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PETROSTEROL, THE MAJOR STEROL WITH A CYCLOPROPANE SIDE CHAIN IN THE SPONGE PETROSIA FICIFORMIS

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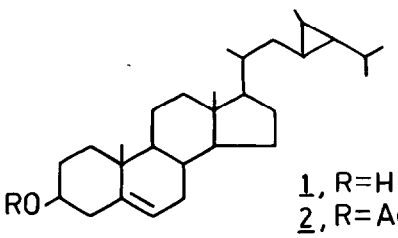
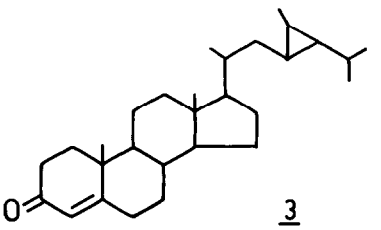
In the last few years some unusual cyclopropane-containing sterols, gorgosterol[1], 23-demethylgorgosterol[2], acanthasterol[3] and the cyclopropene-containing sterol calysterol[4], have been isolated from marine invertebrates.

We now report the isolation and structure elucidation of a new marine sterol, 23,28-cyclostigmast-5-en-3β-ol, named petrosterol (1), present as the major sterol in the marine sponge Petrosia ficiformis.



1, R=H
2, R=Ac



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The acetone extract of the sponge was chromatographed on silica gel and the sterol fraction, after acetylation[5], was further fractionated on silica gel impregnated with 25% $AgNO_3$. Elution with 40-70° light petroleum-benzene 8:2 gave 2, m.p. 112-114° (ethanol), $[\alpha]_D$ -41.5° ($CHCl_3$), $C_{31}H_{50}O_2$ (m/e 394.3595, M^+ -AcOH; $C_{29}H_{46}$ requires 394.3599). Its mass spectrum showed ions at m/e 394 (M^+ -AcOH, base peak), 379 (M^+ - AcOH and CH_3), 255 (M^+ - AcOH and side chain) and 213 (M^+ - AcOH and ring D fission), indicating that 2 is a C_{29} acetyl sterol with a double bond in the nucleus and an unsaturated $C_{10}H_{19}$ side chain[6]. The absence of molecular ion peak suggested a Δ^5-3β-acetoxy sterol[7] in accordance with the 90-MHz ^{1}H-NMR spectrum ($CDCl_3$) which comprised a signal for one olefinic proton at δ 5.38 (br d, 6-H), a 1H broad signal at δ 4.60 (br m, 3-H) and methyl singlets at δ 2.01 (CH_3CO_2-), 1.02 (19-H_3), 0.69 (18-H_3). Additional high-field signals at δ 0.36-0.54 (1H,m) and 0.03-0.25 (2H,m) indicated that the $C_{10}H_{19}$ side chain contained a cyclopropane ring bearing three hydrogens. The ^{13}C-NMR spectra (25.20 MHz, ppm rel. to TMS) confirmed the presence of two olefinic carbons at 139.5 (s, C-5) and 122.5 ppm (d, C-6) and indicated that there are only three quaternary carbons C-5, C-10 (36.5 ppm) and C-13 (42.3 ppm) in addition to that of the ester carbonyl (170.0 ppm). Hydrolysis of the acetate 2 gave the free sterol (1) m.p.

123-125°, $C_{29}H_{48}O$ (M^+ measured m/e 412.3701; calculated 412.3705) which exhibited a rotation $[\alpha]_D$ -40.4° ($CHCl_3$) typical of Δ^5-3β-hydroxy sterols[8]. Oppenauer oxidation of 1 afforded an α,β-unsaturated ketone (3) M^+ m/e 410, λ_{max}^{EtOH}, 242 nm (log ε =4.19), which showed a CD curve superimposable to that of cholest-4-en-3-one. Mass spectral analysis of 1 gave a molecular ion at m/e 412 and significant peaks at m/e 397 (M^+- CH_3), 394 (M^+- H_2O), 379 (M^+- CH_3 and H_2O), 273 (M^+- side chain), 271 (M^+- side chain and 2 H), 255 (M^+- side chain and H_2O), 231 (ring D fission) and 213 (M^+- H_2O and ring D fission). The 300-MHz ^{1}H-NMR spectrum ($CDCl_3$) of 1 showed an olefinic proton signal at δ 5.37 (br d, 6-H), a proton due to a secondary alcohol at δ 3.54 (m, 3-H), two quaternary methyl signals at δ 1.02 (19-H_3) and 0.68 (18-H_3), doublet methyl signals at δ 0.89 (3H, J=7.5 Hz, 21-H_3), 0.92 (6H, J=7.5 Hz, 26-H_3 and 27-H_3) and 1.01 (3H, J=6 Hz, 29-H_3), and high-field signals at δ 0.40-0.52 (1H, m, 28-H) and 0.04-0.20 (2H, m, 23-H and 24-H). Irradiation at δ 0.46 collapsed the methyl doublet at δ 1.01 into a singlet and, conversely, irradiation at δ 1.01 simplified the multiplet at δ 0.46. These data and the absence of quaternary carbons in the side chain (determined for 2) indicated the partial structure CH_3-$CH\langle^{CH-}_{CH-}$ located at either C-22,23 or C-23,24 position. However, only the last possibility is consistent with the formation of β-sitostanol (identified by GLC measurements with a glass capillary column) which was obtained by catalytic hydrogenation of 1 in a mixture of AcOH-HCl over platinum (20 hr, 80°, 3 atm). From these data, structure 1 was deduced for petrosterol. It is interesting that 1 is present in a sponge belonging to the same family (Renieridae, order Haplosclerida[9]) of the sponge Calyx nicaeensis which yielded calysterol[4], a compound which differs from 1 only in the presence of a 23,24-double bond.

References and notes

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