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FRIEDELIN, D:A-FRIEDO-OLEAN-3, 21-DIONE AND 21α-HYDROXY-D:A-FRIEDO-OLEAN-3-ONE FROM *KOKOONA ZEYLANICA**

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Key Word Index—*Kokoona zeylanica*; Celastraceae; friedelin; D:A-friedo-olean-3, 21-dione; 21α-hydroxy-D:A-friedo-olean-3-one; structure elucidation; triterpenoids; chemotaxonomy.

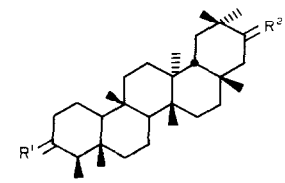
Abstract—*Three triterpenes obtained from the inner bark of Kokoona zeylanica have been identified as* friedelin, D:A-friedo-olean-3, 21-dione and 21α-hydroxy-D:A-friedo-olean-3-one by spectroscopic properties and chemical interconversions. Their chemotaxonomic significance is emphasized.

INTRODUCTION

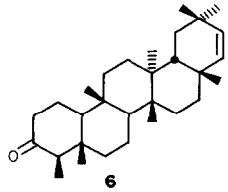
Celastraceae, a tropical family of plants, is represented in Sri Lanka by 22 species distributed in 12 genera [1] of which five species are endemic to the country [2]. Eight species have been recorded for the genus *Kokoona* [3] and *K. zeylanica* is the only species occurring in Sri Lanka. We have undertaken a comprehensive phytochemical study of this plant and our previous reports dealt with the isolation of several new D:A-friedo-oleanan triterpenes [4–6], a phenolic 24-nor-D:A-friedo-oleanan triterpene [7], dulcitol and (D-methylepigallocatechin) [8]. In this paper we report the occurrence of friedelin (**1**), D:A-friedo-olean-3, 21-dione (**2**) and 21α-hydroxy-D:A-friedo-olean-3-one (**3**) in the stem bark of *K. zeylanica*.

RESULTS AND DISCUSSION

The dried and powdered inner bark of *K. zeylanica* defatted with hot petrol was exhaustively extracted with hot benzene and the extract was separated by CC and prep. TLC. The least polar compound, eluted with 50% benzene in petrol, was identified as friedelin (**1**). The two polar triterpenes, eluted with 50% benzene in petrol and benzene alone, were identified as D:A-friedo-olean-3, 21-dione (**2**) and 21α-hydroxy-D:A-friedo-olean-3-one (**3**), respectively from the evidence presented below. The more polar triterpenoid **3**, $C_{30}H_{50}O_2$, had in its IR spectrum bands at 3490 and 1712 cm^{-1} indicating the presence of hydroxyl and carbonyl groups. Acetylation gave a monoacetate, mp 281–283° and oxidation gave a diketone $C_{30}H_{48}O_2$, mp 258–260°. This diketone was shown to be identical (co-TLC, mmp and IR) with the less polar triterpene **2**. In their mass spectra, both



1 R¹ = O; R² = H₂
2 R¹ = R² = O
3 R¹ = O; R² = α – OH, β – H
4 R¹ = O; R² = α – OAc, β – H
5 R¹ = β – OH, α – H; R² = O



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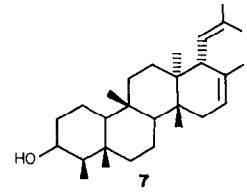

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triterpenes had prominent fragments at *m/z* 355 and 273 indicating the presence of one oxygen substituent in ring E (see Scheme 1). Further, the sodium borohydride reduction of the diketo triterpene gave a keto-alcohol, mp 274–276°, different from the natural triterpene keto-alcohol, suggesting the presence of one oxo group in a sterically hindered environment. Dehydration ($POCl_3$–pyridine) of the natural keto-alcohol triterpene yielded an enone, $C_{30}H_{48}O$, whose ^1H NMR spectrum showed the presence of a 2H double doublet centered at δ 5.50 and 5.56 (J = 11 Hz); suggesting the attachment of the hydroxyl group to C-21 or C-22. Catalytic hydrogenation of this enone gave friedelin (**1**), supporting the presence of the oxo group at C-3. The foregoing evidence sug-

*Part 4 in the series "Studies on Terpenoids and Steroids". For Part 3 see ref. [5].

