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STRUCTURES OF TWO NEW HALOGENATED CHAMIGRANE-TYPE SESQUITERPENOIDS FROM THE RED ALGA LAURENCIA NIPPONICA YAMADA(1)

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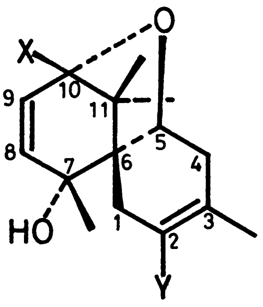
Two new halo-chamigrane derivatives have been isolated from the title alga and the structure of one of them was determined on the basis of the spectral and chemical evidence. The structure of another compound was established by X-ray diffraction study of its monoacetate epoxide.

In connection with our continuing studies on the constituents of the red alga Laurencia nipponica Yamada collected in the Pacific Coast of Hokkaido, we have reported the isolation and structures of new chamigrane,2) secochamigrane,3,5) and rearranged chamigrane4) derivatives. Further investigations of the minor components of the specimen collected at Akkeshi yielded new additional halo-chamigrane derivatives, the structures of two of which were determined and are reported in this communication.

Repeated column chromatography of the methanol extracts over silica gel provided a sesquiterpene alcohol **1** and a diol **2** in 0.53 and 0.35% yields of the extracts, respectively.

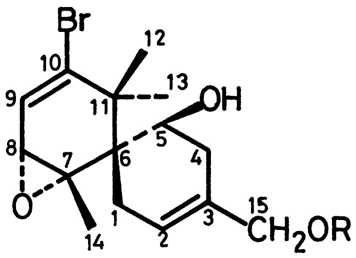
The sesquiterpene alcohol **1**, colorless oil, $[\alpha]_D$ -23.8° (c 4.0; $CHCl_3$), was analyzed for $C_{15}H_{20}O_2Br_2$ by EI-MS m/e 394, 392, and 390 (M^+)6) and had the following spectral characteristics; IR (film), ν_{max} 3450, 3010, 1640, 1128, 1073, 1030, 982, 968, 922, 772, and 737 cm^{-1}; ^1H NMR ($CDCl_3$), δ 1.12 (6H, s), 1.39 (3H, s), ca. 1.8 (1H; OH), 1.81 (3H, br s), 2.1-2.9 (4H, m), 4.65 (1H, dd, J=8, 5 Hz), 5.40 (1H, d, J=10 Hz), and 6.04 (1H, d, J=10 Hz); ^{13}C NMR ($CDCl_3$), δ 133.5 (d), 132.8 (d), 129.5



1: X=Y=Br

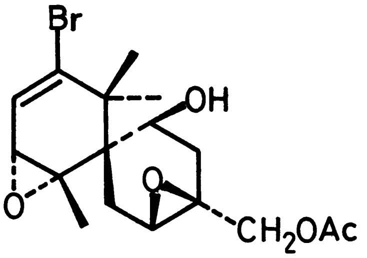
3: X=Br, Y=H

4: X=Y=H



2: R=H

5: R=Ac



6

(s), 116.4 (s), 100.2 (s), 75.6 (s), 74.3 (d), 53.2 (s), 52.5 (s), 38.6 (t), 35.4 (t), 24.7 (q), 24.5 (q), 22.8 (q), and 21.9 (q). In view of these data for 1 coupled with comparison of its ^{1}H NMR spectrum with that of 10-bromo-7-hydroxy-5,10-epoxychamigra-2,8-diene (3)[7] previously isolated from *L. nipponica*, formula 1 was readily proposed for this alcohol. Confirmation of the structure of 1 was obtained by the following reactions. 1, when treated with LiAlH$_4$ in ether at room temperature, afforded the debromination product 4 (58% yield), $C_{15}H_{22}O_2$ (m/e 234; M^+), $[\alpha]_D$ -50.9° (c 0.59; CHCl$_3$),[8] which was also produced by the same treatment of 3. Therefore, the structure of this alcohol is represented by formula 1 including the absolute configuration.

The sesquiterpene diol 2, mp 61-62 °C, $[\alpha]_D$ +60.0° (c 1.00; CHCl$_3$), was analyzed for $C_{15}H_{21}O_3Br$ by CI-MS m/e 348 and 346 (M^+NH_4),[6] and seemed to be assigned to formula 2, based upon its spectral data[9] together with proton selective and gated decoupling experiments of the ^{13}C NMR spectra.[10]

Acetylation of 2 with acetic anhydride in pyridine in the usual manner gave the corresponding monoacetate 5 (100% yield), $C_{17}H_{23}O_4Br$ (m/e 372 and 370; M^+), $[\alpha]_D$ +32.4° (c 2.3; CHCl$_3$),[9] which regenerated the parent alcohol 2 on mild saponification with K_2CO_3 in methanol, indicating that no rearrangement had occurred during the acetylation. Treatment of 5 with *m*-chloroperbenzoic acid in dichloromethane yielded only a monoacetate epoxide 6 (77% yield), $C_{17}H_{23}O_5Br$ (m/e 388 and 386; M^+), mp 73-74 °C (hexane-isopropyl ether), $[\alpha]_D$ +16.5° (c 0.43; CHCl$_3$),[9] whose single crystal was subjected to X-ray crystallographic analysis.

