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HIGHER ISOPRENOIDS—1
TRITERPENOIDS FROM THE OLEORESIN OF *DIPTEROCARPUS PILOSUS*: HOLLONGDIONE AND DIPTEROCARPOLIC ACID*†

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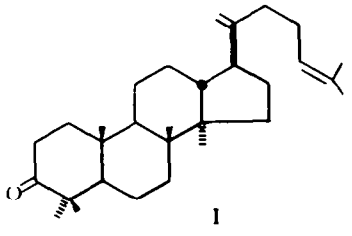
Abstract—The triterpene fraction (~80%) of the oleoresin from *Dipterocarpus pilosus* has been found to contain dipterocarpol and several known (dammara-20,24-dien-3-one, dammara-24-ene-3,20-diol, ocotillone-II, ocotillol-II) and new triterpenes related to this. Structure elucidation of two of these new triterpenes *viz* hollongdione and dipterocarpolic acid, is discussed. The resin also contains significant quantities of asiatic acid and two of its acetyl derivatives and 2α-hydroxyursolic acid.

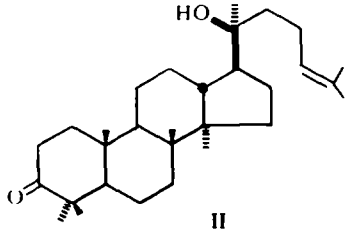
THE oleoresin from *Dipterocarpus pilosus* (Assamese, *Hollong*) is a complex mixture of sesquiterpenes and triterpenes (~80%). The sesquiterpene components have already been reported in another communication[1] and, the present paper describes some aspects of the triterpenoid constituents.

As already reported[1] steam non-volatile fraction of the light petroleum extract and, benzene and ethyl acetate extracts of the oleoresin consist essentially of triterpenoids. It will be convenient to describe the various triterpene components in terms of these three extracts.

Light petroleum extract which constitutes ~67% of the oleoresin, on steam-distillation yields an essential oil (~25%; sesquiterpenes) and a residue consisting mostly of triterpenes. This residue was separated into neutral (~95%) and acid components and the former shown to contain four sesquiterpenoids (consisting ~4% of the neutral fraction and described elsewhere[1]) and several triterpenoids (Table 1). Of these, dammara-20,24-dien-3-one (I),[3] dipterocarpol (II),[3–6] ocotillone-II (III)[7,9] and ocotillol-II (IV)[8,9] could be readily identified by reference to their physical characteristics (m.p., $[\alpha]_D$), spectral data (IR, PMR, Mass) and comparison (mixed m.p., PMR) with authentic specimens. Another constituent (No. 8, Table 1) could only be obtained as a foam, but its identification as dammar-24-ene-3β,20s-diol



I



II

* Communication No. 1487, National Chemical Laboratory, Poona, India.

† Abstracted, in part, from the Ph.D. thesis (Panjab Univ., 1965) of A. S. Gupta.

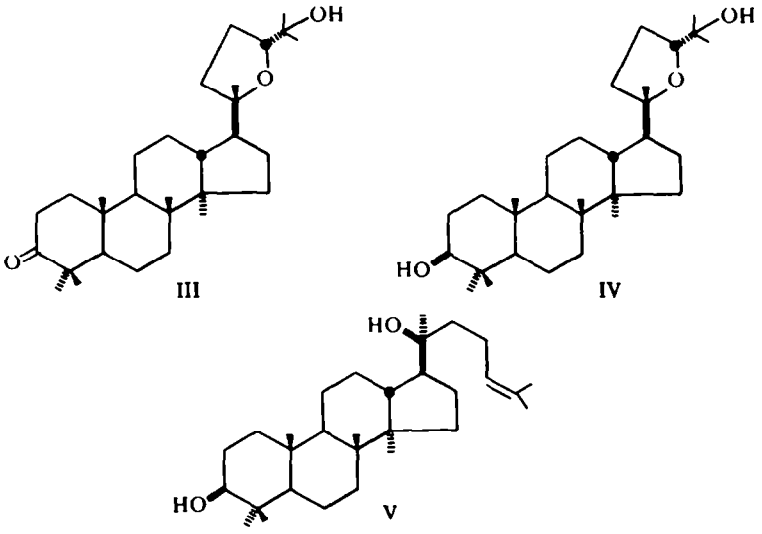


TABLE 1. TRITERPENOIDS FROM PET. ETHER EXTRACT OF THE OLEORESIN FROM *Dipterocarpus pilosus*

No.[a]	m.p.	$[\alpha]_D^{CHCl_3}$	M^+	Mol formula	% of light petroleum extract[c]	Remarks
1	188–190°	+130·9	410	—	0·5	?
2	129–130°	+65·3	424	—	0·6	?
3	154–156°	+ 69·4	410	—	0·2	?
4	75–76°	+ 87·6	424	$C_{30}H_{48}O$	0·5	Dammardienone (I)
5	173–175°	+ 98·9	358	$C_{24}H_{38}O_2$	0·3	New nor-triterpenoid (Hollongdione, XII)
6	135–136.5°	+ 68·4	(424)[b]	$C_{30}H_{50}O_2$	37·5	Dipterocarpol (II)
7	160–161·5°	+ 67·0	458	$C_{30}H_{50}O_3$	13·1	Ocotillone-II (III)
8	72–74° (amorphous)	+ 34·3	(426)[b]	$C_{30}H_{52}O_2$	3·2	Dammarenediol-II (V)
9	194–196°	+ 36·7	460	$C_{30}H_{52}O_3$	1·8	Ocotillol-II
10	228–230°	+ 47·9	428	—	1·3	?
			(M + ?)			?
11	205–210°	+ 56·9	(440)[b]	$C_{30}H_{50}O_3$	1·5	
12	228–230°	+ 43·2	454	$C_{30}H_{46}O_3$	0·7	Lactone
13	212–214°	+ 52·8	414	$C_{27}H_{42}O_3$	0·7	γ-Lactone
			Acids (as Methyl esters)			
14	145–146°	+ 72·4	486	$C_{31}H_{50}O_4$	1·24	New triterpenic acid (Dipterocarpolic acid; XIV)
15	143–148°	See Table 2			0·6	X
16	118–125° (amorphous)				0·5	VIII
17	224–225°				0·5	VI

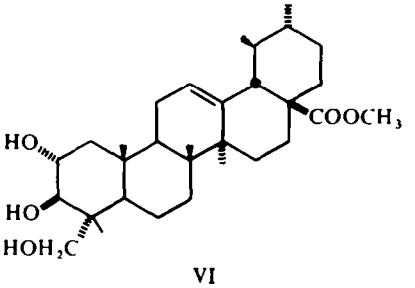
[a] In order of increasing polarity (chromatography)
[b] M^+-18 ion
[c] roughly computed from chromatography data.

