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VENUSTIN A AND B, NEW HALOGENATED C_{15} METABOLITES FROM THE RED ALGA *LAURENCIA VENUSTA* YAMADA[1]

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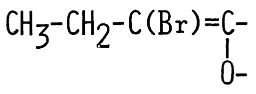
Two new halogenated non-terpenoid C_{15} compounds, venustin A (**1**) and B (**2**), were isolated from the red alga *Laurencia venusta* Yamada. The structures of these compounds were determined by chemical and spectroscopic evidence.

Red algae of the genus *Laurencia* (Rhodomelaceae) have produced many halogenated non-terpenoid C_{15} metabolites, among which laurencin,[2] laureatin,[3] isolaureatin,[3] laurefucin,[4] acetyllaurefucin,[4] isoprelaurefucin,[5] laurallene,[6] laureepoxide,[7] and the possible acyclic precursors, laurediols,[8] have been isolated from the Japanese species of *Laurencia, L. glandulifera* Kützing[2] and *L. nipponica* Yamada.[3-8] In connection with our interest in the halogenated metabolites of the *Laurencia* species and their chemotaxonomic studies, we examined the methanol extracts of *L. venusta* Yamada ('Hime-sozo' in Japanese), collected in August 10, 1979, at Moheji, Hakodate Bay, Hokkaido. *L. venusta* has contained several halogenated non-terpenoid C_{15} compounds, named as venustins, which may be characteristic metabolites of this alga. We wish to report herein the structures of two compounds of them, venustin A (**1**) and B (**2**).

The neutral methanol extracts were submitted to a combination of column and thin-layer chromatography on silica gel to yield venustin A (**1**) and B (**2**).

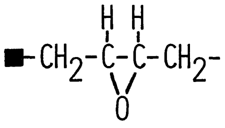
The major component, venustin A (**1**) (10% of the neutral extracts), $C_{15}H_{18}O_2BrCl$,[9] mp 94-95°C (from hexane), $[\alpha]_D^{27}$ -40° (c 0.81; $CHCl_3$), possesses a conjugated *trans*-pentenyne side chain [λ_{max} (EtOH) 213 nm (ε 20,000), λ_{inf} 222 (19,000) and 232 (13,000); ν_{max} ($CHCl_3$) 3320, 2110 and 965 cm^{-1}; δ ($CDCl_3$) 2.84 (1H, br s), 5.66 (1H, br d, J=16 Hz) and 6.18 (1H, sextet, J=16, 7, 7 Hz); *m/e* 65 (base peak)] and CH_3-CH_2-$\underset{|}{C}$=$\underset{|}{C}$- moiety [δ 1.13 (3H, t, J=7 Hz) and 2.47 (2H, q, J=7 Hz)]. The ^1H NMR spectrum of **1** revealed the remaining complex signals at δ 2.0-3.2 (8H, m) and partly overlapping signals at δ 4.12 (1H, ddd, J=10, 5, 2 Hz) and 4.22 (1H, sextet, J=7, 7, 2 Hz), which were obviously observed in the spectrum in C_6D_6 at δ 3.33 and 3.64, respectively, and coupled to each other by 2 Hz.

Hydrogenation of **1** over PtO_2 in ethyl acetate afforded, in almost quantitative yield, the hexahydro derivative (**3**), $C_{15}H_{24}O_2BrCl$, oil, ν_{max} ($CHCl_3$) 1657, 1265, 1197, 1150, 1095 and 993 cm^{-1}; δ 1.12 (3H, t, J=7 Hz), 2.47 (2H, q, J=7 Hz), 1.8-3.3 (6H, m), 4.12 (1H, ddd, J=10, 5, 2 Hz) and 4.21 (1H, sextet, J=7, 7, 2 Hz).



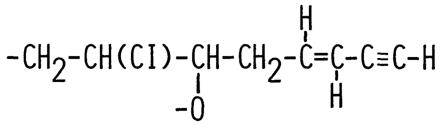
$CH_3-CH_2-C(Br)=\underset{O-}{\underset{|}{C}}-$

A



$-CH_2-\underset{O}{\underset{\diagdown\;\diagup}{\overset{H}{\overset{|}{C}}-\overset{H}{\overset{|}{C}}}}-CH_2-$

B



$-CH_2-CH(Cl)-\underset{-O}{\underset{|}{CH}}-CH_2-\overset{H}{\overset{|}{C}}=\underset{H}{\underset{|}{C}}-C\equiv C-H$

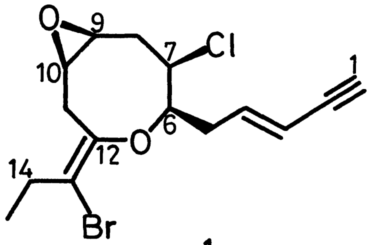
C

Since the IR spectrum of **1** showed the absence of hydroxyl and carbonyl functionalities, the two oxygen atoms in **1**, having six degrees of unsaturation, were assumed to be involved as two ether links (ν_{max} 1265, 1195, 1140, 1077, 1057 and 992 cm^{-1}). The existence of the trisubstituted vinyl ether function in **1** was indicated by the ^{13}C NMR spectrum of **1**,[10] the signals at δ 145.0 (s) and 112.7 (s) ppm, and further by the IR spectrum of **1**, the intense absorptions at ν_{max} 1657 and 1265 cm^{-1}, which were still present in the ^{13}C NMR and IR spectra of **3**. Therefore, the aforementioned data and the relatively intense fragments due to $CH_3-CH_2-C(Br)=C=O^+$ at *m/e* 150 and 148[10] in the mass spectra of **1** and **3** were strong evidence for the presence of partial structure **A** in the molecule.

