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# BIOGENETICALLY SIGNIFICANT TRITERPENES IN A SPECIES OF MELIACEAE: *CABRALEA POLYTRICHA* A.JUSS.

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**Abstract**—Four triterpenes have been isolated from the fruits of *Cabralea polytricha* A.Juss. (Meliaceae). Two of them are new $C_{30}$ compounds whose structures have been established as the C-3, C-24 epimer of ocotillol-II and the C-24 epimer of ocotillone-II: 20*S*, 24*S*-epoxy-dammarane-3α,25-diol (IIa) and the corresponding 3-keto compound (IVa).

The other two are the synthetically known trisnorlactone of Mills and the corresponding 3α-hydroxy compound (also new), that is, 25,26,27-trisnor-20β-hydroxy-3-oxo-dammarane-24-oic acid 20,24-lactone (VII) and 25,26,27-trisnor-3α,20β-dihydroxy-dammarane-24-oic acid 20,24-lactone (VIa).

PLANTS OF THE FAMILY Meliaceae have been the source of novel triterpenes, especially tetranor-triterpenes (limonoids) and $C_{30}$ protolimonoids (related to the limonoids by common stereochemistry, but possessing a tetrahydrofuran ring in the side chain instead of a furan).[1] These compounds apparently are formed by enzymatic oxidation and degradation of the tetracyclic triterpenoid precursor, euphol.

*Cabralea polytricha* A.Juss., family Meliaceae, sub-family Melioideae, is a shrub known in Brazil by the popular name of "cangerana", a generic denomination for various *Cabralea* species. It is not so well known as *Cabralea cangerana* Sald., a large tree much employed for timber, whose root bark has widespread use in popular medicine as a panacea against many ills. *Cabralea* fruits are also reported to have insecticidal properties. To date, the genus *Cabralea* has received very little chemical attention.

Extraction of the fruits of *C. polytricha* and chromatography on silica gel resulted in the isolation of four triterpenes, not belonging to the limonoid or protolimonoid type, but shown instead to possess the dammarane skeleton. Dammarane triterpenes have previously been isolated from resins of Dipterocarpaceae, roots of Areliaceae and Compositae, and leaves of Betulaceae.[2] There is also one known occurrence of a triterpene with this skeleton in the Meliaceae: aglaiol (I) from *Aglaia odorata*[3] with a 24,25-epoxide, possessing a side chain of intermediate structure between that of dipterocarpol and those of the compounds isolated from *Cabralea*.

The main component of the fruits of *Cabralea polytricha* is cabraleadiol (IIa), yield 0·25%, m.p. 175–176°, $[\alpha]_D$ + 18°. IR absorption at 3600 $cm^{-1}$ and 1030–1070 $cm^{-1}$ indicates the presence of OH and ether groups. The NMR spectrum (Table I) shows 8 peaks for quarternary C-Me groups and signals for an equatorial proton ($J$ = 3, 3 Hz) under an OH group, and a further proton under an oxygen function, presumably an ether. The mass spectrum presents a molecular ion peak at $m/e$ 460 ($C_{30}H_{52}O_3$) with base peak at $m/e$ 143 ($C_8H_{15}O_2$), presumably derived from the side chain which could thus include either an hydroxylated tetrahydropyran ring or a tetrahydrofurylisopropanol, similar to that of ocotillol (III).[9] The chemistry of IIa (below) suggests an ocotillol side chain, although cabraleadiol is not identical to that triterpene.

Cabraleadiol is inert to alkali, acid and LAH, and yields upon acetylation at room temp a monoacetate (IIb) m.p. 148–149°, and under vigorous conditions (reflux for several hr) a diacetate, m.p. 129–132° (IIc). The monoacetate shows NMR signals