(dammarenediol-II, V) was established by direct comparison (PMR, Mass) with a sample of V prepared by KBH_4 reduction[4] of dipterocarpol (II). The remaining compounds (Table 1) appear to be new triterpenoids, but structure of only one of these (No. 5, Table 1), which has been designated *hollongdione*, has been elucidated so far and this is reported below.

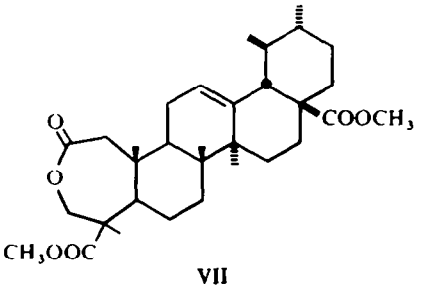
The acid fraction was esterified (CH_2N_2) and separated into light petroleum soluble and petroleum insoluble fractions by trituration. Chromatography of the pet. ether soluble fraction yielded a crystalline Me ester (No. 14, Table 1) which has been shown to be a new triterpenoid. Structure elucidation of this compound, which has been named *dipterocarpolic acid* is described in the sequel.

Benzene and ethyl acetate extracts. Benzene extract (~10% of oleoresin) was separated into acidic (~30%) and neutral fractions and the acidic portion esterified (CH_2N_2); TLC of the resulting product showed it to contain at least five components. By extraction with suitable solvents, followed by chromatography it has been possible to isolate four of these (Table 2) in a pure state.

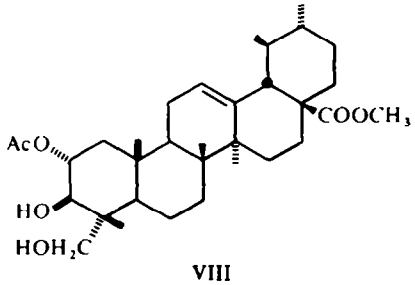
The EtOAc extract consisted only of acids and the esters derived from this have been shown to be identical with those obtained from the C_6H_6 extract (Table 2).



VI



VII



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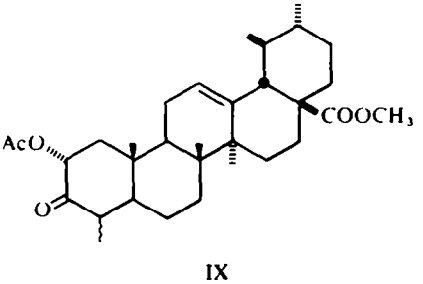

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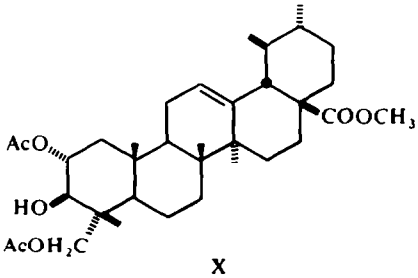

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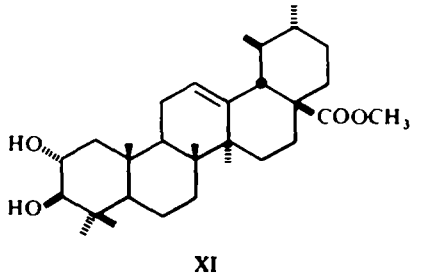


XI

TABLE 2. TRITERPENE ACIDS FROM THE BENZENE AND ETHYL ACETATE EXTRACTS OF THE OLEORESIN FROM *Dipterocarpus pilosus*

No.	R_{dye}[b]	m.p.	$[\alpha]_D$	Mol. formula	Structure	% composition[c]	
						C_6H_6 extract	EtOAc extract
1	0·131	224–225	+52·30	$C_{31}H_{50}O_5$	VI	24·71	75·18
2	0·357	118–125 (amorphous)	+32·43	$C_{33}H_{52}O_6$	VIII	1·88	4·85
3	0·476	215–217	+59·19	$C_{31}H_{50}O_4$	XI	1·00	10·87
4	0·702	143–148	+27·38	$C_{35}H_{54}O_7$	X	2·90	9·10

[a] As methyl esters.

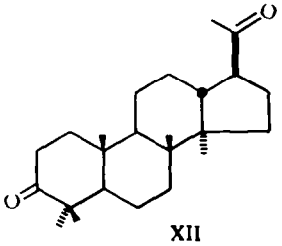
[b] $R_{dye} = \frac{\text{Movement of substance from start in nm}}{\text{Movement of Sudan III from start in mm}}$

TLC: silica gel (0·3 mm), toluene-EtOAc-acetone (1 : 1 : 1), solvent front 10 cm, temp. 25°.

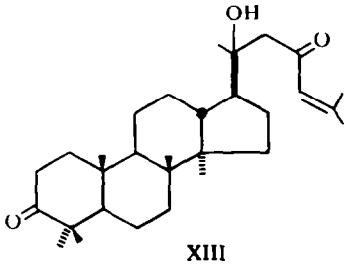
[c] Computed from chromatographic separation data.

