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CUPRENENOL AND ROSULANTOL, NEW CUPARANE CLASS SESQUITERPENE ALCOHOLS FROM THE LIVERWORT *JUNGERMANNIA ROSULANS*

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In a course of our investigation on terpene constituents of the liverworts, two new sesquiterpene alcohols named cuprenenol(1) and rosulantol (2) were isolated from a methanol extract of *Jungermannia rosulans* (Steph.) Steph. by means of combination of column chromatography and preparative thin layer chromatography using silica gel together with (+)-cuparene(3), $C_{15}H_{22}$(M^+ 202); $[\alpha]_D$ +35°, and (+)-δ-cuparenol(4), $C_{15}H_{22}O$(M^+ 218); $[\alpha]_D$ +50°.[1] The structures and absolute configurations of these alcohols were determined, and we here describe the evidence of the proposed stereostructures.

CUPRENENOL(1). The compound, $C_{15}H_{26}O$(M^+ 222); mp 95-96.5 °C; $[\alpha]_D$ +64°, was characterized, based on the spectral evidence, to be a bicyclic sesquiterpenoid containing a tertiary hydroxyl group[ν 3610, 3350; δ(c) 69.7 s], a disubstituted double bond[ν 710; δ 5.60, 5.83(each 1H, d, J=10); δ(c) 130.2 d, 135.1 d], four tertiary methyls[ν 1382, 1373, 1363; δ 0.78, 0.97, 1.07, 1.28 (each 3H, s); δ(c) 17.6 q, 25.5 q, 25.9 q, 28.3 q, 44.0 s, 47.4 s], a methine [δ(c) 42.1 d] and five methylenes[δ(c) 19.1 t, 24.5 t, 38.5 t, 39.1 t, 42.1 t].

The alcohol was treated with $POCl_3$ in pyridine to give a diene mixture (5), $C_{15}H_{24}$(M^+ 204); λ 219, 223 nm, showing two peaks in gas chromatography(PEG 20M and SE 30). The mixture, in allowing to stand at room temperature for 3 days,[2] changed spontaneously into (+)-cuparene(3), $C_{15}H_{22}$(M^+ 202); $[\alpha]_D$ +55°, which was identified in spectral comparison with the cooccurring (+)-cuparene. These facts revealed that the alcohol was consisted of the cuparane skeleton, the tertiary hydroxyl group and the double bond of the alcohol were located on C-3 and between C-1 and C-2 of the skeleton and the cyclopentane moiety of cuparene retained that of the alcohol with no affecting the structure and stereochemistry. Accordingly, the absolute configuration of the C-7 asymmetric center in the alcohol may be represented by S as well as that of (+)-cuparene.

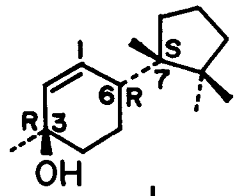
For elucidation of the absolute configuration of two remained asymmetric centers, C-3 and C-6, the alcohol was first oxidized with Jones reagent to afford an α,β-unsaturated ketone(6), $C_{15}H_{24}O$(M^+ 220); $[\alpha]_D$ +38°; λ 232 nm(ε 2400); ν 1678, 1642; δ 0.90(6H, s), 1.15(3H, s), 1.90(3H, br.s), 5.68(1H, br.s), along with an isomeric alcohol(7), $C_{15}H_{26}O(M^+$ 222); $[\alpha]_D$ +39°; ν 3610, 3400, 895; δ 0.82, 0.87, 1.10, 1.20(each 3H, s), 5.55, 5.83(each 1H, d, J=10).$^{3)}$ Since the α,β-unsaturated ketone thus obtained showed a negative curve($[\theta]_{344}^{min}$ -216, $[\theta]_{331}^{min}$ -241, $[\theta]_{320}^{min}$ -207, in dioxane) on the CD spectrum,$^{4)}$ the absolute configuration of the asymmetric center bearing the cyclopentane ring should be expressed by R.

