New Xenia Diterpenoids from a Soft Coral, *Xenia* Species

Tetsuo Iwagawa,* Yasuhisa Amano, Tsunao Hase,* and Motoo Shiro*†
Department of Chemistry, Faculty of Science, Kagoshima University, Kagoshima 890
†*Rigaku Corporation, 3-9-12 Matsubara-cho, Akishima, Tokyo 196*

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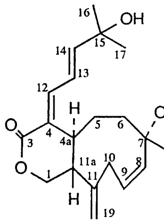
Two new xenia diterpenoids, xeniatine A (**1**) and xeniaether A (**2**), the latter containing a tetrahydrofuran, have been isolated from a soft coral, *Xenia* sp.

Soft corals belonging to the genus *Xenia* have proved to be a rich source of 9-membered monocarbocyclic diterpenoids called xenia diterpenoids.[1] In the course of the investigation of biologically active constituents of *Xenia* sp. collected in the area of Bonotsu, Kagoshima,[2] we have isolated two new xenia diterpenoids, xeniatine A (**1**) and xeniaether A (**2**) from the methanol extract of an unidentified *Xenia* species.

Xeniatine A (**1**),[3] $C_{20}H_{28}O_4$, was isolated as needles, mp 150-152 °C. The IR spectrum showed absorption bands for a hydroxyl group (3300 cm^{-1}), a conjugated lactone carbonyl (1725 cm^{-1}), and a double bond (1670 cm^{-1}). The ^{1}H NMR spectral data were similar to those of xeniolide-A,[4] except for resonances due to the 9-membered ring, the structure of which was elucidated as follows. Resonances due to methyl protons on a carbon bearing a hydroxyl group (δ 1.36; s, H-18) and doubly allylic methylene protons (δ 2.88; dd, J=7.3 and 12.1 Hz and δ 3.21; t, J=12.1 Hz, H-10) were observed. The methylene protons were coupled to an olefinic proton at δ 5.42 (dt, J=7.3 and 12.1 Hz, H-9), which in turn was coupled to another olefinic proton at δ 5.73 (d, J=12.1 Hz, H-8). Two singlets at δ 4.59 and 4.91 (1H each) was assigned to exo methylene protons at C-19. These results suggested a gross structure shown in **1**. Final confirmation of the structure and stereochemical details was provided by single-crystal X-ray diffraction as depicted in Figure 1.[5]



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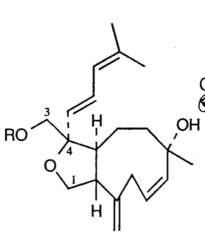


2 R=H
3 R=Ac

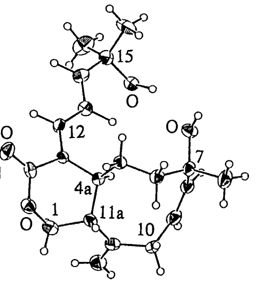


Figure 1. Perspective ORTEP drawing of **1**.

Xeniaether A (**2**),[6] $C_{20}H_{30}O_3$, oil, had absorption bands for a hydroxyl group (3400 cm^{-1}) and a conjugated diene (1630 cm^{-1}), but no lactone carbonyl in the IR spectrum. The gross structure was assigned by use of extensive NMR techniques including ^{1}H-^{1}H-COSY and ^{13}C-^{1}H COSY experiments and by comparison of the NMR spectra of **2** with those of **1**. Thus, resonances due to two olefinic methyl protons at δ 1.77 (6H, s, H-16 and H-17) and olefinic protons at δ 5.51 (1H, d, J=15.4 Hz, H-12), 5.83 (1H, br d, J=11.0 Hz, H-14), and 6.50 (1H, dd, J=11.0 and 15.4 Hz, H-13) were assigned, suggesting a 4-methyl-1,3-pentadine moiety. The presence of a hydroxymethyl group was deduced by the lowfield chemical shifts of the proton signals (δ 3.52 and 3.60; AB, J=11.4 Hz). This was also confirmed by acetylation of **2** to give a monoacetate (**3**),[7] $C_{22}H_{34}O_5$. The chemical shifts of the corresponding protons in the ^{1}H NMR spectrum of **3** were shifted to downfield by 0.55 *ppm* compared to those of **2**. Oxymethylene protons at δ 3.78 (1H, t-like, J=8.4 Hz, H-1α) and 3.95 (1H, t-like, J=8.4 Hz, H-1β) in the ^{1}H NMR spectrum of **2** were coupled to H-11a (δ 2.83; overlapped), which in turn was coupled to H-4a (δ 2.79; dt, J=4.0 and 9.2 Hz). The chemical shifts of C-1 (δ 69.9, d) and C-4 (δ 87.3, s) in the ^{13}C NMR spectrum indicated that C-1 and C-4 could be connected to the same oxygen atom, implying that **2** contained a tetrahydrofuran ring, and hence both side chain and hydroxymethyl group were located at C-4.