These four esters have been identified as methyl asiatate (VI), its two acetyl derivatives VIII and X and methyl 2α-hydroxyursolate (XI)[12] (Table 2). The occurrence in nature of these two acetyl derivatives of asiatic acid has, apparently, not been reported so far and their structure elucidation is briefly reported under Experimental.

Hollongdione. This compound (No. 5, Table 1) shows the following spectral characterestics, IR (KBr): C=O 1709 cm^{-1}; no OH absorption. PMR: five quaternary Me's, s's, at 52, 57, 59, 61 and 62·5 c/s; $C\underline{H}_3-\underset{\underset{C}{|}}{C}=O$, 3H, s at 122 c/s; $-C\underline{H}_2-\underset{\underset{C}{|}}{C}=O$ 2H, m centred at 141 c/s. The quaternary Me's pattern in its PMR spectrum is reminiscent of a dammarane type[13] and, the fact that it has M^+ at $m/e = 358$ and has no vinylic Me's (PMR), suggested that the compound may be XII. This indeed



XII



XIII

proved to be so by comparing (mixed m.p., IR, PMR) it with an authentic sample prepared from dipterocarpol (*vide infra*).

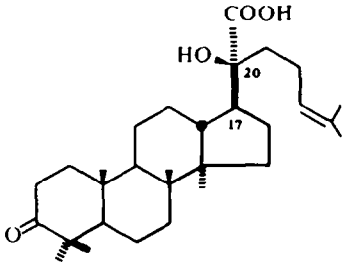
This would appear to be the first recorded example of the occurrence of a hexanortriterpene in nature, though the occurrence of pregnane derivatives in nature is well known[14]. It is conceivable that XI arises in nature from a precursor such as XIII by a

biological equivalent of a retro-aldol condensation. However, a detailed screening of the oleoresin for the presence of XIII proved futile.

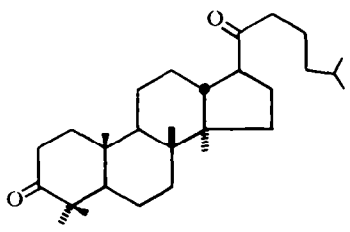
The compound has been named hollongdione, after the local name (*Hollong*) of the tree and its resin.

Dipterocarpolic acid.† The acid could be obtained crystalline only as its Me ester (No. 14, Table 1). The Me ester which analyses for $C_{31}H_{50}O_4$, is clearly a hydroxy keto ester as revealed by its IR spectrum: OH 3460, 1170 cm^{-1}; COOMe 1745 cm^{-1}; —C(=O)— 1705 cm^{-1}. Its PMR spectrum displays signals for five quaternary Me's (3H, s at 49, 55, 58, 60 and 61 c/s), two vinylic Me's (two d's centred at 92 and 97 c/s, each with $J \simeq 1$ c/s), COOMe (3H, s at 218 c/s), —$COCH_2$— (2H, m centred at 141 c/s) and —C=CH—CH_2— (1H, diffused tr, centred at 298 c/s); since, no signal for CHOH is observed, the OH must be tertiary and in accord with this is the finding that the compound cannot be acetylated readily (Ac_2O–pyridine, room temp). The new acid (amorphous powder) shows pK^* aqueous alcohol 6·25, which suggests that the OH function may be located on the carbon α to the COOH group, as the α-hydroxy acids are strong acids.[15] This is further supported by ease of hydrolysis (0·5N alc. KOH, 2 hr) of its Me ester; esters of α-hydroxy acids hydrolyse several times faster than the unsubstituted analogues.[16]

The above data, taken in conjunction with the fact that its PMR spectrum is reminiscent of that of dipterocarpol (II)[12], with which it co-occurs in the oleoresin, it was assumed that the new acid might have arisen in nature by a terminal oxidation



XIV



XV

of a methyl group of dipterocarpol, which has six quaternary Me's (PMR: 53, 57, 59, 61, 63 and 66 c/s) in contrast to five in the new acid. Since, the new acid is an α-hydroxy acid, structure XIV appeared very plausible.

The above conclusion was unequivocally established by a direct correlation of the new acid with dipterocarpol (II). Dihydrodipterocarpol[4] was dehydrated (Ac_2O, pyridine) and the resulting mixture of olefins ozonolysed to give a mixture of two diketones (XII, XV), which were separated by chromatography (Al_2O_3). The diketone XII, as already stated above, was identical with hollongdione. The second diketone (XV; m.p. 55–60°, $[\alpha]_D^{CCl3}$ + 85·4) was the targeted reference compound for correlation with the new acid. Methyl dipterocarpolate was hydrogenated (PtO_2, AcOH) to the

† Presented (by A. S. Gupta) at the Second Indo-Soviet symposium on the Chemistry of Natural Products, held in New Delhi, Feb. 1970.

tetrahydro derivative which was saponified and the resulting acid oxidised with PbO_2, a reagent specific for the oxidative decarboxylation of α-hydroxy acids,[17] to furnish a hydroxy ketone (IR: OH 3425 cm^{-1}; C=O 1724 cm^{-1}). The latter compound on Jones oxidation yielded a diketone, the IR spectrum of which showed slight differences when compared with the IR spectrum of the diketone XV, described above. Assuming this difference to arise from possible equilibration at C_{17} during the chromatographic separation of XII and XV, the diketone obtained from dipterocarpolic acid was also passed through a column of Al_2O_3. The resulting product was found to be identical with XV, in all respects (m.p., mixed m.p., $[\alpha]_D$, IR).

Thus, dipterocarpolic acid* can be represented by XIV, the stereochemistry at C_{20} being tentatively assumed to be directly related to that in dipterocarpol (II).