TABLE I. NMR OF *Cabralea polytricha* TRITERPENES AND THEIR DERIVATIVES (IN $CDCl_3$ OR § $CCl_4$)

| Compound | Quarternary C-Me groups of nucleus (5) | of sidechain (1 or 3) | $C_3$–H | $C_{24}$–H | Acetates |
|---|---|---|---|---|---|
| cabraleadiol (IIa) | 0·85s, 0·88s, 0·94s, 0·95s, 0·99s | 1·11s. 1·15s. 1·19s | 3·39 t ($J$ = 3 Hz) | 3·70 m | |
| ocotillol-II (III) (from ref. 7) | 0·78s, 0·85s, 0·87s, 0·97s, 0·98s | 1·12s. 1·12s. 1·21s | 3·18 dd | 3·73 dd | |
| aglaiol (I) (from ref. 3) | 0·77s, 0·85s, 0·87s, 0·98s, 0·98s, | 1·27s. 1·30s | 3·23 | 2·75 t ($J$ = 6 Hz) | |
| cabraleadiol monoacetate (IIb) | 0·84s, 0·89s, 0·89s, 0·92s, 0·98s | 1·02s. 1·12s. 1·12s | 4·60 t ($J$ = 3 Hz) | 3·50 m | 2·02s |
| cabraleadiol diacetate (IIc) | 0·85, 0·90s, 0·90s, 0·95s, 1·00s | 1·20s. 1·50s. 1·50s | 4·60 t ($J$ = 3 Hz) | 3·85 m | 2·00s 2·10s |
| cabraleone (IVa) | 0·90s, 0·96s, 1·02s, 1·04s, 1·08s | 1·11s. 1·15s. 1·19s | | 3·70 m | |
| cabraleone acetate (IVb) § | 0·88s, 0·95s, 1·00s, 1·00s, 1·10s | 1·35s. 1·35s. 1·35s | | 3·90 m | 1·95s |
| cabraleone reduction prod. (Va) | 0·78s, 0·88s, 0·88s, 0·98s, 0·98s | 1·11s. 1·16s. 1·20s | 3·30 dd ($J$ = 6.10 Hz) | 3·70 m | |
| monoacetate of reduction prod (Vb) | 0·87s, 0·87s, 0·87s, 0·87s, 0·96s | 1·10s. 1·15s. 1·19s | 4·52 dd | 3·70 m | 2·05s |
| monoacetate of ocotillol (ref. 7) | 0·87s, 0·87s, 0·87s, 0·87s, 0·96s | 1·12s. 1·12s. 1·21s | | | 2·03s |
| monoacetate of ocotillol epimer (ref. 4) | 0·87s, 0·87s, 0·87s, 0·87s, 0·96s | 1·10s. 1·15s. 1·19s | 4·50 dd | 3·70 | 2·07s |
| cabraleahydroxy-lactone (VIa) | 0·85s, 0·88s, 0·94s, 0·95s, 0·99s | 1·37 | 3·40 t ($J$ = 3 Hz) | | |
| cabraleahydroxy-lactone acetate (VIb) | 0·85s, 0·88s, 0·90s, 0·95s, 0·99s | 1·37 | 4·64 t ($J$ = 3 Hz) | | 2·08s |
| cabralealactone (VII) | 0·90s, 0·95s, 1·02s, 1·04s, 1·08s | 1·37 | | | |

(Table I) for eight quarternary C-Me groups, an acetyl Me, a proton under an AcO group, and the additional proton under the ether, as in cabraleadiol. The diacetate shows corresponding signals (Table I) for 8 quarternary C-Me groups, with two much more deshielded than in the monoacetate, supoorting the presence of a substituted isopropanol group in the sidechain: and for two acetyl Me's, one proton under an AcO group, and the proton under the ether, also somewhat deshielded by the second acetate.

The monoacetate cannot be oxidised with $CrO_3$ in pyridine (Sarett's reagent); under the same conditions cabraleadiol yields cabraleone (see following paragraph). Jones' reagent ($CrO_3$/acetone) smoothly oxidises cabraleadiol to Mills' keto-trisnor-lactone (VII), strongly supporting structure IIa for the natural diol.

Cabraleone (IVa), m.p. 160–161°, $[\alpha]_D$ + 54°, is a lesser component of the fruits (yield 0·09%). It forms a crystalline oxime and dinitrophenylhydrazone. IR absorption at 3600 $cm^{-1}$ indicates the presence of an OH group, at 1680 $cm^{-1}$ a ketone and at 1050–1100 $cm^{-1}$ an ether linkage. The same eight quarternary C-Me groups as in cabraleadiol appear in the NMR spectrum, along with the multiplet for the proton under the ether.

