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GYMNOCOLIN, A NEW cis-CLERODANE DITERPENOID FROM THE LIVERWORT *Gymnocolea inflata*. CRYSTAL STRUCTURE ANALYSIS.

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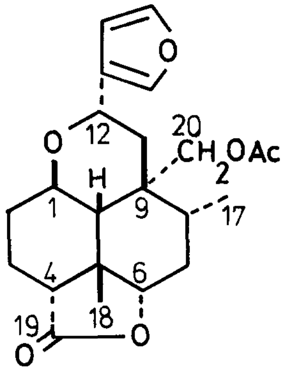
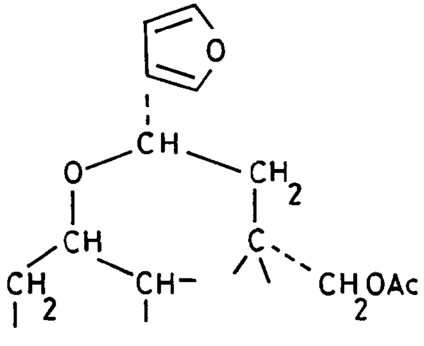
Summary. Gymnocolin, a new diterpenoid from the liverwort *Gymnocolea inflata* (Huds) Dum., has been shown to have the *cis*-clerodane structure (1) by X-ray crystallographic analysis.

Extraction of the liverwort *Gymnocolea inflata* (Huds) Dum., collected in the Ore mountains, GDR,[1] in Le Tanet, France[2] and in Hokkaido, Japan,[3] afforded a new *cis*-clerodane, gymnocolin, which has been assigned the structure and relative configuration (1) on the basis of spectroscopic evidence and an X-ray crystal structure analysis.



(1)



(2)

Gymnocolin, $C_{22}H_{28}O_6$, m/z 388.1894 (calc. 388.1886), m.p. 196-197°, (ex MeOH), u.v. (MeOH) 210 nm (log ε, 3.54), c.d. 230 nm (Δε +0.66) and 202 nm (Δε -3.40), has γ-lactone and acetate absorption in its infrared spectrum [ν_{max} (CCl_4) 1790 and 1745 cm^{-1}]. The ^1H and ^{13}C spectra suggest that the lactone terminus is secondary [δ_H 4.23 (br d, J 8 Hz, H-6); δ_C 81.6 (d, C-6)] and the acetate [δ_H 1.90; δ_C 169.4 and 21.1] is primary [δ_H 4.52 and 3.84 (ABq, J 12 Hz, 2H-20); δ_C 62.3 (t, C-20)] and, in addition, reveal the presence of a β-substituted furan. These functional groups account for five of the six oxygen atoms. Resonances for two secondary carbons bearing oxygen [δ_H 5.12 (br d, J 7 Hz, H-12) and 3.74 (d t, J 11, 4 Hz, H-1); δ_C 68.3 (d, C-12) and 67.5 (d, C-1)] indicate that the sixth oxygen must be present as an ether, presumably cyclic.

On this basis the molecule is bicarbocyclic. Other features of the ^{1}H and ^{13}C spectra[4] include a tertiary methyl group [δ_H 1.40 (3H-18); δ_C 31.9 (q, C-18)], a secondary methyl group [δ_H 0.96 (d, J 7 Hz, 3H-17); δ_C 15.8 (q, C-17)], a methylene group [δ_H 2.56 (d, J 14 Hz, H-11$_{eq}$) and 1.70 (dd, J 14, 7 Hz, H-11$_{ax}$); δ_C 17.7 (t, C-11)] and a methine [δ_H 1.75 (d, J 11 Hz, H-1); δ_C 55.6 (d, C-1)].

Double irradiation experiments permitted the part structure (2) to be assembled in the following way. The proton on the ether terminus at δ 5.12 (H-12) is situated at C-12 since it has a long-range coupling to the furan. It also forms the X-part of an AMX system involving the C-11 methylene group. Irradiation at the frequency of the C-11 axial proton (δ_H 1.70) causes sharpening of the -$\underline{CH_2}$OAc protons by removal of ^{4}J coupling. This group can therefore be attached to the adjacent fully substituted carbon (C-9). The highfield chemical shift of the acetate methyl group (δ 1.90) suggests shielding by the furan ring[5] and hence these two groups must lie on the same face of the molecule. The proton attached to the other ether terminus (H-1) is a doublet of triplets and is flanked by a methylene and a methine. The latter (H-10) identified by double irradiation, is a sharp doublet (J 11 Hz) which lacks further coupling. On the assumption that the ether ring is six-membered, part structure (2) can be readily expanded, on biogenetic grounds, to give the clerodane structure (1) for gymnocolin. Since the coupling information did not permit a decision on the stereochemistry of gymnocolin an X-ray crystal structure analysis[6] was undertaken. This confirmed the proposed structure and revealed that gymnocolin is a *cis*-clerodane with the relative stereochemistry as in (1). In the crystalline state gymnocolin has a conformation in which rings A and B are slightly distorted twist boats and ring C is a chair.

Gymnocolin is the first example of a *cis*-clerodane to be isolated from the Hepaticae and provides a further example of the ability of this family to synthesise a fascinating array of terpenoid structures.[7,8]

References

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4. The remaining ^{13}C resonances appear at δ_C 177.7 (s, C-19), 142.9 (d), 137.7 (d), 128.1 (s) and 108.4 (d) (furan), 40.3 (s), 37.6 (s), 45.8 (d), 38.0 (d), 38.7 (t), 30.0 (t) and 26.1 (t).
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6. Crystal data: Monoclinic, $\underline{a}$ = 12.431, $\underline{b}$ = 9.714, $\underline{c}$ = 8.306 Å, β = 98.18°, $\underline{Z}$ = 2, $\underline{U}$ = 992.7 Å^3. F (000) = 416. Space group $\underline{P}\ 2_1$.
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