EXPERIMENTAL

For general remarks see Ref 1

Oleoresin extracts. The various solvent extracts of *Dipterocarpus pilosus* oleoresin have already been described.[1]

Light petroleum extract (steam-non-volatile, neutral). The above extract (110 g) was chromatographed on Al_2O_3/II-III (2150 g, 45 cm × 8·5 cm) and the various broad cuts monitored by TLC (for light petroleum and benzene fractions, solvent: C_6H_6; for other fractions, solvent: 1% acetone in CH_2Cl_2):

Fraction A	light petroleum	2l × 8	11·4 g,	compounds* ①, ②, ③, ④, ⑤, 6
Fraction B	C_6H_6	2l × 14	51·3 g,	compounds 5, ⑥, 7
Fraction C	C_6H_6	2l × 5	5·9 g,	compounds 6, ⑦
Fraction D	1% MeOH in C_6H_6	2l × 10	27·2 g,	compounds ⑧, ⑨, ⑩, ⑪ and sesquiterpenes B and C.
Fraction E	MeOH	2l × 3	5·4 g,	clovanediol, sesquiterpene-D.
Fraction F	10% Na_2CO_3 aq.	'extraction'†	6·9 g	compounds ⑫, ⑬, ⑭

* The numbers refer to compounds in Table 1; circled numbers indicate the compounds actually isolated from that fraction, others were indicated by TLC.

† Al_2O_3 was removed from the column and extracted with Na_2CO_3 aq. with addition of MeOH by refluxing (30 min).

Dammara-20,24-dien-3-one (I) *and compounds* 1,2,3 of *Table* 1.

Fraction A (7·0 g) was mixed with silica gel (13 g) and the mixture loaded on an IDCC column (silica gel/Grade IIA; 25 cm × 6·6 cm), which was developed with C_6H_6 (solvent rise 19 cm). Small sections were dug out at a time and later pooled according to TLC behaviour. This provided cuts A_1 (least polar, 1·3 g; compounds 1,2,3,4) and A_2 (most polar, 3·1 g; compounds 5,6), besides other cuts containing some, so far, unidentified compounds.

Cut A_1 (1·05 g) was subjected to IDCC on silica gel-$AgNO_3$/Grade IIA (25 cm × 4·7 cm) using benzene (solvent rise 19 cm). Various sections of the column were monitored by TLC (silica gel-$AgNO_3$; solvent: C_6H_6), suitably pooled and the following compounds obtained (in order of increasing R_f):

Compound No. 1 (Table 1): crystallisation from MeOH and then from acetone gave crystals (20 mg), m.p. 188–190°. IR(KBr): C=O 1725 cm^{-1}. PMR: Me signals at 54·5, 56·5, 60 and 63 c/s (≃21 H); olefinic proton (1H, m centered at 312 c/s).

Compound No. 2 (Table 1): crystallised first from dilute EtOH and then from MeOH to give crystals (11·5 mg), m.p. 129–130°; IR(KBr): C=O 1725 cm^{-1}; $-\underset{|}{C}=CH_2$ 1660, 890 cm^{-1}.

Compound No. 3 (Table 1): recrystallisation first from MeOH, then from acetone furnished crystals, (19 mg), m.p. 154–156°; IR (KBr): C=O 1712 cm^{-1}; $-\underset{|}{C}=CH_2$ 1655, 890 cm^{-1}; PMR: Me signals at 54, 57, 61 and 62·5 cm (≃15H); one vinylic Me (3H, s at 100 c/s); $-\underset{|}{C}=CH_2$ (2H, broad s at 276 c/s).

* The primary alcohol (dryobalanone) corresponding to dipterocarpolic acid, has been described recently[18].

Dammara-20,24-dien-3-one (I). Crystallization from dil EtOH gave a product (94 mg, m.p. 71–75°), which on repeated crystallisation yielded crystals, m.p. 75–76°; IR (KBr): C=O 1710 cm^{-1}; —C=CH_2 | 1650, 887 cm^{-1}; PMR: five quaternary Me's at 53, 57, 59·5, 61·5 and 61·5 c/s; two vinylic Me's (3H, broad s at 97 and 101 c/s); —C=CH_2 (2H, broad s at 284 c/s); —C=CH— (1H, m centred at 310 c/s). Mass: major peaks at *m/e* 424, 315, 205, 135, 121, 109, 107, 95, 93, 81, 69 (base), 67, 55. An authentic sample of I was obtained by treatment of dipterocarpol with Ac_2O-pyridine according to a known procedure.[4*]

Hollongdione (XII). Cut A_2 (3·1 g), above, was triturated with pet. ether, the solid (dipterocarpol, 1·65 g) was removed by filtration and the filtrate freed of solvent and subjected to IDCC (silica gel/II, 25 cm × 4·7 cm; solvent, 2% EtOAc in C_6H_6). The zone containing material corresponding to compound 5 (Table I) was worked up to give a material (44 mg), which after further purification (IDCC) and crystallisation from aq EtOH furnished hollongdione (13 mg), m.p. 174–175°. Mass: important peaks at *m/e* (relative intensity) 358 (M^+; 2·5%), 315 (M^+—CH_3CO; 5%), 109 (7·5%), 95 (17%), 81 (14%), 69 (19%), 67 (21%), 55 (38%), 43 ($MeCO^+$; 100%), 41 (58%).

Preparation of an authentic sample of XII is described under dipterocarpolic acid.

Dipterocarpol (II). Fraction B (51·2 g) on trituration with light petroleum and recrystallisation of solids (20·2 g m.p. 131–133°) from aq EtOH gave dipterocarpol (18·9 g), m.p. 135–136·5°, $[\alpha]_D$ +68·4. (Lit.[4]: m.p. 127, 135–136°, $[\alpha]_J$ +65).

Ocotillone-II (III). Fraction C (5·6 g) was crystallised from ether to give a product (2·4 g), m.p. 158–160°, which was recrystallised from aq EtOH to yield pure ocotillone-II, m.p. 160–161·5°, $[\alpha]_D$ + 67·0 (Lit.[7]: m.p. 165°, $[\alpha]_D$ + 63°); IR: C=O 1700; OH 3500, 1080; PMR: quaternary Me's at 53, 57, 60, 60, 62, 62, 66 and 68 c/s; —CHOR (1H, tr centred at 217 c/s). (Found: C, 78·54; H, 11·11; $C_{30}H_{50}O_3$ requires: C, | 78·55: H, 10·99%).