In the mass spectrum the highest detectable peak is at *m/e* 443, evidently resulting from the loss of 15 units (Me) from *m/e* 458, the presumed molecular ion ($C_{30}H_{50}O_3$). The base peak, as in cabraleadiol, is at *m/e* 143 (now formulated as *a*). These data indicate the identity of the sidechain in IIa and IVa, with a 3α (axial)-alcohol in IIa and a 3-keto function in IVa.

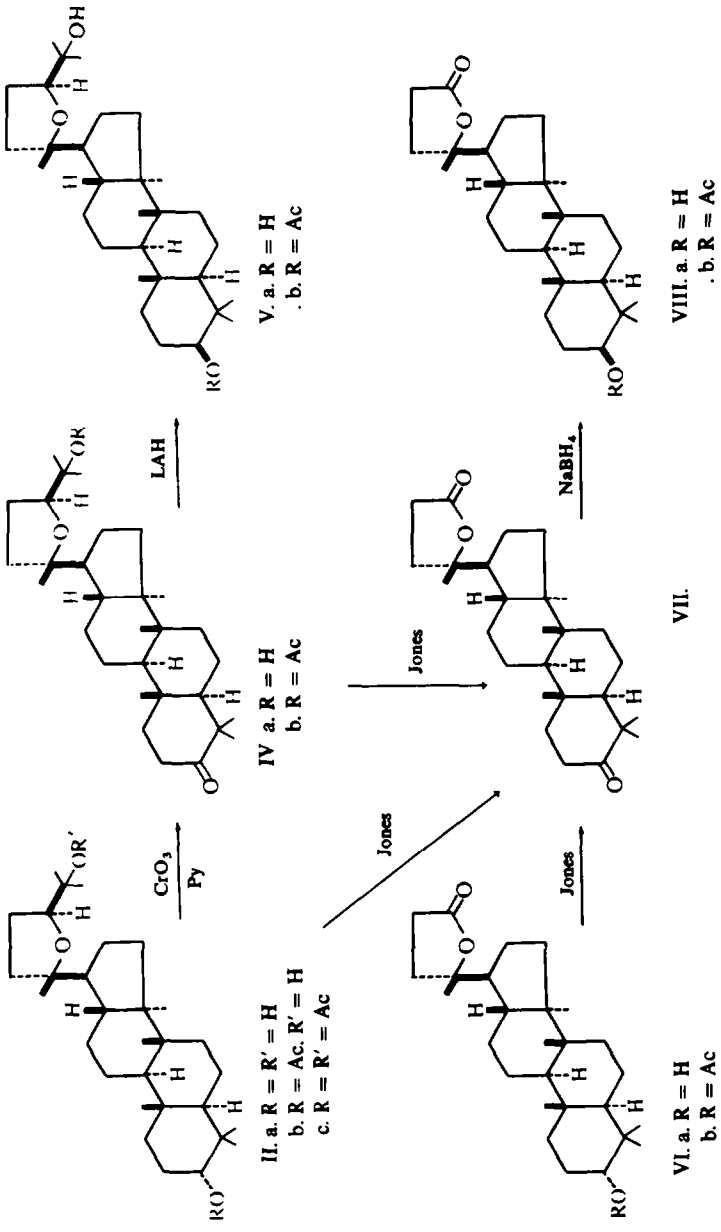
Cabraleone, like cabraleadiol monoacetate (IIb), is not oxidised by Sarett's reagent. Jones oxidation yields, in like manner, Mills' lactone (VII). Cabraleone may be monoacetylated under forcing conditions.

Reduction of cabraleone by LAH gives an isomer (Va) of cabraleadiol which upon acetylation gives a monoacetate (Vb), m.p. 171–173°, with IR bands at 3550 $cm^{-1}$ (OH) and 1730 $cm^{-1}$ (OAc). The NMR spectrum shows signals for 8 quarternary C-Me groups and one acetyl Me. The multiplet under the ether is present and unchanged, but the proton under the OH group is now axial ($J$ = 6, 10 Hz). This compound was shown to be identical to the monoacetate of the C-24 epimer of ocotillol-II, prepared by Biellmann[4] during oxidation of 3-acetyl-dammarenediol (IX) with *p*-nitroperbenzoic acid. The comparison was made through m.m.p., IR and NMR spectra.

