(-)-HERBERTENEDIOL AND (-)-HERBERTENOLIDE, TWO NEW SESQUITERPENOIDS OF THE ENT-HERBERTANE CLASS FROM THE LIVERWORT HERBERTA ADUNCA

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The structures of (-)-herbertenediol and (-)-herbertenolide, the new aromatic sesquiterpenoids with the *ent*-herbertane skeleton isolated from the liverwort *Herberta adunca*, have been determined on the basis of the chemical and spectral evidence.

Previously, we isolated the sesquiterpene phenol $(-)-\alpha$ -herbertenol (1) together with the key hydrocarbon (-)-herbertene (2) and other phenolic derivatives from the liverwort Herberta adunca (Dicks.) S. Gray.^{1,2)} In continuing study on chemical constituents of the liverwort, we obtained two kinds of additional sesquiterpenoids named (-)-herbertenediol and (-)-herbertenolide and established their structures including the absolute configurations to be the formulae (3) and (4) having the same ent-herbertane framework, respectively. The present paper deals with the chemical and spectral evidence for the proposed structures.

The two new sesquiterpenoids, (3): $C_{15}H_{22}O_2$; mp 90.5-91.5 °C; $[\alpha]_D$ -46.5°, and (4): $C_{15}H_{18}O_2$; mp 95.5-96.5 °C; $[\alpha]_D$ -86.4°, were isolated from a polar fraction of the methanolic extract by a combination of column and thin layer chromatographies over silica gel in yields of 0.6 and 0.2 % to the extract, respectively.³

The IR and NMR spectra of (-)-herbertenediol (3), which afforded a diacetate (5), $C_{19}H_{26}O_4$, suggested the presence of two hydroxy groups [v 3630, 3570, and 3410 cm^{-1} ; δ 5.28 (2H, br.s: exchangeable with D_2^{O})], a tetrasubstituted benzene nucleus with a methyl [v 1600 and 1495 cm⁻¹; δ 2.18 (3H, s), 6.39 and 6.58 (each 1H, br.s)], and three tertiary methyl groups [v 1380, 1370, and 1360 cm⁻¹; δ 0.75, 1.18, and 1.38 (each 3H, s)]. Substitution pattern of the two phenolic hydroxy groups was recognized as a catechol type since the UV spectrum underwent the bathochromic shift (9 nm) by addition of H_3BO_3 and NaOAc.⁴⁾ By the resemblance of the NMR spectrum, especially the chemical shifts of the tertiary methyls, to that of (-)- α -herbertenol (1), the structure of the diol was deduced to be a hydroxy derivative of α -herbertenol, that is, the structure (3). (-)- α -Herbertenol (1) was, therefore, submitted to benzoyloxylation with (PhCOO) /benzene to give a benzoyloxy-phenol mixture (1:1) of the positional isomers of the hydroxy and benzoyloxy groups. The mixture was then esterified with PhCOCl/pyridine to a single dibenzoate (6), C₂₉H₃₀O₄; mp 150-151 °C, treatment of which with LAH/ether produced a diol (3), $C_{15}H_{22}O_2$; mp 91-92 °C; [α]_D -51.1°. The optical rotation and the spectral data of (-)-herbertenediol (3) were in good agreement with those of the diol (3) derived from (-)- α -herbertenol (1) by the above



Chemical reactions. Accordingly, the structure, and the absolute configuration, of (-)-herbertenediol was represented by the formula (3).

(-)-Herbertenolide (4) was revealed by the spectroscopic properties as a tricyclic sesquiterpenoids containing a six-membered phenol lactone ring [v 1770 cm⁻¹], a trisubstituted benzene ring with a methyl [v 1490 cm⁻¹; δ 2.33 (3H, s) and 6.7-7.1 (3H)], and two tertiary methyl groups [δ 0.90 and 1.11 (each 3H, s)]. Reduction of the δ -lactone (4) with LAH/ether gave a phenol (7), $C_{15}H_{22}O_2$; mp 139.5-140.5 °C, having a primary hydroxy group. When the diol (7) and its methyl ether (8), C₁₆H₂₄O, were, respectively, treated with (PhO)₃PCH₃I/HMPA,⁵⁾ they did not give any alkyl iodides but formed a six-membered cyclic ether (9), $C_{15}H_{20}O$. The cyclic ether was transformed by a reaction with AlCl, and EtSH into a hydroxythioether (10), C₁₇H₂₆OS, which was, furthermore, reduced with Ra-Ni/EtOH to give a phenol (1), $C_{15}H_{22}O$; $[\alpha]_D$ -66.7°. The spectra and the optical rotation were identical with those of $(-)-\alpha$ -herbertenol (1).²⁾ Finally, determination of the carbon atom forming the lactone carbonyl was performed by examination of the chemical shifts of tertiary methyls in the diol (7) and the methyl ether (8): one methyl [δ 0.80 to (7) and 0.64 to (8)] resonated at the upper field, and the value was analogus to that of one methyl signal [δ 0.75 to (1) and 0.67 to (11)] of the three tertiary methyls in $(-)-\alpha$ -herbertenol (1) and its methoxy derivative (11).²⁾ The methyl group shielded by the anisotropic effect of benzene ring was assigned as β -configurational methyl holding a *cis*-relationship to benzene ring.^{6,7)}

References

- 1) A. Matsuo, S. Yuki, M. Nakayama, and S. Hayashi, J. Chem. Soc., Chem. Commun., <u>1981</u>, 864.
- 2) A. Matsuo, S. Yuki, M. Nakayama, and S. Hayashi, Chem. Lett., 1982, 463.
- Satisfactory analyses of the natural products and their new derivatives were obtained, and all new compounds gave spectral data in good agreement with the assigned structures.
- 4) L. Jurd, Arch. Biochem. Biophys., <u>63</u>, 376 (1956).
- 5) S. R. Landauer and H. N. Rydon, J. Chem. Soc., <u>1953</u>, 2224.
- 6) B. Tomita, Y. Hirose, and T. Nakatsuka, Tetrahedron Lett., 1968, 843.
- 7) T. Irie, T. Suzuki, Y. Yasunari, E. Kurosawa, and T. Masamune, Tetrahedron, <u>25</u>, 459 (1969).

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