Dammarenediol-II (V). Fraction D (11·0 g) was subjected to IDCC (silica gel/II, 25 cm × 6·6 cm; solvent, 3% EtOAc in C_6H_6) and the column worked up in the usual fashion with TLC monitoring to finally give the following cuts in order of increasing R_f): D_1 (1·31 g), D_2 (1·1 g), D_3 (1·3 g), D_4 (0·74 g), D_5 (1·24 g), D_6 (2·00 g), D_7 (2·68 g) and D_8 (0·25 g).

Cut D_7 (0·9 g) was rechromatographed over $AgNO_3$-silica gel (IDCC; 25 cm × 4·7 cm; solvent, 10% EtOAc in C_6H_6) and the TLC single spot material (440 mg) was crystallised from aq acetone to furnish a white powder (60 mg), m.p. 72–74°. This was identified as dammarenediol-II (V) by direct comparison (IR, PMR) with an authentic sample (m.p. 82–83°, resolidifies and melts again at 130–132°) obtained by reduction of dipterocarpol (500 mg in 50 ml MeOH) with KBH_4 (92 mg) at room temp (20 hr), followed by crystallization first from MeOH and finally from light petroleum (Lit.[3]; m.p. 130–132°).

Ocotillol-II (IV). Cut D_6 (2·0 g) was subjected to IDCC (silica gel/II, 25 cm × 4·7 cm; solvent, 10% EtOAc in C_6H_6) and the appropriate fraction recrystallised from acetonitrile to give ocotillol-II (23 mg), m.p. 194–196°, identified by direct comparison (mixed m.p., IR) with an authentic sample obtained by reduction of ocotillone (500 mg in 50 ml MeOH) with KBH_4 (95 mg). PMR: quaternary Me signals at 44, 50, 52, 56, 58, 62, 66 and 68 c/s. Mass: M^+, *m/e* = 460; major peaks at *m/e* 445 427, 402, 401, 384, 383, 341, 316 (Lit.[8]: m.p. 198–200, $[\alpha]_D$ +28°).

Compound No. 11 (*Table* 1). Cut D_3 (1·3 g) in acetone, slowly deposited some solid, which was recrystallised from benzene-ether to give crystals (25 mg), m.p. 205–210°. IR: OH 3333, 1080 cm^{-1}; C=O 1709 cm^{-1}. Mass M^+-18 ion at *m/e* 440; major peaks at *m/e* 143, 125 (base), 109, 107, 95, 93, 82, 81, 79, 71, 69, 67. (Found: C, 77·27; H, 11·03. $C_{30}H_{50}O_3$ requires: C, 78·55; H, 10·99%).

Compound No. 10 (*Table* 1). The above mother liquor was combined with cut D_4 and the total (1·9 g) chromatographed over silica gel/IIB (55 g). After rejecting the first 200 ml of eluate (10% EtOAc in C_6H_6), the next 250 ml portion, on removal of solvent, yielded a product which on crystallisation from ether gave compound No. 10 (36 mg), m.p. 228–230°; IR (KBr): OH 3460; C=O 1720 cm^{-1}; PMR ($CDCl_3$): quaternary Me's at 57, 60, 60, 62·5, 66, 88 (?) and 88 (?) c/s; CH_3CO (3H, s at 133 c/s. Mass: major peaks at *m/e* 428, 410, 400, 367, 205, 191, 190, 177, 161, 149, 147 (base).

The compound was recovered unchanged after exposure to Ac_2O-pyridine at room temp (16 hr).

* However, this method does not give only I, though this is the main product. Three other compounds are formed and the mixture could be separated only by $AgNO_3$-silica gel chromatography. These results will be reported elsewhere.

Sesquiterpene-B[1]. The first mother liquor from the crystallisation of the fraction containing the compound No. 10 (above) was freed of solvent, the residue (0·45 g) acetylated (Ac_2O-pyridine; room temp 16 hr) and the product subjected to IDCC (silica gel/III, 25 cm × 3·3 cm; solvent: 10% EtOAc in C_6H_6) to get some more quantity (15 mg) of compound No. 10 (from polar fractions), followed by sesquiterpene-B (60 mg), m.p. 131–135° (light petroleum).

Sesquiterpene-C[1]. Cut D_1 (1·31 g; three spots on TLC) was subjected to IDCC (silica gel/III, 25 cm × 4·7 cm; solvent, EtOAc) in the usual fashion and the various segments monitored by TLC. The material (380 mg) corresponding to the spot with least R_f, crystallised and was recrystallised from light petroleum to give sesquiterpene-C (183 mg), m.p. 80–82°.

Clovanediol[1] *and sesquiterpene*-D[1]. Fraction E (4·0 g) from the original chromatography of the light petroleum extract (steam-non-volatile) was chromatographed (IDCC: silica gel/III, 25 cm × 4·7 cm; solvent, 50% EtOAc in C_6H_6) and various segments of the column pooled after TLC monitoring. The more polar material (1·2 g) showing essentially a single spot on TLC, slowly crystallised and the product was recrystallised from light petroleum to give clovanediol[1] (203 mg), m.p. 152–153°.

Sesquiterpene-D[1] (278 mg) was obtained from the less polar fractions after a column chromatography over silical gel/II.

Compound No. 12 *and* 13 (*Table* 1). Fraction F (5·0 g) in ether (200 ml) was extracted with $NaHCO_3$ aq (saturated, 15 ml × 3) to remove free acids and the material (4·5 g) from ether layer, refluxed with ethanolic KOH (N/2, 100 ml) for 4 hrs, the neutral part removed in the usual fashion and the aq alkaline soln acidified, heated on the steambath for 0·5 hr, cooled, the product taken up in ether, the ether extract washed with $NaHCO_3$ aq then with brine and dried. The product (4·0 g) obtained after removal of solvent was chromatographed (IDCC; silica gel/II, 9·4 cm × 25 cm; solvent 20% EtOAc in C_6H_6) in the usual fashion to finally give (after rechromatography) the following two compounds (lactones) in order of increasing polarity.