By this interrelation, the structure of cabraleadiol is established as the C-3, C-24 epimer of ocotillol-II; cabraleone is the C-24 epimer of ocotillone-II. Recent work[5] has proven through chemical interrelations and X-ray crystallography that the stereochemistry at C-24 of ocotillol-II is *R*, with the hydroxyisopropyl at C-24 *trans* to the Me at C-20. The same work reports a C-24 epimer, the structure of which was established as 24*S*, that is, with the substituents at C-24 and C-20 in a *cis* configuration. Cabraleadiol and cabraleone should have the latter stereochemistry.

A third component of the fruits is cabraleahydroxylactone (VIa), yield 0·03%, m.p. 240–242°, $[\alpha]_D$ + 24°, with IR absorption at 3550 $cm^{-1}$ (OH) and 1760 $cm^{-1}$ (γ-lactone). The NMR spectrum (Table I) shows signals for 6 quarternary C-Me groups, with only one downfield of 1 ppm. An additional signal at 3·4 ppm is identical to that corresponding to the 3β-proton in the spectrum of cabraleadiol (IIa). The mass spectrum shows a molecular ion at *m/e* 416, corresponding to a trisnor-triterpene, $C_{27}H_{44}O_3$. The base peak, at *m/e* 189, is derived from separation of rings A and B (*b*).

Under mild acetylation conditions, cabraleahydroxylactone forms a monoacetate,


CrO3
Py
LAH
Jones
Jones
Jones
NaBH4
II. a. R = R' = H
b. R = Ac. R' = H
c. R = R' = Ac
IV a. R = H
b. R = Ac
V. a. R = H
. b. R = Ac
VI. a. R = H
b. R = Ac
VII.
VIII. a. R = H
. b. R = Ac

I.
III.
IX.
X.
a m/e 143
b m/e 189
c m/e 99
d m/e 203
e m/e 205
f m/e 103
CH2CH2CH2OH
Me
OH
HO
AcO
H+

m.p. 125–127°, with IR bands at 1720 $cm^{-1}$ (OAc) and 1760 $cm^{-1}$ (γ-lactone). The NMR spectrum (Table I) shows one acetyl Me and 6 quarternary C-Me signals; the signal for the 3β-proton is moved downfield to 4·64 ppm.

Reduction of VIa with LAH yields a compound melting at 210–211°, with no IR absorption in the carbonyl region. Jones oxidation of VIa, as with IIa and IVa, forms the lactone VII.

Cabralealactone (VII), yield 0·07%, m.p. 181–183°, $[\alpha]_D$ + 70°, shows IR absorption at 1700 $cm^{-1}$ (ketone) and 1760 $cm^{-1}$ (γ-lactone). The NMR spectrum (Table I) shows six signals for quarternary C-Me groups, and no signals downfield of 2·8 ppm. The mass spectrum indicates a molecular weight of 414, corresponding to $C_{27}H_{42}O_3$; the base peak is at *m/e* 99 (*c*). These spectral data suggest that cabralealactone is a trisnor-triterpene ketone-γ-lactone.

As mentioned, the other triterpenes isolated from the fruits of *C. polytricha* all yield VII upon Jones oxidation, thus interrelating these four compounds. The product, cabralealactone, has spectral characteristics identical to those reported for the keto-trisnor-lactone, first prepared by the $CrO_3$ oxidation of dipterocarpol by Mills.[6] Comparison by m.m.ps, IR and NMR spectra showed the two compounds to be identical.

For further confirmation, mild $NaBH_4$ reduction of VII and subsequent acetylation yielded a compound identical to the 3β-acetoxy-dammar-γ-lactone VIII, prepared by Biellmann[4] through $CrO_3$ oxidation of 3-acetyl-dammarenediol (IX).