Next, the alcohol was oxidized with *m*-$ClC_6H_4CO_3H$ in dichloromethane to afford an epoxy-alcohol(8), $C_{15}H_{26}O_2(M^+$ 238); $[\alpha]_D$ +27°; ν 3590, 3420, 955; δ 0.92, 1.07, 1.12, 1.32(each 3H, s), 2.92, 3.37(each 1H, d, J=4), in which the epoxy ring may be introduced with *cis* configuration against the hydroxyl group because of neighboring group effect.$^{5)}$ The epoxide thus obtained was reduced, with $LiAlH_4$ in ether, to a 1,2-glycol(9), $C_{15}H_{28}O_2(M^+$ 240); $[\alpha]_D$ +42°, ν 3400, δ 0.77(3H, s), 0.98(6H, s), 1.15(3H, s), 3.52(1H, t, J=2), which was further oxidized with Jones reagent to give a keto-acid(10), $C_{15}H_{26}O_3(M^+$ 254); $[\alpha]_D$ +7°; ν 3400-2500, 1708; δ 0.83, 0.97, 1.03, 2.13(each 3H, s), and an α-hydroxy-ketone(11), $C_{15}H_{26}O_2(M^+$ 238); $[\alpha]_D$ +78°; ν 3500, 1710, 1424; δ 0.90, 0.92, 0.97, 1.37(each 3H, s) in a ratio of 2 and 1. The production of both compounds(10 and 11) revealed that, in the glycol, the newly formed hydroxyl group was introduced on the carbon atom adjacent to the tertiary carbon bearing the original hydroxyl group with an axial configuration. The absolute configuration of this secondary carbon atom bearing the newly formed hydroxyl group was then determined to be S according to the benzoate rule,$^{6)}$ based on the fact that glycol monobenzoate(12), $C_{22}H_{32}O_3(M^+$ 344); $[\alpha]_D$ +50°; ν 3610, 3480, 1725, 1600; δ 0.77, 0.88, 0.97, 1.25(each 3H, s), 4.95(1H, t, J=3), 7.30-8.10(5H), prepared by treatment with C_6H_5COCl in pyridine showed a large molecular rotation, $[M]_D$ +172°, compared with that of the glycol, $[M]_D$ +101°. Therefore, the tertiary carbon atom should be expressed by R because the secondary newly formed hydroxyl group was introduced with the *cis* configuration to the tertiary hydroxyl group as mentioned above.

ROSULANTOL(2). The compound, $C_{15}H_{24}O_2(M^+$ 236); mp 125-126 °C; $[\alpha]_D$ -10°, was characterized to be a bicyclic sesquiterpene keto-alcohol containing an α-methyl-α,β-unsaturated ketone system[λ 228 nm(ε 6000); ν 1677; δ 1.77(3H, d, J=1), 6.73(1H, d.q, J=8, 1)], a secondary hydroxyl group[ν 3600, 3425; 4.37(1H, d.d, J=8, 2)], an active methylene[ν 1440; δ 2.78(1H, d.d, J=16, 12), 2.47(1H, d.d, J=16, 4)] and three tertiary methyls[ν 1382, 1370, 1360; δ 0.90, 1.01, 1.07 (each 3H, s)]. The keto-alcohol was treated with $POCl_3$ in pyridine to give (+)-δ-cuparenol(4), $C_{15}H_{22}O(M^+$ 218); $[\alpha]_D$ +55°, which was identified by spectrometric comparison with the compound isolated from the same liverwort. In addition, when the alcohol was oxidized with CrO_3 in pyridine, it gave a *p*-hydroquinone derivative(13), $C_{15}H_{22}O_2(M^+$ 234); mp 147-148 °C; $[\alpha]_D$ +41°; λ 258 (1300), 295 nm(ε 1100); ν 3600, 3370, 1654; δ 0.77, 1.17, 1.38, 2.15(each 3H, s), 6.45, 6.77(each 1H, s), and a *p*-quinone derivative(14), $C_{15}H_{20}O_2(M^+$ 232);

mp 72-73 °C; $[\alpha]_D$ +10°; λ 257 nm(ε 9600); ν 1655, 1645, 1633, 1590; δ 0.75, 1.13, 1.30(each 3H, s), 2.01(3H, d, J=2), 6.48(1H, q, J=2), 6.63(1H, s), in yields of 15 % and 35 %. These results revealed that rosulantol was cuparane-type sesquiterpenoid expressed by structure 2 except for the absolute configurations of C-5 and C-6.

