 1926, **48**, 2987.
[14] Bernstein and Wallis, *J. Org. Chem.*, 1937, **2**, 341.

+91° (*c* 1·45), $\lambda_{max.}$ 2900 Å (log ε 3·86), $\nu_{max.}$ 1640, 1540, and 886 cm.$^{-1}$ (Found: C, 82·3; H, 10·4. $C_{31}H_{48}O_2$ requires C, 82·2; H, 10·7%). It gave a strong purple ferric reaction.

2-*n*-*Butylthiomethylenecycloeucalenone*. The foregoing compound (2·5 g.) in dry benzene (20 c.c.) was added to n-butanethiol (0·65 g.) containing toluene-*p*-sulphonic acid (5 mg.) and the mixture was refluxed for 3 hr. under nitrogen in a Dean–Stark apparatus. Sodium hydrogen carbonate solution (8·5%) was added, giving a yellow organic phase which, after washing with water, gave a yellow gum (2·83 g.). This was purified by t.l.c. on silica gel using benzene(50)–ether(50) as solvent. The main band had R_F 0·403 compared with R_F 0·605 of the hydroxymethylene compound. After elution from the plates, the required *n-butylthiomethylenecycloeucalenone* was obtained as a gum (0·215 g.), $[\alpha]_D^{20}$ +114° (*c* 0·51), $\lambda_{max.}$ 3115 Å (log ε 4·2), $\nu_{max.}$ 1664, 1536 (O=C–C=CHS), 995 (cyclopropane), and 883 cm.$^{-1}$ (C=CH_2) (Found: C, 79·35; H, 10·6; S, 6·95. $C_{35}H_{56}OS$ requires C, 80·1; H, 10·8; S, 6·1%).

2-*n*-*Butylthiomethylene*-24-*methylenecycloartanone*. n-Butylthiomethylenecycloeucalenone (2·14 g.) in t-butyl alcohol (9 c.c.) was added, with stirring in an atmosphere of nitrogen, during 5 min. to a solution of potassium (0·65 g.) in t-butyl alcohol (16 c.c.). After cooling to 0°, methyl iodide (3 c.c.) was added and the mixture was slowly heated on a water-bath and then refluxed for 1 hr. More methyl iodide (7 c.c.) was added and refluxing was continued for 1 hr. Solvent was removed *in vacuo* and the residue was poured into hot water (20 c.c.), cooled, and extracted with ether, from which a gum (1·74 g.) was isolated. It (0·31 g.) was purified by t.l.c. on silica gel using benzene(50)–ligroin(50)–ether(10). The main band, R_F 0·712, was the required *methylated compound* and this was extracted with ether from the silica giving a pale yellow gum (0·21 g.), $[\alpha]_D^{20}$ +94° (*c* 0·14), $\lambda_{max.}$ 3115 Å (log ε 3·91), $\nu_{max.}$ 1701, 1664, 1536, 995, and 883 cm.$^{-1}$ (Found: C, 80·2; H, 10·9. $C_{36}H_{58}OS$ requires C, 80·2; H, 10·85%).

24-*Methylenecycloartanone*. The foregoing compound (0·79 g.) was refluxed, under nitrogen, for 5 hr. with 25% potassium hydroxide (4 c.c.) in diethyleneglycol (6 c.c.). The mixture was cooled and the supernatant liquid was poured off from a gum which was dissolved in ether (30 c.c.) and added to the ether extract of the supernatant liquor. Removal of ether from the dried extracts gave a gum (0·63 g.) which was dissolved in ligroin and run on to a column of neutral alumina from which it was eluted with the same solvent. 24-Methylenecycloartanone formed plates (30 mg.), m. p. and mixed m. p. with a sample isolated from *Cephalosphaera*, 101—102° (from methanol), $[\alpha]_D^{20}$ +24·2° (*c* 0·19) (lit.,[2] m. p. 111—112°, $[\alpha]_D$ +20°), $\nu_{max.}$ 1712, 1639, 1109 (CMe_2), 1002, and 880 cm.$^{-1}$ (Found: C, 85·1; H, 11·55. Calc. for $C_{31}H_{50}O$: C, 84·9; H, 11·5%). It gave only a single spot on silica gel.