Compounds IIa, IVa, VIa, and VII have not been previously isolated from natural sources, though VII has been prepared in the laboratory by different oxidation reactions of dipterocarpol and dammarenediol.[4,6] They apparently represent oxidative degradation products of a normal triterpenoid precursor, which may be the 3-epimer of dammarenediol (unknown to date). Cabraleadiol and cabraleone would be intermediates in the pathway to the further oxidation products, cabraleahydroxylactone and cabralealactone. A model experiment along this lines was performed *in vitro* by E. H. Warnhoff,[7] who demonstrated the formation of ocotillol-II (III) as well as its $C_{24}$ epimer from acetyl-dammarenediol (IX), by treatment with perphthalic acid. These two epimers are also formed when *p*-nitroperbenzoic acid is employed instead.[4]

The occurrence in *C. polytricha* of dammarane triterpenes, instead of the euphol degradation products normally encountered in the Meliaceae, may be explained by the relatively close chemical relationship of the two groups. For example, it is well known that euphenol and tirucallenol, upon acid treatment *in vitro*, are rearranged to iso-euphenol and isotirucallenol, with the dammarane carbon skeleton and stereochemistry, a fact which was used by Ruzicka, Jeger and Arigoni[8] and D. H. R. Barton[9] to elucidate the euphol structure. A. Eschenmoser, L. Ruzicka, O. Jeger e D. Arigoni[10] assumed that euphol and tirucallol should have a common precursor *in vivo* (which would also be the precursor of dammarenediol), formed by a *trans-anti-trans* cyclisation of squalene (epoxide) in a chair, chair, chair boat conformation. This cationic tetracyclic triterpene precursor (X), either by a series of concerted or ethylenic intermediate migrations, could attain the euphol or tirucallol structure, differing only in configuration at C-20. Euphol and tirucallol possess a chair-boat conformation in rings B and C[9] while dammarenediol, which could arise from direct reaction of the precursor (X) with water at C-20, has the more stable chair conformation in rings A, B and C.

## EXPERIMENTAL

M.ps were determined on a Kofler block and are uncorrected. IR spectra were taken as KBr pellets on a Perkin–Elmer Model 12C. NMR spectra were recorded at 60 MHz on Varian T-60 or A-60A instruments or at 100 MHz on a Varian HA-100 instrument, using $CDCl_3$ or $CCl_4$ as solvents. The line positions or centers of multiplets are given as parts per million ($\delta$) downfield from TMS as internal standard. The multiplicity, integrated area and types of protons are indicated in Table I. The mass spectra were measured on an Atlas CH-2, direct insertion at 70 ev. Optical rotations were measured in $CHCl_3$, unless otherwise stated.

TLC plates were prepared with Merck silica gel G. As developing solvents, petroleum ether–ether or petroleum ether–EtOAc were used; spots were located by exposure to $I_2$. For column chromatography, Merck silica gel (70–325 mesh ASTM) was employed.

*Isolation procedure*

*C. polytricha* was collected near Sete Lagoas, State of Minas Gerais, Brazil, in typical "cerrado" country (woody savanna).

Fresh fruits (1500 g) were expressed and extracted consecutively, with cold petroleum ether (extract I), hot petroleum ether (extract II), hot benzene (extract III) and hot alcohol (extract IV).

*Extract* I. This extract concentrated was chromatographed on a column of silica gel (300 g). Cabraleadiol (IIa) was eluted with petroleum ether–ether 7:3.

*Extract* II. The concentrate of this extract was chromatographed on a 300 g column, elution with petroleum ether-ethyl ether mixtures. Cabraleone (IV) was eluted by a mixture of these solvents in the ratio 8:2, cabraleadiol (IIa) by 7:3, cabralealactone (VII) by 6:4 and cabraleahydroxylactone (VIII) by a 1:1 mixture of the two.

*Extract* III. This extract, chromatographed as above, gave no crystalline compounds.

*Extract* IV. The concentrate of this extract was chromatographed on a 500 g column. Small amounts of the above products were obtained together with a crystalline glycoside mixture, eluted by AcOEt-EtOH 9:1, which was not further investigated.

*Cabraleadiol* (IIa). The crude chromatography fractions were united and crystallized several times from EtOH and then EtOAc to give 3·72 g (0·25%) of needles, m.p. 175–176°; $[\alpha]_D$ + 18° (*c* 1·0); $\nu_{max}$ 3600 $cm^{-1}$ (s). multiple bands at 1030–1070 $cm^{-1}$ (s); no selective UV absorption above 220 nm. The mass spectrum showed significant peaks at *m/e* 143 (*a*, 100%), 460 (the molecular ion, 0·2%), 445 (M-15. 0·3%), 427 (M-15-18, 0·4%), 203 (*c*. 1·5%) and 125 (143–18, 12%). NMR spectrum, see Table I. (Found, C, 78·09; H, 11·26. Calc. for $C_{30}H_{52}O_3$: C, 78·20; H. 11·38%).