The spin decoupling studies in the ^1H NMR spectrum of **1** showed the presence of partial structure **C** in the molecule.[11] Furthermore, the ^1H NMR spectrum of **1** in the presence of shift reagent, $Eu(dpm)_3$, provided additional information of the structure. Two signals (each 1H, m) were observed to shift downfield much further than the rest and coupled to each other, indicating that these signals could be attributed to both methine protons on an epoxide moiety. Each signal was further coupled to the adjacent methylene groups, one of which appeared as the signals (each quartet) of the AB part of the ABX system, proving it to be adjacent to a quaternary carbon atom. Above results showed the presence of partial structure **B** in the molecule. A combination of the partial structural units **A**, **B**, and **C** leads to sole formula **1** as a possible planar structure for venustin A, which is closely related to chondriols and rhodophytins from *Laurencia* species.[12]

One of the minor components, venustin B (**2**) (1.5%), $C_{15}H_{18}OBrCl$, mp 77-78°C (hexane), $[\alpha]_D^{25}$ -78° (c 1.18), had the following spectral characteristics; ν_{max} ($CHCl_3$) 3320, 3005, 2110, 1657, 1265, 1182, 1135, 1059, 980 and 963 cm^{-1}; ν_{max} (CS_2) 3025 and 740 cm^{-1}; δ 1.08 (3H, t, J=7 Hz), 2.45 (2H, q, J=7 Hz), 2.83 (1H, d, J=2 Hz), 2.6-3.2 (4H, m), 3.09 (1H, dd, J=17, 2.5 Hz), 3.37 (1H, dd, J=17, 4 Hz), 3.97 (1H, ddd, J=10, 5, 2 Hz), 4.34 (1H, sextet, J=7, 7, 2 Hz), 5.5-5.8 (3H, m) and 6.20 (1H, sextet, J=16, 7, 7 Hz); *m/e* (relative intensity) 332, 330, 328 (M^+; 6), 150, 148 (37), 129 (47), 109 (31), 91 (100), 79 (33), 77 (26) and 65 (55). Comparisons of the spectral properties with those of **1** together with the spin decoupling studies[11] revealed that **2** contained partial structures **A** and **C** as same as **1** and further a $-\underset{|}{C}=\underset{|}{C}-CH_2-CH=CH-CH_2-$ (*cis*) grouping instead of **B** in **1**, indicating that venustin B would be the 9,10-deoxyvenustin A and hence represented by formula **2** as a planar structure.

The stereochemistries at C-6, C-7, C-9, C-10, and C-12 (C-13) were deduced with the aid of the chemical shifts and the multiplicities in the ^1H NMR spectra of **1** and **2**. The coupling constants, J=2 Hz, between the protons at C-6 and C-7 in **1** and **2** were consistent with those of chondriols and rhodophytins,[12] which contain



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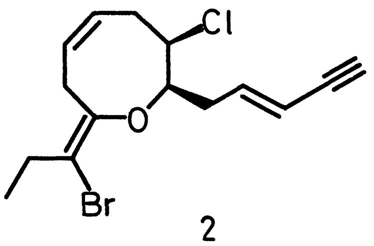

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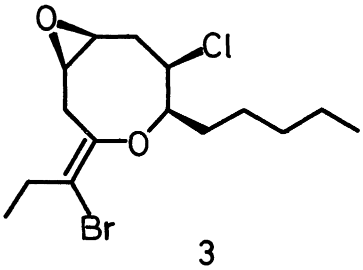
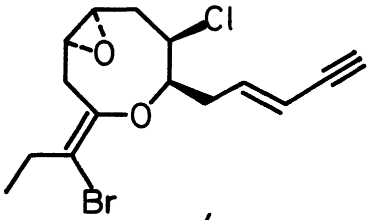


3



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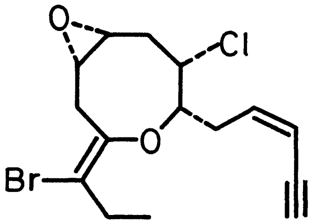

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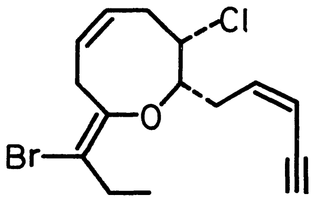

