THREE VERRUCOSANE DITERPENOIDS, VERRUCOSANE TRIOL AND RELATED COMPOUNDS FROM THE LIVERWORT MYLIA VERRUCOSA

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Abstract—Three new diterpenoids of the verrucosane class were isolated as minor constituents of the methanol extract of the liverwort Mylia verrucosa and their structures shown to be 2β,9α,13β-trihydroxyverrucosane (2), 9α-acetoxy-2β,13β-dihydroxyverrucosane (3) and 2β,13β-dihydroxy-9-oxoverrucosane (4), respectively.

INTRODUCTION

Liverworts contain several oil bodies in the cells of the gametophytes which are characteristic of the species. They usually elaborate mono-, sesqui- and diterpenoids as well as esters of fatty acids and aromatic acids. New sesquiterpenoids of various types were isolated from several liverworts and most of the liverwort sesquiterpenoids are the enantiomeric forms corresponding to antipodes of those from higher plants [1-4]. Few investigations have been conducted on the diterpenoids of these plants. Previously, we isolated the diterpene diol (-)-2β, 9α-dihydroxyverrucosane (1), C20H34O2, and the related compounds consisting of a novel verrucosane carbon skeleton from the liverwort Mylia verrucosa belonging to the Jungermanniaceae [5-8]. They had one or two oxygenated functional groups at the C-2 and C-9 or C-11 positions in the verrucosane skeleton having a 3,6,6,5-tetracyclic framework substituted with three tertiary methyls and one isopropyl group. The present paper deals with the isolation and structure determination of three diterpenoids containing three oxygenated functional groups on C-2, C-9 and C-13 of the verrucosane structure. On the basis of the following chemical and spectral evidence their structures were elucidated as 2β,9α,13β-trihydroxyverrucosane (2), 9α-acetoxy-2β,13β-dihydroxyverrucosane (3) and 2β,13β-dihydroxy-9-oxoverrucosane (4), respectively.

RESULTS AND DISCUSSION

The three diterpenoids, (-)-2β,9α,13β-trihydroxyverrucosane (2), (-)-9α-acetoxy-2β,13β-dihydroxyverrucosane (3) and (-)-2β,13β-dihydroxy-9-oxoverrucosane (4), were isolated as minor constituents from a polar fraction of the liverwort extract by a combination of CC and prep. TLC.

The most polar component of the three was characterized by the spectral evidence as a diterpene triol having two secondary hydroxy and one tertiary hydroxy groups. The spectral properties were, furthermore, very close to those of the major diol (-)-2β,9α-dihydroxyverrucosane (1) except for the presence of an extra tertiary hydroxy group. The structure was, therefore, deduced to be a triol (2) containing one more tertiary hydroxy group than in the diol molecule (1). The spectra of another two compounds (3 and 4) suggested both contained the same tetracyclic verrucosane skeleton and 3 was an acetoxy derivative of the triol (2) while 4 was a carbonyl compound. In fact, acetylation of the triol (2) gave the acetoxy-diol (3), and the keto-diol (4) was produced by Jones' oxidation of the triol (2).

The dihydroxyketone (4) was refluxed with sulphuric acid in acetone to afford a tricyclic homoallyl alcohol (5), through a homoallylic ring opening reaction of the cyclopropyl carbino[9]. The other homoallylic alcohol (6), having additional tertiary and secondary hydroxy groups was obtained from the acetoxy-diol (3) by the same reaction. Formation of such homoallylic alcohols (5 and 6) by homoallylic ring expansion demonstrated not only the position but also the stereochemistry of the cyclopropane ring and the C-2 secondary hydroxy group to hold a cis-relationship in the original molecule [10]. By base treatment of the hemiacetal (7), which was produced by...
Table 1. Pyridine-induced solvent shifts (Δ-values) of the three tertiary methyls for 2-6.