*Cabraleadiol monoacetate* (IIb). Cabraleadiol (IIa, 100 mg) was treated with 2 ml of $Ac_2O$ and 2 ml pyridine, at room temp, overnight. To the mixture was added MeOH; after 30 min. the solvent was removed. *in vacuo*, with the aid of successive additions of $CHCl_3$–EtOH 99:1. Crystallization of the residue from petroleum ether gave 85 mg of needles, m.p. 148–149°. $[\alpha]_D$ + 12° (*c* 1·0): $\nu_{max}$ 3600 (s), 1735(s) $cm^{-1}$; NMR spectrum, see Table I. (Found: C, 76·34; H, 10·53. Calc. for $C_{32}H_{54}O_4$: C, 76·44; H, 10·83%).

*Cabraleadiol diacetate* (IIc). Cabraleadiol monoacetate (IIb, 200 mg) was refluxed with 3 ml $Ac_2O$ and 1 ml pyridine for 6 hr. The anhydride and pyridine were removed as above; the residue was chromatographed on a 10 g column of silica gel, the diacetate being eluted with petroleum ether (b.p. 30–60)-EtOAc 95:5. Recrystallization from petroleum ether gave needles (170 mg), m.p. 129–132°, $[\alpha]_D$ + 2° (*c* 1·0). The IR spectrum showed no OH absorption, and strong peaks at 1735 and 1250 $cm^{-1}$ (AcO); NMR spectrum, see Table I. (Found: C, 74·53; H, 10·22. Calc. for $C_{34}H_{56}O_5$: C, 74·96; H. 10·36%).

*Sarett oxidation of Cabraleadiol.* Cabraleadiol (IIa, 79 mg) in pyridine (1 ml) was oxidized with 120 mg $CrO_3$ in 1·5 ml pyridine at room temp for 45 min. Water was added and the product extracted with benzene-ether 1:1. The residue from evaporation of the extracts was chromatographed on a 5 g silica gel column; elution with benzene—10% ether gave cabraleone, crystallized from petroleum ether to give 58 mg, m.p. 159–161°, with IR spectrum identical to that of natural material (below). Cabraleadiol was recovered (21 mg) from the column with benzene–20% ether.

*Jones oxidation of Cabraleadiol.* A solution of IIa (50 mg) in acetone (5 ml) was treated with the Jones reagent (8N $H_2CrO_4$), drop by drop, until a permanent orange color persisted for 3 min. The solution was separated from the inorganic precipitate, water was added, the acetone was removed and the product extracted with $CHCl_3$. The $CHCl_3$ solution was washed with water, evaporated, boiled with benzene (drying), and crystallized from petroleum ether to give needles (44 mg), m.p. 180–183°. This product was identical to cabralealactone (below), by IR and m.m.p.

*Cabraleone* (IVa). The chromatography fractions were united and crystallized 5 times from petroleum ether (b.p. 30–60°) to give 1·33 g (0·09%) of needles, m.p. 160–161°; $[\alpha]_D$ + 54° (*c* 1·0); $\nu_{max}$3600 (s), 1680 (s). 1050–1100 (s) $cm^{-1}$; the UV spectrum showed no absorption above 220 nm. The mass spectrum showed peaks at *m/e* 143 (*a*. 100%), 443 (M-15. 1·5%), 440 (M-18. 1·5%), 399 (10%), 205 (*e*, 5%) and 125 (143–18, 11%); NMR spectrum, see Table I. (Found: C, 78·54; H, 10·73. Calc. for $C_{30}H_{50}O_3$: C, 78·55; H, 10·99%).