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cis configuration between the chlorine atom at C-7 and the pentenyne side chain at C-6. The signals of the methylene protons at C-14 in 1 and 2 were observed at δ 2.47 and 2.45, respectively, as the clear quartets with J=7 Hz, whereas those of chondriols and rhodophytins were displayed at δ ca. 2.6 as the multiplets (magnetically nonequivalent),[12] reflecting the electronic influence of the ether oxygen atom at C-12 which is *cis* to the ethyl group at C-13. These results permitted the assignment of the *Z* configuration to the exocyclic double bond at C-12 in 1 and 2. Moreover, the chloromethine proton at C-7 in 1 occurred in 0.15 ppm lower field region than that in 2 and the proton at C-6 in 1 in 0.12 ppm higher field region than that in 2. Since the same splitting patterns of the protons at C-6 (ddd, J=7, 7, 2 Hz) and C-7 (ddd, J=10, 5, 2 Hz) in 1 and 2 suggested the absence of the major conformational difference between 1 and 2, it was considered that the distinct differences of the chemical shifts of the C_6-H and the C_7-H between 1 and 2 might be ascribed to the shielding and deshielding effects of the epoxide ring[13] at C-9 and C-10 in 1, respectively, showing that the oxirane ring is *trans* to the chlorine atom at C-7 and the pentenyne side chain at C-6 as shown in formula 4. However, the structure of epoxyrhodophytin has recently been determined as formula 5, including the absolute configuration, by X-ray crystallographic analysis.[12d] Contrary to our considerations described above, the C_7-H (ddd, J=12, 6, 2 Hz) in epoxyrhodophytin (5), in the ^{1}H NMR spectra, was observed in 0.18 ppm lower field region than that in *cis*-rhodophytin (6) and the C_6-H (ddd, J=7, 7, 2 Hz) in 5 in 0.18 ppm higher field region than that in 6.[12] Above differences of the chemical shifts of the C_6-H and the C_7-H between 5 and 6 were comparable to those between 1 and 2. Thus, the oxirane ring in venustin A (1) was tentatively assigned as the same configuration as epoxyrhodophytin (5) without further evidence.

Consequently, the structures, including the relative configuration, of venustin A and B would be represented by formulas 1 and 2 respectively.

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References and Notes

1. Part 41 of "Constituents of Marine Plants". Part 40, T. Suzuki, *Chem. Lett.*, 1980, 541.
2. T. Irie, M. Suzuki, and T. Masamune, *Tetrahedron*, 24, 4193 (1968).
3. (a) T. Irie, M. Izawa, and E. Kurosawa, *Tetrahedron*, 26, 851 (1970); (b) E. Kurosawa, A. Furusaki, M. Izawa, A. Fukuzawa, and T. Irie, *Tetrahedron Lett.*, 1973, 3857.
4. A. Furusaki, E. Kurosawa, A. Fukuzawa, and T. Irie, *Tetrahedron Lett.*, 1973, 4579.
5. E. Kurosawa, A. Fukuzawa, and T. Irie, *Tetrahedron Lett.*, 1973, 4135.
6. A. Fukuzawa and E. Kurosawa, *Tetrahedron Lett.*, 1979, 2797.
7. A. Fukuzawa and E. Kurosawa, *Tetrahedron Lett.*, 21, 1471 (1980), and the related references cited therein.
8. E. Kurosawa, A. Fukuzawa, and T. Irie, *Tetrahedron Lett.*, 1972, 2121.
9. Molecular formulas of **1**, **2**, and **3** were obtained by the mass spectra and the acceptable elemental analyses.
10. ^{13}C NMR and mass data for venustin A (**1**): δ ($CDCl_3$) 145.0 (s), 140.2 (d), 112.7 (s), 112.7 (d), 81.8 (d), 77.7 (d), 76.8 (s), 59.6 (d), 53.2 (d), 52.0 (d), 37.1 (t), 34.3 (t), 29.8 (t), 29.1 (t) and 13.5 (q); δ (C_6D_6) 76.9 (s) and 76.2 (d); *m/e* (relative intensity) 348, 346, 344 (M^+; 18), 150, 148 (58), 117 (34), 115 (29), 105 (16), 91 (35), 79 (19), 77 (26) and 65 (100).
11. Details of the spin decoupling studies will be discussed in a full paper.
12. (a) W. Fenical, J. J. Sims, and P. Radlick, *Tetrahedron Lett.*, 1973, 313; (b) W. Fenical, K. B. Gifkins, and J. Clardy, *Tetrahedron Lett.*, 1974, 1507; (c) W. Fenical, *J. Am. Chem. Soc.*, 96, 5580 (1974); (d) B. M. Howard, W. Fenical, K. Hirotsu, B. Solheim, and J. Clardy, *Tetrahedron*, 36, 171 (1980).
13. K. Tori, K. Kitahonoki, Y. Takano, H. Tanida, and T. Tsuji, *Tetrahedron Lett.*, 1964, 559.

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