Rosulantol exhibited a positive sign($[\theta]^{max}_{324}$ +412, $[\theta]^{max}_{313}$ +423, in MeOH) on the CD spectrum,4) and its benzoate(15), $C_{22}H_{28}O_3$(M^+ 340); $[\alpha]_D$ -182°; ν 1720, 1685, 1680, 1600; δ 0.98, 1.05, 1.08(each 3H, s), 1.72(3H, d, J=1), 5.55 (1H, br.d, J=6), 6.85(1H, br.d, J=6), 7.25-8.20(5H), prepared by treating with C_6H_5COCl in pyridine, showed a smaller molecular rotation, $[M]_D$ -919°, than that of the original alcohol, $[M]_D$ -24. From these results the absolute configuration of each of C-5 and C-6 in rosulantol was determined as R.



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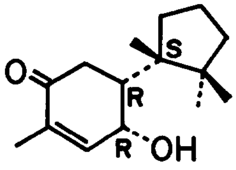

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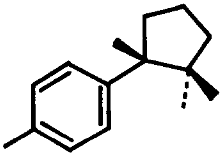

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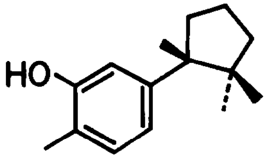

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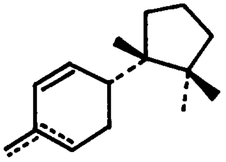

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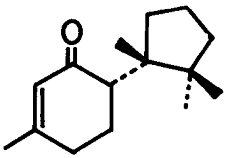

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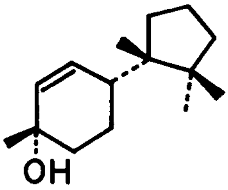

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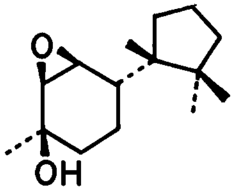

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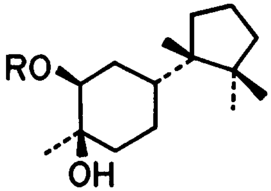
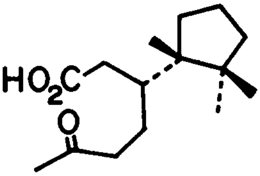


9 R=H

12 R=COC_6H_5



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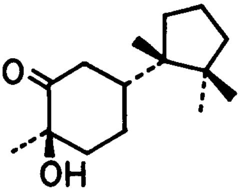

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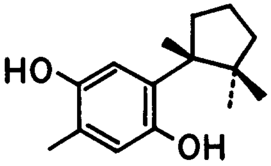

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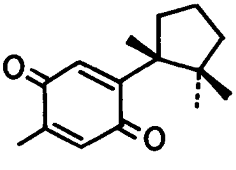

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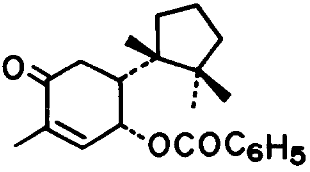

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Thus, the structures and absolute configurations of cuprenenol and rosulantol were, respectively, elucidated to be expressed by stereostructures 1 and 2. This is the first case of sesquiterpenoids isolated from the genus *Jungermannia*, and these compounds are very unique sesquiterpene alcohols in that they are in the preceding stage for the aromatization of the cyclohexane ring of the cuparane type sesquiterpenoids.$^{7)}$

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