*Cabraleone acetate* (IVb). Cabraleone (IVa, 80 mg) was refluxed with 2 ml of $Ac_2O$ and 2 ml pyridine, for 4 hr. $Ac_2O$ and pyridine were eliminated as described above and the acetate was purified on a column of 8 g silica gel, eluting with petroleum ether (b.p. 30–60°)-ether 85:15. The acetate, homogeneous on TLC, crystallized poorly from ether to give needles, m.p. 115–120°; $\nu_{max}$ 1680 (s), 1730 (s) $cm^{-1}$, no hydroxyl absorption evident. For NMR spectrum, see Table I.

*Reduction of cabraleone with lithium aluminium hydride.* Cabraleone (IVa, 100 mg), in dry ether, was refluxed with LAH (100 mg) for 38 hr. Excess reagent was destroyed with water-saturated EtOAc. The reduction product (Va) was purified on a 4 g silica gel column and eluted with petroleum ether–ether 8:2. Crystallization from petroleum ether gave a microcrystalline powder (71 mg), m.p. 161–164°; $[\alpha]_D$ + 32° (*c* 0·57). For NMR spectrum, see Table I.

*Acetate of the reduction product* (Vb). The diol (Va, 50 mg) was acetylated, at room temp, as above. The product was purified by elution from a column of 5 g silica gel with petroleum ether–EtOAc 9:1. When crystallized three times from MeOH it melted at 171–173°. The m.m.p. with the acetate of the 24-epimer of ocotillol-II, (prepared by Biellmann, m.p. 180–181°) was 178–180°; $[\alpha]_D$ + 34° (c = 0·57); $\nu_{max}$3550 (m), 1730 (s) $cm^{-1}$ (spectrum identical to Biellmann's product). For NMR data see Table I; the NMR spectrum was likewise identical to that of Biellmann's product. (Found: C, 74·10; H, 10·68. Calc. for $C_{32}H_{54}O_4.H_2O$: C, 73·91; H, 10·86%).

*Cabraleone oxime.* A solution of IVa (100 mg), in 1 ml of EtOH, was treated with $NH_2OH$·HCl (50 mg), in 0·5 ml of water and 160 mg of powdered KOH. The mixture was refluxed for 10 min., dilute HCl was added and the oxime extracted with $CHCl_3$. The product (one spot on TLC, with EtOAc), precipitated from EtOAc as an amorphous solid (55 mg), m.p. 200–201°, $\nu_{max}$3500 (s), 1600–1690 (s) $cm^{-1}$.

*Cabraleone dinitrophenylhydrazone.* An ethanolic solution of IVa (50 mg in 2 ml) was added to 10 ml of DNPH reagent. The precipitate which formed immediately was filtered and washed with cold EtOH. Recrystallization from EtOH gave yellowish-red needles, m.p. 198–201°, $\lambda_{max}$ 234 and 367 nm (ε 14,400, 24,000); $\nu_{max}$3550, 3400, 1700, 1500 $cm^{-1}$. (Found: C, 65·94; H, 8·28; N, 9·08. Calc. for $C_{36}H_{54}O_6N_4.H_2O$: C, 65·91; H. 8·60; N. 8·54%).

*Jones oxidation of cabraleone.* A solution of IVa (50 mg) in 5 ml of acetone was oxidized as usual. The oxidation product was in all respects identical to cabralealactone (below), by m.m.p. and IR.

*Cabraleahydroxylactone* (VIa). The chromatography fractions were united and crystallized three times from EtOH and finally from EtOAc to give 0·45 g (0·03%) of needles, m.p. 240–242°; $[\alpha]_D$ + 24° (*c* 0·57); $\nu_{max}$3550 (s), 1760 (s) $cm^{-1}$. The mass spectrum showed peaks at *m/e* 189 (*b*, 100%), 416 (the molecular ion, 10%). 398 (M-18, 33%), 383 (M-18-15, 9%). 203 (*d*, 8%). For NMR spectrum, see Table I. (Found: C, 78·10; H, 10·45. Calc. for $C_{27}H_{44}O_3$: C, 77·83; H, 10·65%).

*Cabraleahydroxylactone acetate* (VIb). The hydroxy-lactone VIa (100 mg) was acetylated at room temp, as usual. The acetate was crystallized from petroleum ether to give 84 mg of needles, m.p. 125–127°; $[\alpha]_D$ + 17° (*c* 0·23); $\nu_{max}$1720, 1760 $cm^{-1}$. For NMR spectrum, see Table I. (Found: C, 76·29; H, 9·97. Calc. for $C_{29}H_{46}O_4$: C, 75·94: H, 10·11%).

