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THREE ACETYLATED DITERPENE DIOLS OF VERRUCOSANE TYPE FROM THE LIVERWORT, *Mylia verrucosa*

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Three new monoacetates of diterpene diols were isolated from *Mylia verrucosa* and the structures were determined as [2], [3] and [9] on the basis of chemical and spectral evidence.

Recently, we have reported the isolation and structural determination of (-)-2,9-dihydroxyverrucosane [1], a novel fused 3,6,6,5-tetracyclic diterpene diol, from an ethanolic extract of *Mylia verrucosa* Lindb.[1] In continuous investigation of chemical components of the plant, now, three monoacetates of diterpene diols were isolated in the ratios to compound [1] of 0.8, 0.6 and 0.1 respectively by means of repeated preparative TLC on silicagel plate with a mixed solvent of hexane, benzene and ethanol [10 : 10 : 1 v/v]. The first compound was identified as (-)-9-acetoxy-2-hydroxyverrucosane [2] which had been synthesized by acetylation of 2,9-dihydroxyverrucosane.[1] This represents the first case of its isolation from nature. The second and the third were determined to be two kinds of monoacetate of a new verrucosane type diterpene diol, which are different in the position of the acetoxyl group. The present communication deals with the chemical and spectral evidences for the structural determination of these compounds.

(-)-9-Acetoxy-2-hydroxyverrucosane [2]. The first compound, $C_{22}H_{36}O_2$ (M^+ 348); $[\alpha]_D$ -82.7° (c 1.2, $CHCl_3$), contained a secondary hydroxyl [ν_{CCl_4} 3600 and 3525 cm^{-1}; 3.54 (1 H, d, J=10)], a secondary acetoxyl [ν 1735 and 1252 cm^{-1}; δ 2.00 (3 H, s)

and 4.14 (1 H, t, J=2.5)] and an isopropyl [ν 1378 and 1389 cm^{-1}; δ 0.86 and 0.91 (each 3 H, d, J=7)] group, three tertiary methyl groups [δ 0.87, 0.97 and 1.22 (each 3 H, s)] and a cyclopropane ring [ν 3060 cm^{-1}; δ 0.1-0.8 (3 H, m)]. The spectra were superimposable with those of (-)-9-acetoxy-2-hydroxyverrucosane which had been obtained by acetylation of [1] with acetic anhydride in pyridine.

(-)-2-Acetoxy-11-hydroxyverrucosane [3]. The second compound, mp 203-204°C; $[\alpha]_D$ -103.3° (c 2.2, $CHCl_3$), was analyzed for $C_{22}H_{36}O_3$ (M^+ 348) and the spectra indicated that it contains a secondary hydroxyl [ν_{KBr} 3495 cm^{-1}; δ_{CDCl_3} 3.59 (1 H, d, J=5)], a secondary acetoxyl [ν 1707 and 1260 cm^{-1}; δ 2.07 (3 H, s) and 4.93 (1 H, d, J=9) and an isopropyl [ν 1375 and 1388 cm^{-1}; δ 0.82 and 0.89 (each 3 H, d, J=7)] group, three tertiary methyl groups [δ 0.76, 0.93 and 1.33 (each 3 H, s)] and a cyclopropane ring [ν 3060 cm^{-1}; δ 0.2-0.7 (3 H, m)]. Since the molecular formula and functional groups were coincident with those of the first compound [2], a detailed comparison was carried out between NMR spectra of both compounds; it was confirmed that the signal due to the proton located on the acetoxyl group-bearing carbon atom corresponds to that of the carbinyl proton (d, J=10 Hz, axial) in [2], in the signal pattern and value of the coupling constant, but the carbinyl proton signal in the compound [3] does not resemble to the resonance of the proton located on the acetoxyl group-bearing carbon atom of [2]. These facts suggested the compound to be 2-acetoxyverrucosane with the additional hydroxyl group at other position than C-9.

