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Marine Terpenes and Terpenoids. II.[1] Structures of Three Cembrane-type Diterpenes, Sarcophytol-C, Sarcophytol-D, and Sarcophytol-E, from the Soft Coral, *Sarcophyton glaucun* Q. *et.* G

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Three new minor cembrane-type diterpenes, sarcophytol-C, sarcophytol-D, and sarcophytol-E, were isolated from the lipid extract of the soft coral, *Sarcophyton glaucum* Q. *et* G., collected in southern Japan. Their structures were characterized on the basis of spectral evidence and degradative studies by ozonolysis.

Keywords——sarcophytol-C; sarcophytol-D; sarcophytol-E; cembrane-type diterpenes; *Sarcophyton glaucum*; Alcyonacea; Coelenterate

During the past decade, a number of cembrane-type diterpenes have been found in coelenterates belonging to the orders Gorgonacea and Alcyonacea (soft corals).[3,4] In some cases they have been reported to have anticancer activities.[5] A cembrane-type lactone, sarcophine (I), which is believed to be a repellent protecting the soft coral against predators, and its 16-deoxo derivative (II) have been found in the soft coral, *Sarcophyton glaucum* Q. *et* G., in the Red Sea.[6] Considerable variation in the relative contents of these two compounds and related minor constituents was noted,[6] depending on the collection and period of the year.

This species is commonly distributed in the coral reefs of the Indian and Pacific Oceans. Our study on the lipid extract of *S. glaucum* collected at Ishigaki Island, Okinawa prefecture, in June of 1977 revealed that it contained four major cembrane-type diterpenes named sarcophytol-A (IIIa), sarcophytol-A acetate (IIIb), sarcophytol-B (IV), and sarcophytonin-A (V).[1]

On further investigation of minor constituents of subsequently collected samples, three new cembrane-type diterpenes were found in addition to the major ones, as mentioned below. However, the compound corresponding to I or II, which was reported to amount to 4% in some cases, has not yet been confirmed to be present. This paper describes the isolation and characterization of three minor cembrane-type diterpenes.

The lipid extract of *S. glaucum* collected in the same place as before in September of 1978 was subjected to repeated silica gel column chromatography, and yielded sarcophytol-C (VI), sarcophytol-D (VIIIa), and sarcophytol-E (IXa), as well as IIIa, IIIb, and IV. Only sarcophytol-D (VIIIa) was obtained in a crystalline state. The former three compounds as well as IIIa, IIIb, IV, and V were found to be susceptible to autoxidation when purified. Sarcophytol-C (VI), $[\alpha]_D$ +121°, obtained as an oil, corresponded to a molecular formula of $C_{20}H_{32}O_2$ on the basis of its elemental analysis and mass spectrum (MS) (M^+, *m/e* 304), and contained five unsaturations. Compound VI showed a hydroxyl absorption at 3300 cm^{-1} in its infrared (IR) spectrum, but was resistant to acetylation with acetic anhydride (Ac_2O) and pyridine (C_5H_5N). The carbon magnetic resonance (^{13}C-NMR) spectrum of VI in pyridine-d_5 (C_5D_5N) (Table I) indicated the presence of six sp^2 carbons and three carbon atoms bearing oxygen atoms. Accordingly, it appeared that VI possessed three double bonds, an ethereal linkage, and two rings.

The proton magnetic resonance (^{1}H-NMR) spectrum of VI in deuterochloroform ($CDCl_3$) indicated the presence of two secondary methyl groups due to an isopropyl group (δ 0.97, 1.10, each 3H, d, J=7 Hz), a tertiary methyl group geminal to an oxygen atom (δ 1.13, 3H, s), and