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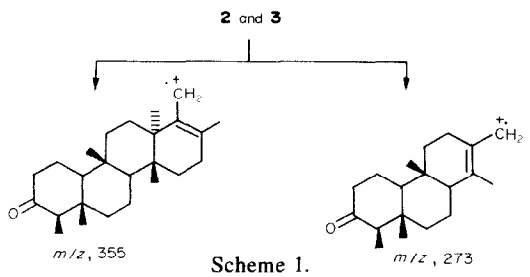

Scheme 1.

gested the enone to be D:A-friedo-olean-21(22)-en-3-one (**6**). Thus, it remained to locate the oxygen function in ring E of the two natural triterpenoids.

Photochemical irradiation of the sodium borohydride reduction product **5** of the above diketo triterpene aided the location of the oxygen function at C-21 [5, 9]. The spectral data (see Experimental) of the irradiation product indicated it to be the non-conjugated diene, 3β-hydroxy-21,22-bisnor-E-seco-D:A-friedo-olean-16,19-diene (**7**), thus confirming the presence of a 21-oxo group in **5** [9].

Friedelane-3:*x*-dione and *x*(*ax*)-hydroxyfriedelan-3-one obtained from *Siphonodon australe* Benth. (Celastraceae) [10, 11] were later shown to be **2** and **3**, respectively [9]. The difference in physical constants of our two natural triterpenes as well as their derivatives to those reported and incorrect names given to those triterpenes from *S. australe* in a recent review [12], made it necessary to prove independently the structures of our two dioxygenated D:A-friedo-oleananes from *K. zeylanica*.

Despite the wide variety of natural D:A-friedo-oleananes known, the restricted occurrence of **2** and **3** in *K. zeylanica*, *Siphonodon australe* [10, 11] and *Salacia reticulata* [13] is of some chemotaxonomic significance. In a recent classification, Dahlgren [14] places the genus *Siphonodon* under a monogeneric family Siphonodontaceae and *Salacia* under Hippocrataeceae, both in the order Celastrales. Our finding, however, supports the previous grouping of the genera *Siphonodon* and *Salacia* in the family Celastraceae.

EXPERIMENTAL

General procedures. Mps are uncorr. IR spectra were taken in KBr discs. ^{1}H NMR spectra were recorded in $CDCl_3$ and CCl_4 solns with TMS int. standard at 60 MHz. $[\alpha]_D$ values were measured with a Perkin–Elmer 241 polarimeter. Petrol refers to the fraction of bp 60–80°. Si gel (Merck) plates (0.25 mm) were used for TLC; for prep. TLC these were 1 mm thick.

Extraction. K. zeylanica bark collected at Kanneliya rain forest, Sri Lanka, was separated into inner and outer bark. The dried and powdered inner bark (5.5 kg) was successively and exhaustively extracted with hot petrol, hot C_6H_6 and hot MeOH. The hot C_6H_6 extract on concn yielded an off-white solid (48 g) which was dissolved in $CHCl_3$ (200 ml) and reppted by the addition of petrol (300 ml). The ppt was filtered, washed several times with petrol to afford a white powder (35 g) and 20 g of this was chromatographed on a column of Si gel (400 g).

Isolation of friedelin (**1**). Elution of the column with 10% C_6H_6 in petrol gave a white solid which on crystallization from $CHCl_3$–MeOH afforded **1** as white needles (500 mg, 1.8×10^{-4}%); mp 265°, $[\alpha]_D$ −22.4° (lit. [10] mp 264°, $[\alpha]_D$ −22.1°); IR ν_{max}^{KBr} cm^{-1}: 1713. Identical (mmp, IR, co-TLC) with an authentic sample.

Isolation of D:A-friedo-olean-3, 21-*dione* (**2**). Elution of the column with 50% C_6H_6 in petrol gave a white solid which on crystallization from $CHCl_3$–petrol yielded **2** as white needles (550 mg, 2.7×10^{-4}%), mp 258–260°, $[\alpha]_D$ +110.5° (lit. [10] mp 248–250°, $[\alpha]_D$ +115°); IR ν_{max}^{KBr} cm^{-1}: 1713 and 1723; ^{1}H NMR: δ 2.80–1.30 (satd. CH_2), 1.16 (3 Me's), 1.06 (2 Me's), 0.96 (3H, *d*, J = 6 Hz, 4-Me), 0.9 (1 Me) and 0.74 (1 Me); MS *m/z* (rel. int.): 440.3653 [M]$^+$. Calc. for $C_{30}H_{48}O_2$ 440.3654; 440 [M]$^+$ (100), 425 (70), 422 (40), 407 (30), 355 (90), 273 (90), and 219 (70).