On oxidation with Jones reagent [3] gave a cyclic five-membered ketone [4], $C_{22}H_{34}O_3$ (M^+ 346); mp 135-136°C; $[\alpha]_D$ -147° (c 1.1, $CHCl_3$), [ν 1730 cm^{-1}], which, on refluxing with 0.5N-H_2SO_4-acetone solution (1 : 4) for 2h, underwent hydrolysis followed by homoallylic ring expansion of the cyclopropyl carbinol part and afforded an unsaturated hydroxyl ketone [5], $C_{20}H_{34}O_2$ (M^+ 304); $[\alpha]_D$ -38° (c 0.84, $CHCl_3$) [ν_{CCl_4} 3400 and 1730 cm^{-1}; δ 1.83 (3 H, s), 3.66 (1 H, br t, J=11) and 5.47 (1 H, br t, J=6)]. The hydroxyl ketone thus obtained, after having been converted to tosylhydrazone, was reduced with $NaBH_4$ in dioxane to give a tricyclic homoallylic alcohol [6], $C_{20}H_{34}O$ (M^+ 290); mp 153-154°C; $[\alpha]_D$ +17.2° (c 0.3, $CHCl_3$), which was identical in the mixed melting point determination and the spectral comparison with an unsaturated alcohol prepared from 2,9-dihydroxyverrucosane [1] by the similar procedure as shown in scheme. These results revealed the compound to be either 2-acetoxy-11-hydroxyverrucosane or 2-acetoxy-12-hydroxyverrucosane.

When the NMR spectrum of the hydroxyl ketone [5] was examined under addition of $Eu(fod)_3$ shift reagent (molar ratio of $Eu(fod)_3$: 0.3), the methylene group

(1) R=H
(2) R=Ac
(3) R1 = Ac , R2 = H
(9) R1 = H , R2 = Ac
(10) R1 = Ac , R2 = Ac
(4)
(5)
(6)
(7)
(8)

adjacent to the carbonyl group (δ 2.58) and the C-10 methyl group (δ 1.01) showed remarkable deshielding shifts to δ 3.83 and 4.37 (each 1 H, d d, J=19.5, 8.3) and 2.06 (3 H, s)] respectively, the signal of the former appearing as two double doublets. From this fact the carbonyl group in [4] and hence the hydroxyl group-bearing carbon in [3] was assigned to C-11. This hydroxyl group probably takes the trans configuration to the C-10 methyl group, because the NMR spectrum of the compound did not show any pyridine-induced solvent shift on the methyl group.[2] Thus, the structure of the second compound was determined to be 2-acetoxy-11-hydroxyverrucosane.

(-)-11-Acetoxy-2-hydroxyverrucosane [9]. The third compound, $C_{22}H_{34}O$ (M^+ 348); mp 101-102°C $[\alpha]_D$ -31.9° (c 0.92, $CHCl_3$), contained a secondary hydroxyl [ν_{KBr} 3490 cm^{-1}; δ 3.12 (1 H, d, J=9.5)], a secondary acetoxyl [ν 1710 and 1240 cm^{-1}; δ 2.06 (3 H, s) and 4.71 (1 H, d, J=4.5)] an isopropyl [ν 1380 and 1390 cm^{-1}; δ 0.82 and 0.85 (each 3 H, d, J=6.5)] group, three tertiary methyl groups [δ 0.79, 0.91 and 1.23 (each 3 H, s) and a cyclopropane ring [ν 3040 cm^{-1}; δ 0.1-0.8 (3 H, m)]. Although the functional groups in [9] were the same as those of [3], the splitting patterns and the coupling constant values of the signals due to the carbinyl proton and the proton located on the acetoxyl group-bearing carbon atom reversed between both compounds. In addition, acetylation of [9] by refluxing with acetic anhydride in pyridine for 48h afforded a diacetate [10], $C_{24}H_{38}O_4$ (M^+ 390; mp 134.7-136°C; $[\alpha]_D$ -102° (c 1.3, $CHCl_3$) [ν_{KBr} 1725 and 1240 cm^{-1}; δ 2.10 (6 H, s), 4.73 (1 H, d, J=8) and 5.02 (1 H, d, J=9)] which was identical, in all respects, with a diacetate prepared by acetylation of compound [3] with acetyl chloride in pyridine, $C_{24}H_{38}O_4$ (M^+ 390); mp 135-136°C; $[\alpha]_D$ -99.8° (c 0.14, $CHCl_3$). Thus, the third compound was formulated as 11-acetoxy-2-hydroxyverrucosane.

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