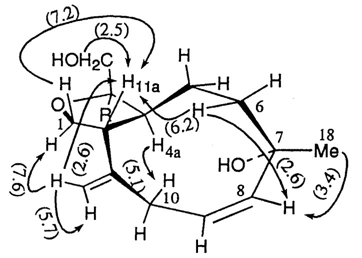
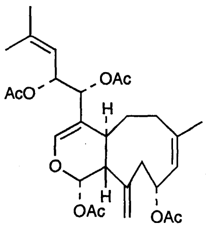


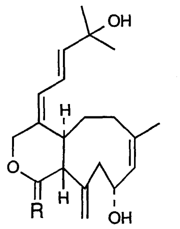
Figure 2. NOE (%) observed for **2**. R=diene moiety.

The relative stereochemistry of all chiral centers was elucidated from the observed NOE data (Figure 2). It was concluded that H-4a and the diene moiety occurred on the same face of the ring, since irradiation of H4a resulted in a 7.2 and 5.8% peak enhancement of H-12 and H-13, respectively. NOEs between H-11a and H-1β (δ 3.95, 7.2%) and H-3 (δ 3.60, 2.5%) were observed, suggesting that H-1β, H-3, and H-11a were on the opposite face to H-4a. The major conformer of the 9-membered ring was inferred from the observation of NOEs from H-4a to H-10α (5.1%) and from H-6endo to H-8 (2.6%) and H-11a (6.2%). The stereochemistry of the methyl group at C-7 was determined to be β on the basis of a NOE between H-8 and H-18 (3.4%). The geometry of the olefinic bond at C-12 was deduced to be *E* from the value of the coupling constant between H-12 and H-13 (J=15.4 Hz). Thus, the relative structure **2** could be assigned to xeniaether A.

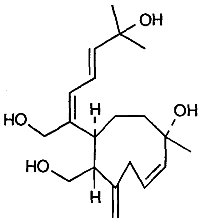
Xenia diterpenoids have been structurally divided into three types: xenicins, xeniolides, and xeniaphyllanes.[4] Xeniaether A is unique in that it contains a 9-membered monocarbocyclic skeleton fused to a tetrahydrofuran. It is noteworthy that the presence of xeniaether A suggested that xenicins, xenialactols,[8] and xeniolides, as well as xeniaether A might be formed from a common precursor such as **4** containing a 1,3-dihydroxymethyl group.



xenicin



R=H, β-OH xenialactol-C
R=O xeniolide-A



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References and Notes

1 D, J. Faulkner, *J. Nat. Prod.*, **1994**, 323.

2 T. Iwagawa, J. Kawasaki, T. Hase, C.-H. Yu, J. A. Walter, and J. L. C. Wright, *J. Chem. Soc., Chem. Comm.*, **1994**, 2073.

3 **1**: $[\alpha]_D^{27}$ +462.0° (*c* 0.08, MeOH); UV λmax 267 nm (ε 17600); IR (Nujol) 3300, 1725, 1670, and 1635 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 1.32 and 1.34 (3H each, s, H-16 and H-17), 1.36 (3H, s, H-18), *ca* 1.36 (1H, m, H-5β), 1.78 (1H, dd, *J*=5.9 and 15.8 Hz, H-6β), 1.91 (1H, tq, *J*=2.2 and 13.6 Hz, H-5α), 2.55 (1H, dt, *J*=2.0 and 14.2 Hz, H-6α), 2.71 (1H, dt, *J*=5.3 and 11.6 Hz, H-11a), 2.88 (1H, dd, *J*=7.3 and 12.1 Hz, H-10endo), 3.21 (1H, t, *J*=12.1 H-10exo), 3.91 (1H, dt, *J*=5.3 and 11.5 Hz, H-4a), 4.01 (1H, t, *J*=11.5 Hz, H-1α), 4.33 (1H, dd, *J*=5.3 and 11.5 Hz, H-1β), 4.59 and 4.91 (1H each, s, H-11), 5.42 (1H, dt, *J*=7.3 and 12.1 Hz, H-9), 5.73 (1H, d, *J*=12.1 Hz, H-8), 6.22 (1H, d, *J*=15.0 Hz, H-14), 6.44 (1H, dd, *J*=11.5 and 15.0 Hz, H-13), and 6.91 (1H, d, *J*=11.7 Hz, H-12); ^{13}C NMR (100 MHz, $CDCl_3$): δ 29.3 and 30.0 (C-16 and C-17), 33.0 (C-18), 33.6 (C-5), 36.1 (C-4a), 37.6 (C-10), 38.4 (C-6), 42.7 (C-11a), 68.8 (C-1), 71.2 (C-15), 73.5 (C-7), 111.8 (C-19), 120.6 (C-13), 127.9 (C-9), 131.5 (C-4), 137.5 (C-8), 137.7 (C-12), 144.7 (C-11), 150.1 (C-14), and 170.5 (C-3). MS *m/z* 314 (M^+-H_2O). Found: *m/z* 314.1881. Calcd for $C_{20}H_{26}O_3$: M-H_2O, 314.1881.