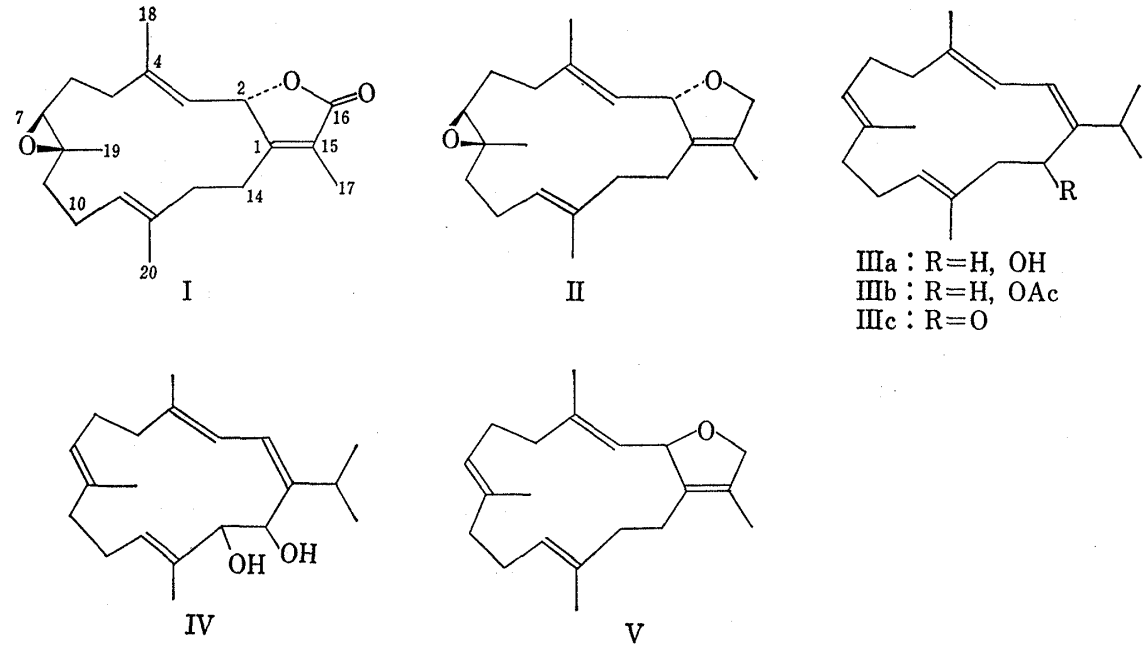

Chart 1

two vinylic methyl groups (δ 1.58, 6H, br. s). The olefinic signals at δ 5.60 and 6.40 (2H, ABq, J=16.4 Hz), appearing as an AB system, and the IR absorption at 960 cm^{-1} indicated the presence of a *trans*-disubstituted double bond. Since VI showed no ultraviolet (UV) absorption corresponding to conjugated double bonds, the *trans*-disubstituted double bond should be located between two quaternary carbons bearing oxygen atoms. Compound VI possesses two additional isolated trisubstituted double bonds, each of which carries a methyl group, and their olefinic signals were observed between δ 4.9 and 5.1 as broad multiplets. Although the signal at δ 3.03 (1H, d.d, J=10, 3.7 Hz), together with the signal at δ 1.13 (3H, s), is indicative of the presence of a trisubstituted epoxide ring carrying a methyl group, which has frequently been found in cembrane-type diterpenes from soft corals,[3,4] the signals at δ 27.1 (q) and 72.9 (s) in its ^{13}C-NMR spectrum suggested the presence of a methyl group linked to a quaternary carbinyl carbon in VI. Reduction of VI with lithium aluminium hydride ($LiAlH_4$) in ether (Et_2O) afforded VIIa as the sole product, mp 102—104°, $[\alpha]_D$ −121°, $C_{20}H_{34}O_2$ (M^+, *m/e* 306), which could be led to a monoacetate (VIIb) in the usual manner. In the ^{1}H-NMR spectrum of VIIa, the signals of the epoxide-methine proton and an AB system of olefinic protons in VI had disappeared and the signals appeared as follows: δ 2.55, 1H, sept, J=7 Hz; 4.66, 1H, t, J=7 Hz; 5.25, 1H, d.d, J=8, 5 Hz, while the methyl signals in VIIa remained unchanged. The signal at δ 2.55, (1H, sept, J=7 Hz) indicated that the isopropyl group was linked to an sp^2 quaternary carbon in view of its multiplicity and chemical shift,[1] and the signal at δ 4.66 (1H, t, J=7 Hz), showed it to be a hydroxy-methine signal. The acetoxy-methine signal was observed at δ 5.55 (1H, t, J=6 Hz) in the monoacetate VIIb. The ^{13}C-NMR data (see "Experimental") for VIIa, as well as the ^{1}H-NMR data, suggested that treatment of VI with $LiAlH_4$ yielded an allylic secondary hydroxyl group by opening an epoxide ring in VI with migration of a double bond, as has been reported in the conjugate reduction of α,β-unsaturated epoxides.[7] The above result can be rationalized only by assuming an allylic epoxide ring moiety having an isopropyl group in VI. The ^{13}C-NMR spectrum of VI accounts for 20 carbons, and would result in a structure possessing a 14-membred ring with an isopropyl, two vinylic methyls, and a tertiary carbinyl methyl group. Ozonolysis of VI gave levulinic acid. Based on the above results and the assumption of biogenetic similarity between VI and four major cembrane-type diterpenes, IIIa, IIIb, IV, and V, the structure