(*b*) *From cycloartenone. Epoxide of cycloartenyl acetate*. Cycloartenone (34 g.) from the resin [7] of *Artocarpus integrefolia* was chromatographed on neutral alumina and eluted with ligroin. The product, crystallised from methanol, had m. p. 107°, $[\alpha]_D^{16}$ +22° (*c* 1·43) (lit.,[8] m. p. 109°, $[\alpha]_D$ +24°), $\nu_{max.}$ 1712, 1109, and 1007 cm.$^{-1}$. It was reduced with sodium in boiling propan-1-ol giving cycloartenol (18·5 g.), m. p. 109—110° (from methanol) (lit.,[15] 106—107°), $[\alpha]_D^{21}$ +50° (*c* 0·81). Its acetate had m. p. 122—123° (lit.,[8] 122·5—123·5°), $[\alpha]_D^{21}$ +60° (*c* 0·42), $\nu_{max.}$ 1740 cm.$^{-1}$.

Epoxide. A solution of perbenzoic acid (0·11N; 545 c.c.) in benzene was added slowly to the acetate (15 g.) in benzene (125 c.c.) and the mixture was set aside overnight. It was washed with 1·5% sodium hydroxide, then with water, dried, and solvent removed, giving an oil (14·5 g.) which became solid. It was crystallised from acetone giving the *epoxide* as microneedles, m. p. 142—143°, $[\alpha]_D^{16}$ +55° (*c* 1·06), $\nu_{max.}$ 905, 800, and 790 cm.$^{-1}$ (epoxide) (Found: C, 79·6; H, 11·0. $C_{32}H_{52}O_3$ requires C, 79·3; H, 10·8%). It gave a single spot on silica gel, R_F 0·8, using benzene(75)–ligroin(45)–ether(5). Cycloartenyl acetate had R_F 0·47 under these conditions.

24-*Oxocycloartanyl acetate*. Boron trifluoride etherate (4·5 c.c.) was added to the epoxide (6·23 g.) in dry benzene (90 c.c.), and the mixture was set aside overnight. The mixture was washed with 5% sodium hydrogen carbonate and water, dried, and solvent removed giving a solid (6·2 g.), m. p. 90—92°. It was first crystallised from methanol and then chromatographed on neutral alumina using ligroin as eluant. A saturated fraction (A) (3·85 g.), m. p. 103—105°, an unsaturated ketone fraction (B) (0·8 g.), m. p. 100—108°, and an alcohol fraction (0·55 g.), m. p. 128—135° were obtained. Fraction (A) was crystallised several times from light petroleum giving the required ketone, m. p. 117—118°, $[\alpha]_D^{21}$ +56·2° (*c* 0·53) (lit.,[2] m. p. 121—123°, $[\alpha]_D$

[15] Nath, *Z. physiol. Chem.*, 1937, **247**, 17.

+52°), $\lambda_{max.}$ (hexane) 2800 Å (log ε 1·78), $\nu_{max.}$ 1740 (acetate), 1720 (C=O), and 1000 cm.$^{-1}$ (cyclopropane) (Found: C, 79·3; H, 10·9. Calc. for $C_{32}H_{52}O_3$: C, 79·3; H, 10·8%). Its oxime consisted of needles, m. p. 190—191° (from ethyl acetate), $[\alpha]_D^{21}$ +53·5° (*c* 0·52) (lit.,[2] m. p. 192—194°, $[\alpha]_D$ +50°), $\nu_{max.}$ 3300 (N–OH), 1740 (acetate), and 1640 cm.$^{-1}$ (C=N) (Found: C, 77·3; H, 10·8. Calc. for $C_{32}H_{53}O_3N$: C, 76·95; H, 10·6%). Its 2,4-*dinitrophenylhydrazone* consisted of yellow needles, m. p. 227—228° (from methanol–chloroform), $[\alpha]_D^{20·5}$ +42° (*c* 0·46), $\lambda_{max.}$ 3680 Å (log ε 4·43) (Found: C, 69·4; H, 8·8. $C_{38}H_{56}N_4O_6$ requires C, 68·6; H, 8·5%).

24-*Methylenecycloartanyl acetate*. The ketone (1·67 g.) in ether (20 c.c.) was slowly added to a mixture made from methyltriphenylphosphonium bromide (2 g.) in ether (30 c.c.) and phenyl-lithium (1·034N; 30 c.c.) in ether. The mixture was shaken for 2 hr. and refluxed overnight, in an atmosphere of nitrogen. Water (250 c.c.) was added, the ether layer separated, and the aqueous layer extracted with ether. The combined extracts gave a yellow oil which was set aside for 12 hr. with acetic anhydride (3 c.c.) and pyridine (5 c.c.). The product, chromatographed on neutral alumina using ligroin as eluant, gave the ester (1·01 g.) which was crystallised from methanol as plates, m. p. 110—111°, $[\alpha]_D^{18·5}$ +56·6° (*c* 0·49) (lit.,[2] m. p. 116—117°, $[\alpha]_D$ +54°), $\nu_{max.}$ 1740, 1640, and 886 cm.$^{-1}$ (C=CH$_2$) (Found: C, 82·2, 82·5; H, 11·4, 11·6. Calc. for $C_{33}H_{54}O_2$: C, 82·1; H, 11·3%).