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-3 methyl</td>
<td>-0.07</td>
<td>-0.02</td>
<td>-0.03</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>C-7 methyl</td>
<td>-0.29</td>
<td>-0.04</td>
<td>-0.09</td>
<td>-0.08</td>
<td>-0.04</td>
</tr>
<tr>
<td>C-10 methyl</td>
<td>-0.37</td>
<td>-0.34</td>
<td>-0.14</td>
<td>-0.22</td>
<td>-0.30</td>
</tr>
</tbody>
</table>

Δ = δ(CDCl₃) - δ(C₂D₅N).
then poured into H2O and then extracted with Et2O. The Et2O soln was worked-up in the usual way to afford a crude carbonyl substance. The oxidation product (30 mg), which was purified by prep. TLC, was identical with the naturally occurring (-)-2β,13β-dihydroxy-9-oxoverrucosane (4) (IR and 1H NMR spectra).

Acid treatment of the diketone (4). The keto-diol, 4 (80 mg), was dissolved in 0.5 N H2SO4-Me2CO (1:4) (10 ml) and heated under reflux for 24 hr. The reaction mixture was poured into a large vol. of H2O and taken-up into Et2O. The Et2O soln was worked-up in the usual way to give a viscous substance: [α]D +52.9° (c 3.0); IR cm⁻¹: 3520, 1675, 1600, 1565, 1360, 1265, 1045, 820 and 755; 1H NMR: δ 0.78 and 0.89 (each 3H, d, J = 7.0 Hz), 1.24 (3H, s), 2.01 (3H, s), 2.36 (3H, s), 2.52 (3H, s), 3.84 (1H, d, J = 8.0 Hz), 7.64 (1H, dd, J = 8.0 and 2.0 Hz) and 8.32 (1H, d, J = 2.0 Hz); MS m/z (rel. int.): 316 [M]+ (11), 278 (17), 235 (7), 231 (16), 213 (9), 200 (6), 189 (82), 175 (7), 169 (4), 147 (16), 129 (6), 115 (6), 105 (4) and 43 (100).

Acid treatment of the acetoxyl ketone (3). The acetoxy-diol (3, 30 mg) was treated with an Me2CO soln of H2SO4 in the same manner described above to produce the homoallyl alcohol (5, 75 mg), C22H36O4, as a colourless viscous substance: mp 161.5-162.5°; [α]D -47.8° (c 2.8); IR cm⁻¹: 3520, 1675, 1608, 1575, 1385, 1365, 1085, 1040, 995 and 970; 1H NMR: δ 0.94 and 0.97 (each 3H, complex), 1.01 and 1.15 (each 3H, d, J = 7.0 Hz), 1.01, 1.10 and 1.33 (each 3H, s), 2.05 (3H, s), 3.42 (1H, d, J = 13.5 Hz) and 4.89 (1H, t, J = 3.0 Hz).

Formation of the 3,4-disubstituted acetophenone (8). To a soln of the hemiacetal (7, 80 mg) in MeOH (5 ml), a soln of 5 % KOH was added and the mixture was allowed to react at room temp, for 6 hr. The reaction mixture was diluted with H2O, extracted with CHCl3 and the CHCl3 soln, after being dried, was evaporated. The reaction product was purified by prep. TLC to give the 3,4-disubstituted acetophenone (8, 63 mg), C22H23O3, as a viscous substance: [α]D +54.4° (c 3.0); IR cm⁻¹: 3520, 1675, 1600, 1565, 1360, 1265, 1045, 820 and 755; 1H NMR: δ 0.82 and 0.97 (each 3H, d, J = 7.0 Hz), 1.04 and 1.38 (each 3H, s), 2.19 (3H, s), 4.62 (1H, m, W = 12.0 Hz) and 5.07 (1H, d, J = 3.0 Hz); MS m/z (rel. int.): 344 [M - 18]+ (9), 291 (82), 249 (15), 231 (15), 149 (17), 139 (15), 123 (17), 119 (11), 109 (17), 97 (17), 86 (24), 81 (19), 71 (32), 67 (14), 57 (27) and 43 (100).

REFERENCES