The Structure of Platycogenic Acids A, B, and C, Further Triterpenoid Constituents of *Platycodon grandiflorum* A. De Candolle

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Summary Platycogenic acids A, B, and C are 2β,3β,16α,23-tetrahydroxyolean-12-ene-24,28-dioic acid, and 2β,3β,-16β,21β-tetrahydroxyolean-12-ene-24,28-dioic acid and -28-oic acid, respectively.

RECENTLY, polygalacic acid (Ia)[1] and platycodigenin (IIa),[2] which is the first example of a 4,4-di(hydroxymethyl)-triterpene, were isolated on acid hydrolysis of the crude saponins from the roots of *Platycodon grandiflorum.* We describe the isolation of three additional new triterpenes, named platycogenic acids A, B, and C, which are represented by the structures (IIIa), (IVa), and (Va), respectively.

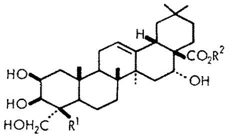
On methylation of the crude acidic sapogenins followed by repeated chromatography on silica gel, platycogenic acids A and B were isolated as their lactone methyl esters (VIa) and (VIIa) and platycogenic acid C as the methyl ester (Vb).†

Platycogenic acid A lactone methyl ester (VIa),‡ $C_{31}H_{46}O_7$ (M^+ 530), $[\alpha]_D$ + 62·1°, ν_{max} 3445, 1770, 1730, and 1715 cm.$^{-1}$, on hydrolysis with ethanolic potassium hydroxide gave the tetrahydroxy-diacid monomethyl ester (IIIb), $C_{31}H_{48}O_8$, m.p. 237—243°, $[\alpha]_D$ +69·8° (EtOH), which on acid treatment under the conditions used for hydrolysis of the saponins regenerated the original lactone (VIa). Since neither fraction of the crude saponins shows the i.r. absorption due to the γ-lactone group, the formation of the γ-lactone (VIa) is assumed to occur during isolation from the diacid, platycogenic acid A (IIIa), which was isolated as $C_{30}H_{46}O_8$, m.p. 243—249°, $[\alpha]_D$ +73·9° (EtOH), by hydrolysis of (VIa) or (IIIb) with sodium hydroxide in dimethyl sulphoxide.[3]

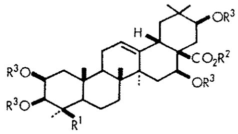
The mass spectrum of the γ-lactone (VIa) exhibits intense fragments at *m/e* 278, 260, and 201 (base peak), similar to those of (Ib)[1] and (IIb).[2] Acetylation of (VIa) by heating with acetic anhydride and pyridine afforded the amorphous triacetate (VIb). In the n.m.r. spectrum of (VIb), signals of an AB quartet due to CH_2OAc [2H, τ 5·80 and 5·56 (J 12 c./sec.)], a singlet (1H, τ 4·97), and a doublet [1H, τ 5·28 (J 4 c./sec.)] suggest a 24,2-lactone ring accompanied by 3β,23-diacetoxy-groups in ring A. The γ-lactone (VIa) was treated with sodium borohydride in ethanol, giving platycodigenin methyl ester (IIb). From the above results, platycogenic acid A is 2β,3β,16α,23-tetrahydroxy-olean-12-ene-24,28-dioic acid (IIIa).

Platycogenic acid B lactone methyl ester (VIIa), M^+ 530, ν_{max} 3440, 1781, and 1706 cm.$^{-1}$, on treatment with refluxing ethanolic potassium hydroxide yielded the dioic acid, platycogenic acid B (IVa), $C_{30}H_{46}O_8$, m.p. 274—277° (decomp.), $[\alpha]_D$ +101·0° (EtOH). Treatment of the diacid (IVa) with hydrochloric acid in aqueous ethanol gave the lactone acid (VIIb), m.p. 301—304° (decomp.), ν_{max} 3390, 1786, and 1685 cm.$^{-1}$, which on treatment with diazomethane regenerated the lactone methyl ester (VIIa).

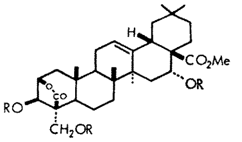
The mass spectrum of the lactone (VIIa) shows significant fragments at *m/e* 276, 258, and 199 (base peak), 2 mass units lower than those observed in (VIa), suggesting the loss of an additional water from a Δ^{12}-oleanene having a methoxycarbonyl and two hydroxy-groups in rings D and E. The peak at *m/e* 244 (relative intensity, 21%) is characteristic of the fragment (A), with reference to *m/e* 246 described for methyl machaerinate.[4] Acetylation of the lactone (VIIa) gave the triacetate (VIIc) (amorphous). Its n.m.r. spectrum shows the presence of six tertiary methyl groups, three acetoxy-groups, a methoxycarbonyl, and a vinylic C(12)–H and on comparison with the spectrum of (VIb), a singlet (1H, τ 5·12) and a doublet (1H, τ 5·35, J 4 c./sec.) indicate a 3β-acetoxy-24,2-lactone structure in ring A. The two protons on acetoxy-bearing carbons in rings D and E appear as quartets at τ 4·43 (J 12 and 4 c./sec.) and τ 5·46 (J 12·5 and 4·5 c./sec.) and both are axial (*i.e.* equatorial acetoxy-groups). Treatment of the lactone acid (VIIb)