The crystal data for 6 are as follows: $C_{17}H_{23}O_5Br$, monoclinic, space group $P2_1$, a=12.274(2), b=6.373(1), c=11.896(3) Å, β=111.30(2)°, Z=2, D_c=1.483 g cm^{-3}, μ(CuKα) = 34.3 cm^{-1}. The unit-cell dimensions and reflection intensities were measured on an automated, four-circle diffractometer with graphite-monochromated CuKα radiation. The intensities were corrected for the Lorentz and polarization factors, but not for the absorption or the extinction effect. In the range of 2θ values up to 120°, 1245 independent structure factors above the 3σ(F) level were selected for the structure determination. The structure was elucidated by the Monte Carlo direct method[11] on the basis of 458|E| values above 1.10. The 6th random phase set for the 20 strongest reflections led to the correct solution; i.e., an E-map based on 430 phases afforded 19 of the 23 non-hydrogen atoms. The 4 remaining atoms were located in a difference Fourier map. After the structure had been well refined by the block-diagonal least-squares method with anisotropic temperature factors, the absolute configulation was determined by taking account of the anomalous dispersion effects of bromine atoms for CuKα radiation. The R ratio for the structure drawn in Fig. 1 and its enantiomer, 1.021, rejected the latter at the 99.5% confidence level.[12] A second difference Fourier map revealed all the 23 hydrogen atoms. Further least-squares refinements were performed including the hydrogen atoms and bromine dispersion corrections.[13] The final R value was 0.041. The molecular skeleton of **6** thus obtained is shown in Fig. 1.

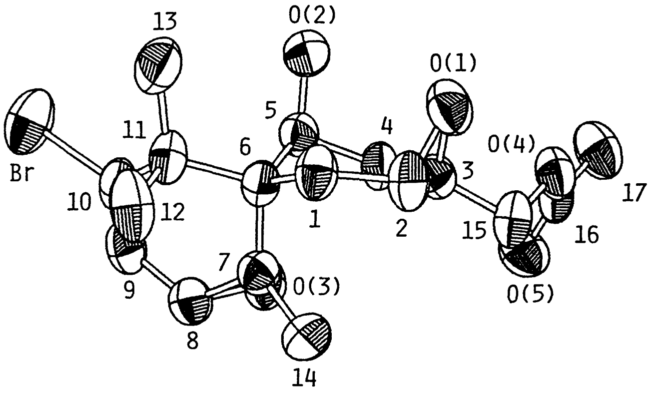


Fig. 1. A perspective view of the **6** molecule.

Consequently, the structure of this new sesquiterpene diol is represented by formula **2** including the absolute configuration.

The vinyl bromide moiety at C-2 in **1** and the hydroxyl group at C-15 in **2** are the first examples of the halogenated chamigrane-type metabolites from the genus Laurencia. Furthermore, the compounds, which contain a double bond at C-2, appear to be important metabolites in the biogenetic sequence for the secochamigrane-type sesquiterpenes probably synthesized from halo-chamigranes.[5]

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5) Part 53 of this series.

6) High resolution mass spectral data; **1**: m/e 389.9848 (calcd for $C_{15}H_{22}O_2{}^{79}Br^{79}Br$, 389.9843) and **2**: m/e 330.0675 (calcd for $C_{15}H_{21}O_3{}^{81}Br$, 330.0655).

7) T. Suzuki, Chem. Lett., 1980, 541.

8) **4**: oil, ν_{max}^{film} 3420, 3030, 3010, 1640, 1112, 1090, 1058, 1032, 1004, 974, 918, 882, 850, 819, 782, 740, and 670 cm^{-1}; δ ($CDCl_3$) 1.01 (6H, s), 1.37 (3H, s), 1.69 (3H, br s), 1.74 (1H; OH), 1.9-2.9 (4H, m), 3.84 (1H, d, J=5 Hz), 4.55 (1H, dd, J=8, 5 Hz), ca. 5.5 (1H, m), 5.60 (1H, d, J=10 Hz), and 5.87 (1H, dd, J=10, 5 Hz).

9) **2**: ν_{max}^{Nujol} 3350, 3275, 1670, 1620, and 990 cm^{-1}; δ ($CDCl_3$) 1.18 (3H, s), 1.35 (6H, s), 1.9-2.9 (6H, m), 2.94 (1H, d, J=4 Hz), 3.99 (3H, br s), 5.76 (1H, m), and 6.25 (1H, d, J=4 Hz); δ ($CDCl_3$) 145.3 (s, C_3), 136.3 (s, C_{10}), 125.8 (d, C_9), 120.8 (d, C_2), 68.5 (d, C_5), 66.7 (t, C_{15}), 61.5 (s, C_7), 57.9 (d, C_8), 49.0 (s, C_6), 46.7 (s, C_{11}), 35.6 (t, C_1), 27.8 (q, C_{12}), 27.6 (q, C_{13}), 26.5 (t, C_4), and 23.0 (q, C_{14}).
5: oil; ν_{max}^{film} 3480, 1739, 1630, 1235, 1122, 880, and 682 cm^{-1}; δ ($CDCl_3$) 1.22 (3H, s), 1.40 (6H, s), 2.07 (3H, s), 1.8-3.2 (5H, m), 2.97 (1H, d, J=3 Hz), 4.06 (1H, m), 4.53 (2H, s), 5.90 (1H, m), and 6.34 (1H, d, J=3 Hz).
6: ν_{max}^{KBr} 3500, 1748, 1634, 1242, 1082, 1040, 930, 840, 788, and 734 cm^{-1}; δ ($CDCl_3$) 1.17, 1.37, 1.46, 2.11 (each 3H, s), 2.33 (2H, m), 2.65 (1H, d, J=4 Hz), 2.97 (1H, m), 2.99 (1H, d, J=3 Hz), 3.05 (1H, d, J=11 Hz), 3.49 (1H, m), 3.84 (1H, ddd, J=11, 3, 3 Hz), 4.19 (2H, s), and 6.33 (1H, d, J=3 Hz).

10) The details will be described in a full paper.

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