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ISOLATION AND STRUCTURE OF ISOCALAMENDIOL

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In the previous paper,[1] we reported the isolation of three monocyclic sesquiterpenes from the rhizomes of *Acorus calamus* L.(Japanese name, *Shyōbu*). We could isolate, in the subsequent studies, a new bicyclic diol as a major component from another sesquiterpenic fraction of the plant, and named it "Isocalamendiol."

The essential oil, which was obtained by means of the steam distillation, was chromatographed on silica gel (Mallinckrodt, 100 Mesh). After elution of three monocyclic compounds (shyobunone, epishyobunone and isoshyobunone) with pet. ether-diethyl ether (10:1),[1] elution with pet. ether-diethyl ether(5:1) afforded calamendiol(or calameone),[2,3] m.p.170.5–171.5°(lit.,169°), $C_{15}H_{26}O_2$, the structure(I) of which was given by W.Treibs in 1949.[3] Further elution with pet. ether-diethyl ether(3:1) gave a new sesquiterpene diol, isocalamendiol(II), m.p. 72.5–73.5°, having the same molecular formula as that of calamendiol. Furthermore, the spectral data of isocalamendiol(II) are fairly close to that of calamendiol(I), as shown below: m/e 238(M^+); ν_{max}^{KBr} 3600, 3380 br. and 1648 cm^{-1}; λ_{max}^{MeOH} 203 mμ (log ε = 3.2) and NMR signals at 0.90(3H, d, J= 7cps) and 0.93(3H, d, J= 7cps)($-CH<^{Me}_{Me}$), 1.22(3H, s)($>\underset{OH}{C}-Me$), 4.80(1H, br. s) and 4.89 ppm(1H, br. s)($>C=CH_2$).

When heated with formic acid(100%) on a water bath for 30 min., isocalamendiol(II) afforded calamenene(III)[4] in *ca.* 50% yield. Accordingly, II must be a decahydronaphthalene having an exocyclic double bond as well as two tertiary hydroxyl groups which can not be acetylated with acetic anhydride - pyridine.

Ozonolysis of isocalamendiol(II) gave a ketone(IV), m.p. 145–146°; m/e 222(M$^+$–18) ($C_{14}H_{24}O_3$); ν_{max}^{KBr} 3480 br. and 1702 cm^{-1}; NMR signals at 0.89 (3H, d, J= 6.8cps), 0.95(3H, d, J= 6.8cps) and 1.25 ppm(3H, s). Further treatment of IV with $POCl_3$-pyridine at room temperature for 40 hr. gave, in 70% yield, a dehydroxy-ketone(V), m.p. 119–119.5°; m/e 222(M$^+$); ν_{max}^{KBr} 3420, 1705 and 1640 cm^{-1}. In its NMR spectrum, two new broad singlets($>C{=}CH_2$) were observed at 4.73 and 5.00 ppm instead of the methyl singlet at 1.25 ppm in the original ketone(IV). The above facts indicate that an equatorial hydroxyl group must be attached to the carbon atom bearing a tertiary methyl group.

Catalytic hydrogenation of V on PtO_2 afforded a dihydro-ketone(VI), m.p. 114.5–116°, which was heated with MeONa-MeOH under reflux for 1 hr. to give, in *ca.* 30% yield, an α,β-unsaturated ketone(VII), specific retention* at 170°, 8.5; m/e 206(M$^+$); ν_{max}^{film} 1679 and 1617 cm^{-1}; λ_{max}^{MeOH} 240 mμ(log ε = ∿4); NMR signals at 0.78(3H, d, J= 6.7cps), 0.9–1.1(6H, m) and 5.84 ppm(1H, s).

In the above experiments, the formation of an α,β-unsaturated ketone coupled with the appearance of a singlet at 5.84 ppm, which can be assigned to the vinyl proton, indicates that the exocyclic double bond and one of the tertiary hydroxyl groups in the original diol(II) must be located at C_3 and C_5-positions, respectively. Accordingly, the remaining equatorial hydroxyl group must be attached to C_9- carbon atom.

Stereochemistry of isocalamendiol(II)

Catalytic hydrogenation of isocalamendiol(II) on PtO_2 followed by dehydration with $POCl_3$-pyridine(at room temperature for 3 hr.) gave, in almost quantitative yield, a mixture of dihydro-dehydroxy-compounds [VIIIa(87%) and

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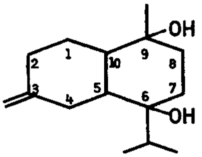
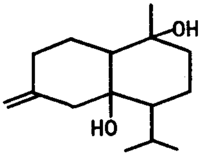
* The numerical values of specific retention were obtained *vs.* cyclohexanol as an internal standard [stationary phase: 5% PEG 20M(on Neopak 1A, 60–80 Mesh); carrier gas: N_2], unless otherwise stated.