Compound No. 12 (180 mg), m.p. 228–230°; IR: C=O 1695, 1705 cm^{-1}; PMR ($CDCl_3$): Me signals at 56, 60, 61, 64 c/s (~18H); C=C$\underline{H}_2$ (two one H, broad s's at 277 and 285 c/s. Mass: major peaks at *m/e* 454, 439, 408, 248, 235, 219, 206, 205, 203, 201, 191, 189 (base), 187, 177, 175, 173, 137, 135, 133.

Compound No. 13 (295 mg), m.p. 212–214°; IR: C=O 1700, 1750 cm^{-1}; PMR ($CDCl_3$): quaternary Me signals at 54, 58, 61, 65 and 82 c/s. Mass: major peaks at *m/e* 414 (base), 315, 208, 206, 205, 195, 135, 109, 107, 99, 95.

Light petroleum extract (*steam-non-volatile, acids*). The total acids (17·9 g) in MeOH were charcoaled, and the material (in EtOAc-MeOH) esterified (CH_2N_2). A part (14·1 g) of this product was triturated with light petroleum (400 ml × 2) to give a light petroleum soluble (9·7 g) and a light petroleum insoluble fraction (4·3 g). The light petroleum insoluble portion was similar in composition to the esters derived from acids from C_6H_6 and EtOAc soluble fraction of the oleoresin (*vide infra*).

Methyl dipterocarpolate. Light petroleum soluble fraction (9·3 g) was chromatographed over Al_2O_3/grade II (22 cm × 4·2 cm) with TLC monitoring (solvent: 5% acetone in C_6H_6). After removal of pet. ether-benzene (1:1; 200 ml × 3; 1·0 g), 0·5% MeOH in C_6H_6 fraction (200 ml × 19) gave a TLC pure product (1·3 g), which on trituration with light petroleum crystallised out, m.p. 138–145°. This after recrystallisation from acetonitrile gave pure methyl dipterocarpolate (650 mg), m.p. 145–146°. Mass: major ions at *m/e* 468 ($M^+ - 18$; 28%), 404(100%), 205(14·5%), 154(14·5%), 95(38%), 82(25·5%), 81(21%), 69(46%), 55(27%). (Found: C, 76·90; H, 10·81. $C_{31}H_{50}O_4$ requires: C, 76·5; H, 10·36%).

Benzene and ethyl acetate extracts. Benzene extract (solid, m.p. 100–135°; 46 g) was treated with Na_2CO_3 (50 g) in 85% EtOH (150 ml) for 1 hr on a water-bath. The solvent was flashed off, the residue thoroughly dried and the dry powder, thus obtained, was soxhleted with EtOAc to give a soluble part (32 g) and insoluble Na salt. The latter was dissolved in water, acidified (HCl) and the liberated acids taken up in EtOAc to finally yield 10·5 g of acids, having a composition (TLC of Me esters) similar to that of acids from the original EtOAc extract (*vide infra*). The neutral portion (EtOAc soluble part) was shown by TLC to be complex mixture, which failed to give any crystalline homogenous component on systematic chromatography and hence was not investigated further.

EtOAc extract (42 g) of the oleoresin[1] was triturated with cold EtOAc repeatedly till an essentially insoluble residue (16 g) remained; the EtOAc extract on solvent removal furnished EtOAc soluble part (26 g). These were separately processed as detailed below.

Methyl asiatate (VI). EtOAc 'insoluble' acids (15·8 g) were dissolved in EtOAc-MeOH and esterified with ethereal CH_2N_2. 14·7 g of this product was chromatographed over Al_2O_3/grade II (26·5 cm × 5 cm). After rejecting C_6H_6 (1000 ml; 37 mg), 0·5% MeOH in C_6H_6 (1000 ml; 16 mg), 1% MeOH in C_6H_6 (1000 ml; 25 mg) and 2% MeOH in C_6H_6 (300 ml × 7; 1·28 g) cuts, 2% MeOH in C_6H_6 (300 ml × 11) and 5%

MeOH in C_6H_6 (300 ml × 9) yielded 12 g of a product consisting essentially of methyl asiatate. Thus, 8·6 g of this material on trituration gave a solid which was crystallised first from dil. ethanol and next from C_6H_6 to yield a product (6·0 g), m.p. 220–221·5°. This material is slightly contaminated with an unsaturated compound, which is best eliminated by hydrogenation. Thus, this material (0·5 g) in AcOH (20 ml) was hydrogenated in presence of PtO_2 (90 mg, pre-reduced) and when no further H_2 (total uptake 0·25 double bond equivalent) was consumed, it was worked up in the usual fashion to give a product which was crystallised from C_6H_6 to give pure methyl asiatate (370 mg), m.p. 224–225·5°, mixed m.p. with an authentic sample* (m.p. 224–225°) undepressed. (Found: C, 73·62; H, 9·82. $C_{31}H_{50}O_5$ requires: C, 74·06; H, 10·03%). (Lit.[19]: m.p. 225°; $[\alpha]_D$ + 54·5°).

Triacetyl methyl asiatate (Ac_2O-pyridine), m.p. 197–198° (aq MeOH), $[\alpha]_D$ +36·5° (*c*, 0·25%): PMR: quaternary Me signals at 45, 53, 65 and 67 c/s; two —CH—C<u>H</u>$_3$ (3H, d's centred at 50 c/s with J = 7 c/s and, 55·5 c/s with J = 6 c/s; three OCOC<u>H</u>$_3$ (3H, s's at 115, 118 and 122 c/s), COOC<u>H</u>$_3$ (s at 213 c/s), —C<u>H</u>$_2$OAc (d located between 215–223 c/s). two —CHOAc (2H, broad signal between 295–310 c/s), —C=C<u>H</u>— (1H, broad s at 315 c/s). (Found: C, 70·57; H, 8·84. $C_{37}H_{56}O_8$ requires: C, 70·67; H, 8·98%). (Lit.[19]: m.p. ? $[\alpha]_D$ + 39·4°).