Isolation of 21α-*hydroxy-D:A-friedo-olean*-3-*one* (**3**). Elution of the column with pure C_6H_6 afforded a white solid which was recrystallized from $CHCl_3$–petrol giving white cubes of **3** (400 mg, 1.4×10^{-4}%), mp 266–268°, $[\alpha]_D$ −13.8° (lit. [11] mp 272–275°, $[\alpha]_D$ −15°); IR ν_{max}^{KBr} cm^{-1}: 3490 and 1712; ^{1}H NMR: δ 3.80 (1H, *m*, $W_{1/2}$ = 14 Hz, –CHOH), 2.44–1.20 (satd. CH_2), 1.06 (3 Me's), 1.00 (2 Me's), 0.86 (1 Me), 0.85 (3H, *d*, J = 6 Hz, 4-Me) and 0.70 (1 Me); MS *m/z* (rel. int.): 442.3859 [M]$^+$. Calc. for $C_{30}H_{50}O_2$ 442.3854; 442 [M]$^+$ (10), 427 (20), 424 (30), 409 (35), 357 (5), 355 (10), 342 (20), 327 (20), 273 (50), 257 (30), 232 (40), 203 (40), 177 (95), and 139 (100).

Pyridine–CrO_3 *oxidation of* **3**. Oxidation of **3** (30 mg) with CrO_3(20 mg) and pyridine (5 ml) at room temp. for 3 hr yielded **2** (25 mg, 28%) as white needles from $CHCl_3$–petrol, mp and mmp 258–260°, $[\alpha]_D$ +110.5°. Identity with **2** was further shown by co-TLC, IR and ^{1}H NMR comparison.

Dehydration of **3**. 21α-Hydroxy-D:A-friedo-olean-3-one (100 mg) in pyridine (5 ml) was refluxed with $POCl_3$ (0.5 ml) for 1.5 hr. Usual work-up and crystallization from $CHCl_3$–MeOH gave D:A-friedo-olean-21-ene-3-one (**9**) as colourless needles (85 mg, 85%); mp 246–248°; $[\alpha]_D$ −19.0°; IR ν_{max}^{KBr} cm^{-1}: 1713 and 745; ^{1}H NMR: δ 5.50 and 5.26 (2H, *dd*, J = 10 Hz, –CH=CH–), 2.50–1.30 (satd. CH_2), 1.10–0.73 (7 Me's), and 0.83 (3H, *d*, J = 8 Hz, 4-Me). (Found C, 84.64; H, 11.30. Calc. for $C_{30}H_{48}O$, C, 84.7; H, 11.1%.)

Catalytic hydrogenation of **9** *to friedelin*. D:A-friedo-olean-21-ene-3-one (**9**) (30 mg) in HOAc (10 ml) was hydrogenated in the presence of Adams catalyst (PtO_2) for 15 hr. The catalyst was removed by filtration and the product ppted by the addition of H_2O. Recrystallization from $CHCl_3$–MeOH gave friedelin (**1**) (22 mg, 73%) as white needles, mp and mmp 263–265°, $[\alpha]_D$ −22.4° (lit. [10] mp 264°, $[\alpha]_D$ −22.1°), It was shown to be identical (co-TLC and co-IR) with an authentic sample.

Acetylation of 21α-*hydroxy-D:A-friedo-olean*-3-*one* (**3**). Acetylation of **3** (30 mg) with Ac_2O (0.5 ml) and pyridine (5 ml), usual work-up and recrystallization of the product from $CHCl_3$–petrol afforded 21α-acetoxy-D:A-friedo-olean-3-one (**4**) as white needles (28 mg, 87%), mp 281–283°, $[\alpha]_D$ −12.0° (lit. [11] mp 265–270°, $[\alpha]_D$ −12.0°); IR ν_{max}^{KBr} cm^{-1}: 1725, 1711 and 1260; ^{1}H NMR: δ 4.96 (1H, *m*, $W_{1/2}$ = 10 Hz, –CHOAc), 2.06 (3H, *s*, OCOMe), 2.5–1.20 (satd. CH_2), 1.10–0.73 (8 Me's). (Found C, 79.07; H, 10.90. Calc. for $C_{32}H_{52}O_3$ C, 79.35; H, 10.74%.)