*Reduction of cabraleahydroxylactone with lithium aluminium hydride.* A solution of VIa (80 mg) in THF was refluxed with LAH (80 mg) for 24 hr. The crude product (64 mg) was recovered as above. Crystallization from MeOH gave a microcrystalline powder, m.p. 210–211°, $[\alpha]_D$ + 27° (*c* 0·43 in dioxan); $\nu_{max}$3450 $cm^{-1}$, no absorption in the carbonyl region. The mass spectrum showed a base peak at *m/e* 103 (*f*) and a strong peak at *m/e* 189 (b). (Found: C, 74·52; H, 11·26. Calc. for $C_{27}H_{48}O_3.H_2O$: C, 73·92; H, 11·49%).

*Jones oxidation of cabraleahydroxylactone.* An acetone solution of VIa (50 mg) was oxidised as above. The oxidation product (45 mg) was in all respects identical to cabralealactone (see below).

*Cabralealactone* (VII). The united chromatography fractions crystallized from EtOH to give needles (1·06 g, 0·07%), m.p. 181–183° (lit. 183°); $[\alpha]_D$ + 70° (*c* 0·57) [lit. + 69° (*c* 1·06)]; $\nu_{max}$1760 (s), 1700 (s) $cm^{-1}$. The mass spectrum showed significant peaks at *m/e* 99 (*c*, 100%), 414 (the molecular ion, 75%), 399 (414–15, 10%), and 205 (*e*, 78%). For NMR data, see Table I. (Found: C, 78·16; H, 10·01. Calc. for $C_{27}H_{42}O_3$: C, 78·21; H. 10·21%).

*Reduction of cabralealactone with sodium borohydride* (1). A solution of VII (100 mg) in abs EtOH was left overnight, in the ice box, with 50 mg of $NaBH_4$. Excess reagent was destroyed with dilute HCl; addition

of water precipitated the product (VII), which was filtered *in vacuo* and taken up in $CHCl_3$; the solution showed one spot on TLC (petroleum ether–ether 1:1). Crystallization from EtOAc, and then MeOH gave a microcrystalline powder (88 mg), m.p. 205–208° (lit. 205–206°); $\nu_{max}$ 1760 (s), 3450 (s) $cm^{-1}$, no ketone absorption.

*Acetate of the reduction product* (VIII). The above reduction product (50 mg) was acetylated, at room temp, as usual. The acetate was crystallized twice from petroleum ether to give needles (45 mg), m.p. 244–246° (lit. 245–248°); m.m.p. with an authentic sample *ex* J. F. Biellmann (m.p. 241–244°), 241–245°; $\nu_{max}$ 1720 (s), 1760 (s) $cm^{-1}$.

*Reduction of cabralealactone with sodium borohydride* (2). A solution of VII (100 mg) in EtOH was refluxed for 20 hr with excess $NaBH_4$. The mixture was treated as above. The crude product (90 mg) was crystallized 3 times from EtOH to give plates, m.p. 216–219° (lit. 217–219°); $\nu_{max}$ 3600 (s) $cm^{-1}$, no carbonyl absorption.

*Reduction of cabralealactone with lithium aluminium hydride.* A solution of VII (100 mg) in THF was refluxed with excess LAH (100 mg) for 18 hr. The crude product, recovered as above, was crystallized twice from EtOH to give platelets, m.p. 216–219°. This product was identical to the one obtained by drastic reduction with $NaBH_4$. The mass spectrum showed significant peaks at *m/e* 103 (*f*, 100%), 405 (M-Me. 1%). 402 (M-$H_2O$, 2%), 387, 384, 369, 366, 361 (M-$C_3H_7O$. 3%). 343 (361-$H_2O$. 5%). 300 (M-102-$H_2O$, 7%). 285 (300-Me. 6%). 257. 247. 207 (189 + $H_2O$, 38%), and 189 (*b*, 27%). (Found: C, 76·81; H, 11·22. Calc. for $C_{27}H_{48}O_3$: C, 77·13; H, 11·45%).

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