Degradation to lactone diester (VII)[10]. Methyl asiatate (100 mg) in MeOH (15 ml) was treated with $NaIO_4$ aq (100 mg in 4 ml H_2O) at room temp (~25°) for 20 hr and worked up in the usual manner to get an amorphous aldehyde (85 mg, m.p. 120–135°, $[\alpha]_D$ + 120°). This product (240 mg) in acetone (24 ml) was oxidised with Jones reagent[20] in the usual fashion to get a material (187 mg), which was esterified (CH_2N_2) and the ester crystallised from dil ethanol to give VII (98 mg), m.p. 231–233°, $[\alpha]_D$ +125·0° (*c*, 0·25%); PMR: quaternary Me signals at 48, 57, 64 and 80 c/s; —O—CO—C<u>H</u>$_2$—C(C)—C (2H, broad s at 152 c/s); —C(=O)—O—C<u>H</u>$_2$—C(COOMe)—C (AB qu centred at 259 c/s, J_{AB} = 13 c/s), two COO<u>M</u>e (3H, s's at 214 and 222 c/s), —C=CH— (1H, diffused tr centred at 319 c/s). (Found: C, 72·21; H, 8·98. $C_{32}H_{48}O_6$ requires: C, 72·69; H, 9·15%).

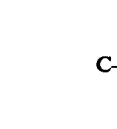
Methyl 2α, 23-diacetoxy-3β-hydroxy-Δ^{12}-ursene-28-oate (X). The EtOAc soluble acids (*vide supra*) were esterified (CH_2N_2) and the ester mixture (m.p. 94–105°; 15·0 g) chromatographed on Al_2O_3/II (26·5 cm × 5 cm) with TLC monitoring (Table 2). After rejecting 0·5% MeOH in C_6H_6 (300 ml × 5; 0·33 g) eluates, 1% MeOH in C_6H_6 (300 ml × 6; 2·71 g, essentially compound X) and 2% MeOH in C_6H_6 (300 ml × 15; 2·45 g, mixture of VIII and XI) cuts were separately collected; later cuts, obtained with 5% MeOH in C_6H_6 and 10% MeOH in C_6H_6 (~6 g), contained essentially methyl asiatate.

The material (2·7 g) eluted with 1% MeOH in C_6H_6 was further purified by rechromatography to finally give after recrystallisation from acetonitrile platelets (357 mg), m.p. 143–148°; IR: OH 3448, 1042 cm^{-1}; C=O 1724 cm^{-1}, 1750; OAc 1250 cm^{-1}; PMR ($CDCl_3$): quaternary Me's at 45, 50, 63, 63 c/s; two OCOC<u>H</u>$_3$ (6H, s at 122·5 c/s), COO<u>M</u>e (3H, s at 213 c/s); C<u>H</u>OH (under COOMe signal); C<u>H</u>$_2$OAc (d centered at 238 c/s), C<u>H</u>OAc (1H, broad m centred at ~290 c/s); —C=C<u>H</u>— (diffused tr centred at 312 c/s). (Found: C, 71·85; H, 9·41. $C_{35}H_{54}O_7$ requires: C, 71·64; H, 9·28%).

That ester No. 4 (Table 2), analysing for $C_{35}H_{54}O_7$ is a methyl diacetyl asiatate (PMR: 6H, s at 122·5 c/s) became clear when on further acetylation it furnished methyl triacetyl asiatate (mixed m.p., IR). Its PMR spectrum shows a 2H doublet centred at 238 c/s and, assignable to C(C)—C—C<u>H</u>$_2$O—; taking into account the

* The authors are grateful to Dr. Polonsky for an authentic sample.

chemical shift for these protons in methyl asiatate (VI), its triacetyl derivative and the monoacetate VIII (*vide infra*) it is clear that in this compound C_{23}—OH must be acetylated. Furthermore, since this

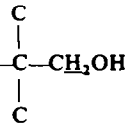


signal is fairly downfield as compared to the chemical shift for the same protons in methyl triacetyl asiatate (219 c/s), C_3—OH must be free, in view of the following argument. It is well-established[11] that a hydroxyl group is capable of deshielding a proton if appropriately situated in the same plane as the one containing the OH group; furthermore, it is also known that when this OH is acetylated it usually exerts a shielding effect on the concerned proton. Since, the two hydroxyl groups and the CH_2OH group in methyl asiatate are all equatorial, the only way in which $C\underline{H}_2OAc$ at C_4 can suffer a downfield shift ($\sim$19 c/s) is if an equatorial OH were present at C_3. Thus, this new ester can be represented by X.

Methyl 2α-acetoxy-3β,23-dihydroxy-Δ[12]-ursene-28-oate (VIII). The material from the above 2% MeOH in C_6H_6 eluates was separated by preparative-layer-chromatography (PLC) (solvent: EtOAc—C_6H_6 1:1) to finally give VIII and XI.

TLC pure material (VIII) was obtained only as an amorphous powder (m.p. 118–125°). (Found: C, 72·64; H, 9·68. $C_{33}H_{52}O_6$ requires: C, 72·75; H, 9·62%).

From its elemental analysis and general similarity of its PMR spectrum to that of methyl asiatate, the compound was considered to be a methyl monoacetyl asiatate. This was confirmed by its further acetylation to the known methyl triacetyl asiatate. Since, the PMR spectrum of the new ester shows a 2H signal



(unresolved doublet, centred at 205 c/s) assignable to C—C—$C\underline{H}_2OH$ (this signal occurs at 210 c/s in methyl asiatate and at 219 c/s in the triacetyl derivative), the compound must be either a 2- or 3-acetoxy methyl asiatate. A decision in favour of the former (VIII) could be made by its oxidation with CrO_3 in acetone, when only a neutral, less polar compound, which must be formulated as IX was obtained.