$NaBH_4$ *reduction of* **2**. D:A-friedo-olean-3, 21-dione (**2**) (150 mg) in MeOH (15 ml) was reduced with $NaBH_4$ (30 mg). Evaporation of MeOH and usual work-up followed by purification by prep. TLC (eluant, $CHCl_3$) and recrystallization from $CHCl_3$–petrol gave 3β-hydroxy-D:A-friedo-olean-21-one (**5**) as white needles, mp 274–276°, IR ν_{max}^{KBr} cm^{-1}: 3520 and 1710; MS *m/z*: 442.3856 [M]$^+$. Calc. for $C_{30}H_{50}O_2$ 442.3859.

Irradiation of 3β-*hydroxy-D:A-friedo-olean*-21-*one* (**5**).

A soln of **4** (75 mg) in dioxan (15 ml) was refluxed for 18 hr in an atmosphere of N_2 whilst being irradiated with a Hg lamp (quartz; 125 W). The solvent was evaporated *in vacuo* and the crude product purified by prep. TLC (eluent, $CHCl_3$). Recrystallization from MeOH afforded 3β-hydroxy-21,22-bisnor-E-seco-D:A-friedo-olean-16,19-diene (**7**) as white needles (28 mg, 41%), mp 169–170° (lit. [9] mp 167–170°); IR ν_{max}^{KBr} cm^{-1}: 3450 and 1640; ^1H NMR: δ 5.33 (1H, *br s*, olefinic), 5.04 (1H, 2 multiplets separated by 10 Hz), 3.73 (1H, *br s*, CHOH), 2.70 (1H, *d*, J = 10 Hz, allylic), 1.76 1.63 (6H, *d*, 2 × allylic Me), 1.53 (3H, *br s*, allylic Me), 2.00–1.10 (satd. CH_2), and 1.03–0.94 (5 Me's); MS *m/z* (rel. int.); 398.3250 $[M]^+$. Calc. for $C_{28}H_{46}O$ 398.3253; 398 $[M]^+$ (15), 383 (3), 344 (5), 329 (3), 275 (7), 249 (10), 231 (40), 163 (25), 149 (40), 122 (100) and 107 (90).

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REFERENCES

1. Abeywickrema, B. A. (1959) *Ceylon J. Sci.* **2**, 187.
2. Bandaranayake, W. M. and Sultanbawa, M. U. S. (1969) *Proc. Ceylon Assoc. Adv. Sci.* **25**, 90.
3. Hou, D. (1962) *Flora Malesiana* **6**, 260.
4. Gunatilaka, A. A. L., Nanayakkara, N. P. D. and Sultanbawa, M. U. S. (1979) *Tetrahedron Letters* 1727.
5. Gunatilaka, A. A. L., Nanayakkara, N. P. D. and Sultanbawa, M. U. S. (1979) *J. Chem. Soc. Chem. Commun.* 434.
6. Gunatilaka, A. A. L., Nanayakkara, N. P. D. and Sultanbawa, M. U. S. (1981) *Tetrahedron Letters* 1425.
7. Gunaherath, G. M. K. B., Gunatilaka, A. A. L., Sultanbawa, M. U. S. and Wazeer, M. I. M. (1980) *Tetrahedron Letters* 4749.
8. Gunaherath, G. M. K. B., Gunatilaka, A. A. L., Sultanbawa, M. U. S. and Balasubramaniam, S. (1981) *J. Nat. Prod.* (in press).
9. Clarke, B. J., Courtney, J. L. and Stern, W. (1970) *Aust. J. Chem.* **23**, 1651.
10. Courtney, J. L. and Gascoigne, R. M. (1956) *J. Chem. Soc.* 2115.
11. Courtney, J. L., Gascoigne, R. M. and Szummer, A. Z. (1956) *J. Chem. Soc.* 2119.
12. Bruning, R. and Wagner, H. (1978) *Phytochemistry* **17**, 1821.
13. Wijeratne, D. B. T., Kumar, V. and Sultanbawa, M. U. S. (1981) *Proc. Inst. Chem. Ceylon* 5
14. Dahlgren, R. M. T. (1980) *J. Linn. Soc. London, Botany* **80**, 91.
15. Gunatilaka, A. A. L., Nanayakkara, N. P. D. and Sultanbawa, M. U. S., *J. Chem. Soc. Perkin Trans.* 1 (submitted).