4 Y. Kashman and A. Groweiss, *Tetrahedron Lett.*, **1978**, 4833.

5 Crystal data for **1**: $C_{20}H_{28}O_4$ MW (332.42), orthorhombic, space group $P2_12_12_1$, a=13.544(3), b=23.034(2), c=6.574(3) Å, V=2050.9(9) Å, λ=1.54178 Å, Z=4, D_c=1.180 g/cm^3, T=296 K, μ(Cu-Kα)=6.3 cm^{-1}. 1811 reflection with $|F_0|>3\sigma(|F_0|)(2\theta max=120.1°)$ converged at R=0.046 and Rw=0.025.

6 **2**: $[\alpha]_D^{27}$ +135.7° (*c* 0.07, MeOH); UV λmax 240 nm (ε 16800); IR (film) 3400, 1660, and 1640 cm^{-1}; ^1H NMR ($CDCl_3$): δ 1.33(3H, s, H-18), 1.48-1.55 (1H, m, H-5β), 1.77 (6H, s, H-16 and H-17), 1.84-1.90 (2H, m, H-5α and H-6α), 2.07-2.13 (1H, m, H-6β), 2.79 (1H, dt, *J*=4.0 and 9.2 Hz, H-4a), 2.83 (1H, overlapped, H-11a), 2.86 (1H, dd, *J*=8.8 and 13.9 Hz, H-10α), 3.28 (1H, dd, *J*=8.4 and 13.9 Hz, H-10β), 3.52 and 3.60 (2H, AB, *J*=11.4 Hz, H-3), 3.78 (1H, t-like, *J*=8.4 Hz, H-1α), 3.95 (1H, t-like, *J*=8.4 Hz, H-1β), 4.87 and 4.92 (1H each, s, H-19), 5.42-5.52 (1H, overlapped with other signals, H-9), 5.51 (1H, d, *J*=15.4 Hz, H-12), 5.54 (1H, d, *J*=12.1 Hz, H-8), 5.83 (1H, br d, *J*=11.0 Hz, H-14), and 6.50 (1H, dd, *J*=11.0 and 15.4 Hz, H-13); ^{13}C NMR ($CDCl_3$): δ18.4 (C-17), 23.6 (C-5), 26.0 (C-16), 32.9 (C-18), 35.4 (C-10), 39.2 (C-6), 49.4 (C-11a), 50.3 (C-4a), 64.7 (C-3), 69.9 (C-1), 73.9 (C-7), 87.3 (C-4), 112.4 (C-19), 124.6 (C-12), 126.7 (C-13), 129.0 (C-9), 132.1 (C-14), 136.0 (C-11), 137.1 (C-8), and 146.3 (C-15); MS *m/z* 318 (M^+). Found: *m/z* 318.2175. Calcd for $C_{20}H_{30}O_3$: M, 318.2193.

7 **3**; oil, IR (film) 3400, 1740, 1650, 1630, and 1235 cm^{-1}; ^1H NMR ($CDCl_3$): δ 2.07 (3H, s, OAc); ^{13}C NMR ($CDCl_3$): δ 21.1 ($OCO\underline{C}H_3$) and 171.0 ($O\underline{C}OCH_3$); MS *m/z* 360 (M^+).

8 A. Groweiss and Y. Kashman, *Tetrahedron*, **39**, 3385 (1983).