Methyl 2α-hydroxyursolate (XI). TLC pure material obtained from the above PLC was recrystallised from acetonitrile to furnish colourless needles, m.p. 215–217°; IR: OH 3380, 1060 cm^{-1}; COOMe 1735 cm^{-1}. (Found: C, 75·48; H, 10·35. $C_{31}H_{50}O_4$ requires: C, 76·5; H, 10·36%). (Lit.[12]: m.p. 212–214°).

Acetate (Ac_2O-pyridine) was obtained only as an amorphous powder, m.p. 105–110°, $[\alpha]_D$ +21·14° (*c*, 0·7%). PMR: quaternary Me signals at 44, 55, 55, 65, 65 c/s; O$\underline{Ac}$, (3H s at 115 and 119 c/s); COO$\underline{Me}$ (3H, s at 213 c/s); two C$\underline{H}$OH (2H, m located between 274–300 c/s); —C=C$\underline{H}$— (1H, diffused tr centred at 313 c/s). (Found: C, 73·57; H, 9·57. $C_{35}H_{54}O_6$ requires: C, 73·64; H, 9·54%).

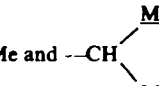
Dipterocarpolic acid (XIV). The methyl ester (*vide supra*) was hydrolysed by refluxing (2 hr) with 0·5N alcoholic KOH. The acid, thus obtained, was chromatographed over silica gel when 25% acetone in C_6H_6 eluted pure acid, which however was obtained only as an amorphous solid; re-esterification (CH_2N_2) regenerated pure (TLC) crystalline ester. pK^*_a value was measured in ethanol-H_2O (4:1) at 25°.

Tetrahydrodipterocarpolic acid. Methyl dipterocarpolate (110 mg) in AcOH (10 ml) was hydrogenated in presence of Adam's PtO_2 catalyst (20 mg, pre-reduced) at 25°/750 mm, when two mole equivalent of H_2 was absorbed in $\sim$1 hr and further consumption of H_2 ceased. Usual work up furnished the tetrahydro ester, which was crystallised from acetonitrile to yield colourless plates (95 mg), m.p. 148·5–149·5°, $[\alpha]_D$ +44·66° (*c*, 0·6%); IR: OH 3460, 1165, 1086, 1050 cm^{-1}; COOMe 1735 cm^{-1}; PMR: quaternary Me and

signals at 45, 50, 50, 50, 55, 57, 59 c/s; COO$\underline{Me}$ (3H singlet at 222 c/s).

The above ester (100 mg) was refluxed with 0·5N alcoholic KOH (5 ml) for 2 hr and worked up to get a solid acid, which was recrystallised from MeOH to give needles (67 mg), m.p. 219–220°, $[\alpha]_D$ +38·85° (*c*, 0·6%). (Found: C, 75·60; H, 11·24. $C_{30}H_{52}O_4$ requires: C, 75·58; H, 11·00%).

3β-Acetoxy-21-nor-dammarane-20-one. The above acid (65 mg) in gl AcOH (1 ml) was treated with PbO_2 (45 mg) at 90–100° for 0·5 hr, when TLC (solvent: 5% acetone in C_6H_6) showed complete disappear-

ance of the starting acid. Usual work up followed by a chromatography over Al_2O_3/II (1·5 g) furnished a sticky solid (44 mg), which failed to crystallise. However, this material (29 mg) on acetylation (Ac_2O–pyridine) yielded a solid, which after crystallisation from acetonitrile gave plates (17·4 mg), m.p. 163–165°, $[\alpha]_D$ +68·4° (*c*, 0·2%). PMR: quaternary Me and  signals at 51, 51, 51, 53, 53, 56·5, 61·5; OAc (3H, s at 118 c/s). (Found: C, 78·59; H, 11·02. $C_{31}H_{52}O_3$ requires: C, 78·76; H, 11·09%). (Lit.[3]: m.p. 164–165°, $[\alpha]_D$ +66°).

21-*Nor-dammarane*-3,20-*dione* (XV). The above alcohol (12 mg) in acetone (2 ml) was oxidised in the usual fashion with Jone's reagent[20] and the product adsorbed on a column of Al_2O_3/I and eluted (C_6H_6) after 18 hr to give 5 mg of a gum, which slowly solidified, m.p. 55–60°, $[\alpha]_D$ +88·08° (*c*, 0·2%) and, was identified as XV, by direct comparison (IR, mixed m.p.) with an authentic sample described below.

21-*Nor-dammarane*-3,20-*dione* (XV) *and hexanor-dammarane*-3,20-*dione* (XII; *hollongdione*) *via dipterocarpol*. Dipterocarpol (300 mg) in EtOH–EtOAc (1:1; 30 ml) was reduced over PtO_2 (30 mg) in the usual manner to give dihydrodipterocarpol as an amorphous powder (295 mg). This (200 mg) was refluxed (24 hr) with Ac_2O (2 ml) and pyridine (1 ml), cooled, diluted with water and the product (gum, 195 mg) isolated by ether extraction, followed by solvent removal.

The above mixture of dienes (195 mg) in EtOAc (20 ml) was subjected to ozonolysis at 0–5° and the ozonised material; after solvent removal, treated with Na_2CO_3 aq (5%, 2 ml) and 30% H_2O_2 (0·75 ml) at ~90° for 20 min. The neutral material was taken up in ether, washed with brine, dried and freed of solvent to get 167 mg of mixture of diketones. This was separated by PLC (solvent: 1% acetone in C_6H_6) to finally give 47 mg of a faster-moving compound and 45 mg of a compound with lower R_f.

The faster-moving compound (36 mg) was kept adsorbed on a column of Al_2O_3/I for 11 hr and then eluted with C_6H_6 to furnish XV (27 mg), m.p. 55–60°, $[\alpha]_D$ +85·4°. IR: C=O 1724, 1690 (sh) cm^{-1}.

The material with lower R_f was crystallised from acetonitrile to furnish XII (28 mg), m.p. 173–175°, $[\alpha]_D$ +93·85° (*c*, 0·2%).

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