24-*Methylenecycloartanol*. The acetate (0·148 g.) was refluxed for 2 hr. with 2% methanolic potassium hydroxide (10 c.c.), giving a solid product (0·079 g.) which crystallised from methanol as needles, m. p. 118—119°, undepressed by specimens of the alcohol isolated from *Cephalosphaera* and from *Tristania conferta*,[3] $[\alpha]_D^{14·5}$ +48·8° (*c* 0·26) (lit.,[2] m. p. 121—123°, $[\alpha]_D$ +43°), $\nu_{max.}$ 3400, 1639, 1003, and 885 cm.$^{-1}$ (Found: C, 84·0; H, 11·7. Calc. for $C_{31}H_{52}O$: C, 84·5; H, 11·9%). Mixtures of this synthetic alcohol with the alcohol from *Cephalosphaera* and with that from *Tristania*, both specimens of naturally occurring alcohol, and the synthetic alcohol alone were chromatographed in two dimensions on thin-layer silica gel using (i) benzene(75)–ether(25) and (ii) cyclohexane(85)–ethyl acetate(15) as solvent. Each chromatogram showed only a single spot.

24-*Methylenecycloartanone*. The synthetic alcohol (0·058 g.) was set aside with chromium trioxide (0·12 g.) in acetone (5 c.c.) containing sulphuric acid (0·5 c.c.) and water (2 c.c.). The ketone (0·057 g.) crystallised from methanol as plates, m. p. 109—110°, undepressed by the ketone obtained from the alcohol of *Cephalosphaera* and by the ketone obtained by the cycloeucalenone route, $[\alpha]_D^{16}$ +20·4° (*c* 0·27) (lit.,[2] m. p. 111—112°, $[\alpha]_D$ +20°), $\nu_{max.}$ 1712 (C=O), 1637 (C=C), 1109 (CMe$_2$), 1002 (cyclopropane), and 884 cm.$^{-1}$ (C=CH$_2$) (Found: C, 84·5, 84·9; H, 11·4, 11·5. Calc. for $C_{31}H_{50}O$: C, 84·9; H, 11·5%). T.l.c. in two dimensions on silica gel of the ketones obtained from both synthetic routes, using as solvents (i) benzene(25)–ligroin(75) and ether(5)–cyclohexane(95); (ii) benzene(50)–ligroin(50)–ether(5) and ethyl acetate(15)–cyclohexane(85), gave identical spots, R_F (i) 0·494, (ii) 0·783. The 2,4-dinitrophenylhydrazone of the ketone obtained by the second route had m. p. 228—229° undepressed by a specimen prepared from the " natural " ketone, $[\alpha]_D^{19}$ −47·1° (*c* 0·09), $\lambda_{max.}$ 3700 Å (log ε 4·5).

Unsaturated fraction isolated from treatment of cycloeucalenyl acetate epoxide with BF_3.—Fraction B (p. 1698), m. p. 100—108° was repeatedly recrystallised from methanol–light petroleum giving needles (87 mg.), m. p. 115—116° depressed to 103—116° by 24-oxocycloartanyl acetate, $[\alpha]_D^{20}$ +51° (*c* 0·32), $\lambda_{max.}$ 2180 and 3150 Å (log ε 3·92 and 2·27), $\nu_{max.}$ 1736 (ester), 1678 (O=C–C=C), 1623 (C=C), 996 (cyclopropane), and 980 cm.$^{-1}$ (C=CH$_2$) (Found: C, 79·9; H, 10·8. Calc. for $C_{32}H_{50}O_3$: C, 79·6; H, 10·4%). Its 2,4-dinitrophenylhydrazone consisted of bright red needles, m. p. 204—205°, $[\alpha]_D^{20·5}$ +37° (*c* 0·175), $\lambda_{max.}$ ($CHCl_3$) 3810 Å (log ε 4·38).

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UNIVERSITY CHEMICAL LABORATORY, TRINITY COLLEGE,
DUBLIN 2.

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