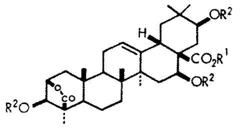
	R¹	R²
(Ia)	Me	H
(Ib)	Me	Me
(IIa)	CH₂OH	H
(IIb)	CH₂OH	Me
(IIIa)	CO₂H	H
(IIIb)	CO₂H	Me



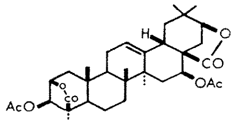
	R¹	R²	R³
(IVa)	CO₂H	H	H
(Va)	Me	H	H
(Vb)	Me	Me	H
(Vc)	Me	Me	Ac



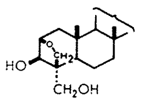
(VIa) R = H
(VIb) R = Ac



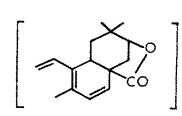
(VIIa) R¹ = Me, R² = H
(VIIb) R¹ = R² = H
(VIIc) R¹ = Me, R² = Ac



(VIII)



(IX)



m/e 244
(A)

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† Besides these three compounds [and (Ib) and (IIb)], the 2,24-oxide (IX), $C_{31}H_{48}O_6$, m.p. 235—248°, $[\alpha]_D$ + 1·0°, derived from (IIb) and the $\Delta^{13(18)}$-isomers corresponding to (Ib), (IIb), (VIa), and (IX) were isolated, but those are artifacts transformed during the acid hydrolysis of the saponins, according to our recent finding. (T. Kubota, H. Kitatani, and H. Hinoh, *Tetrahedron Letters*, 1969, 771).

‡ All new compounds gave satisfactory elemental analyses and/or molecular ion peaks. Unless otherwise stated, rotations and i.r. spectra were determined in $CHCl_3$ solutions and n.m.r. spectra were recorded in $CDCl_3$ at 60 Mc./sec.

with refluxing acetic anhydride gave the dilactone diacetate (VIII), m.p. 266—272°, of which the mass spectrum (M^+ 582) exhibits *m/e* 244 (A) as the base peak. In the n.m.r. spectrum, the signals attributable to C(2)–H and C(3)–H are in good agreement with those in (VIIa) and another lactonic proton [τ 5·88 (1H, d, J 4·5 c./sec.)] and a proton on acetoxy-bearing carbon [τ 5·02 (1H, q, J 10 and 6 c./sec.)] resemble closely the signals of protons at C-21 and C-16 described for 3β,16β, 21β-trihydrosyolean-12-en-28-oic acid 28:21-lactone diacetate.[5] Reduction of the lactone methyl ester (VIIa) with lithium aluminium hydride gave the corresponding hexaol, $C_{30}H_{50}O_6$, m.p. 274—281° (decomp.), and in the n.m.r. spectrum of its hexa-acetate, the signals assignable to the protons at C-12 [τ 4·68 (poorly resolved t)], C-16 [τ 4·47 (q, J 11·5 and 5 c./sec.)], C-21 [τ 5·40 (q, J 12 and 4·5 c./sec.)], and C-28 [τ 5·95 (2H, bs)] again agree with those described for the penta-acetate of gymnestrogenin (olean-12-ene-3β,16β,21β,23,28-pentaol).[6]

Methyl platycogenate C (Vb), $C_{31}H_{50}O_6$, m.p. 175—178°, $[\alpha]_D$ +74·9°, on hydrolysis with ethanolic potassium hydroxide yielded the free acid, platycogenic acid C (Va), $C_{30}H_{48}O_6$, m.p. 282—288° (decomp.), $[\alpha]_D$ +77·8° (EtOH). The mass spectrum of the methyl ester (Vb) (M^+ 518) exhibits intense fragments, *m/e* 276, 258, 244, and 199, similar to (VIIa). In the n.m.r. spectrum of the tetra-acetate (Vc), the signals assignable to C(12)–H, C(16)–H, C(21)–H, and CO_2Me resemble those observed in the spectrum of (VIIc). The remaining two protons on acetoxy-bearing carbons are observed at τ 5·39 (d, J 4 c./sec.) and 4·67 [m. overlapped with the vinylic C(12)–H] and the coupling constant suggests the presence of a *cis*-2β,3β-diacetoxy-function. From the above evidence, platycogenic acids B and C can be represented as 2β,3β,16β,21β-tetrahydroxyolean-12-ene-24,28-dioic acid (IVa) and -28-oic acid (Va), respectively.

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