I



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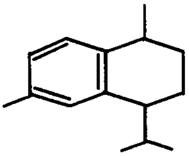

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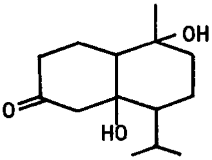

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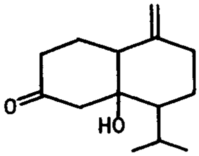

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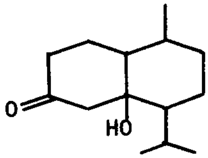
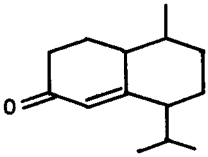


VI



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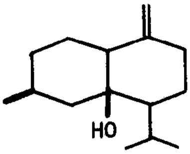
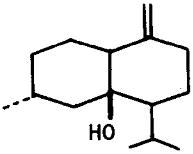
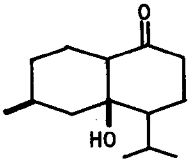


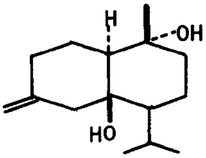
VIIIa



VIIIb



IX



X

VIIIb(13%)], which could be separated carefully by preparative gas-liquid chromatography (25% DEGS on Celite 545 (60–80 Mesh), 110°, N_2). Physical properties of VIIIa and VIIIb are described below.

VIIIa: specific retention at 110°, 10.5; m/e 222(M^+); ν_{max}^{film} 3585 and 1650 cm^{-1}; NMR signals at 0.85(3H, d, J= 7.3cps) and 0.88(3H, d, J= 7.3cps) $(-\mathrm{CH}{<}^{\mathrm{Me}}_{\mathrm{Me}})$, 1.16(3H, d, J= 7.1cps)(>CH–Me), 4.68(1H, br. s) and 4.89 ppm (1H, br. s)($>C{=}CH_2$).

VIIIb: specific retention at 110°, 13.4; m/e 222(M^+); ν_{max}^{film} 3590 and 1650 cm^{-1}; NMR signals at 0.86(3H, d, J= 6.8cps) and 0.90(3H, d, J= 6.8cps) $(-\mathrm{CH}{<}^{\mathrm{Me}}_{\mathrm{Me}})$, 0.90(3H, d, J= 6.6cps)(>CH–Me), 4.65(1H, br. s) and 4.89 ppm (1H, br. s)($>C{=}CH_2$).

In the comparison of NMR spectra between VIIIa and VIIIb, the methyl doublet at 1.16 ppm in the former is observed in a lower magnetic field than the corresponding signal of the latter by 0.26 ppm. This indicates that VIIIa has a 1,3-diaxial relationship between the secondary methyl group and the tertiary hydroxyl group at C_5-position.[5]

Ozonolysis of VIIIa in MeOH at -70° followed by the decomposition with dimethyl sulfide[6] afforded, in 95% yield, an oxidation product(IX), m.p. 145–146°; m/e 224(M^+); ν_{max}^{KBr} 3420 and 1700 cm^{-1}; NMR signals at 0.91(3H, d, J= 6.9cps), 0.98(3H, d, J=6.9cps) and 1.14 ppm(3H, d, J= 7.2cps). Finally, the optical rotatory dispersion curves of both keto-derivatives (IV and IX) showed negative Cotton effect (IV: $[\phi]_{308}^{T}$ -29.7×10^2, $[\phi]_{270}^{P}$ $+22.4 \times 10^2$, A -52.0; IX: $[\phi]_{301}^{T}$ -11.8×10^2, $[\phi]_{264}^{P}$ $+8.2 \times 10^2$, A -20.0).

Therefore, the absolute configuration of isocalamendiol(II) can be represented by X, except for the configuration of the isopropyl group at C_6-position, which may be in an equatorial configuration.[7]

All melting points are uncorrected. All compounds gave satisfactory physical data. The chemical shifts of all NMR spectra are given in ppm from an internal TMS standard using $CDCl_3$ as a solvent (d, doublet; m, multiplet; s, singlet).

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