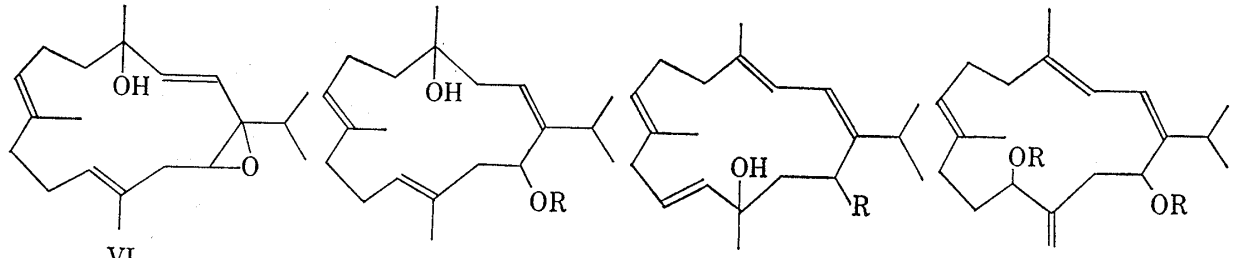

Chart 2

TABLE I. ^{13}C-NMR Chemical Shifts and Splitting Patterns (ppm in C_5D_5N) for Sarcophytol-C (VI), Sarcophytol-D (VIIIa), and Sarcophytol-E (IXa)

Carbons	VI		Carbons	VIIIa		Carbons	IXa	
1	67.2(s)		1	151.8(s)		1, 12	150.6(s)	152.4(s)
2	117.9(d)		2, 3	117.9(d)	121.9(d)	2, 3	118.5(d)	122.4(d)
3	143.2(d)		4, 8	135.0(s)	135.0(s)	4, 8	134.9(s)	135.0(s)
4	72.9(s)		5	39.2(t)		5	40.3(t)	
5	40.4(t)		6	25.1(t)		6	26.0(t)	
6, 10	24.8(t)	25.5(t)	7	125.3(d)		7	125.3(d)	
7, 11	125.3(d)	120.8(d)	9	38.5(t)		9	35.5(t)	
8, 12	132.0(s)	132.9(s)	10	126.4(d)		10	33.6(t)	
9	38.5(t)		11	140.0(d)		11, 14	68.2(d)	68.3(d)
13	43.9(t)		12	72.6(s)		13	43.6(t)	
14	67.2(d)		13	50.9(t)		15	28.1(d)	
15	36.0(d)		14	66.9(d)		16, 17	24.0(q)	24.5(q)
16, 17	18.5(q)	18.7(q)	15	26.1(d)		18, 19	16.0(q)	16.5(q)
18	27.1(q)		16, 17	28.2(q)	28.5(q)	20	110.1(t)	
19, 20	15.0(q)	17.6(q)	18, 19	16.7(q)	17.0(q)			
			20	24.5(q)				

of VI was proposed to be as illustrated in Chart 2. The geometry of each of the two trisubstituted double bonds was assigned as *trans* from their signals in the ^{13}C-NMR spectrum, which showed a significant shielding of methyl groups caused by vicinal carbons in the same way as in *trans*-polyisoprene.[8]

Sarcophytol-D (VIIIa), mp 131—134°, $[\alpha]_D$ +125°. $C_{20}H_{32}O_2$ (M^+, *m/e* 304), displayed a hydroxyl absorption at 3350 cm^{-1} in its IR spectrum. Acetylation of VIIIa in the usual manner gave a monoacetate (VIIIb), whose IR spectrum showed a hydroxyl absorption at 3300 cm^{-1}, so that the two oxygen atoms of VIIIa were attributable to two hydroxyl groups. The ^{1}H-NMR spectrum of VIIIa showed the presence of an isopropyl group (δ 1.11, 3H, d, J=7 Hz; 1.14, 3H, d, J=7 Hz; 2.63, 1H, sept, J=7 Hz), two vinylic methyl groups (δ 1.64, 3H, d, J=1 Hz; 1.75, 3H, s), a tertiary methyl group geminal to a hydroxyl group (δ 1.35, 3H, s), a hydroxymethine proton (δ 4.88, 1H, t, J=7 Hz), and five olefinic protons (δ 5.0, 1H, br. m; 5.56, 1H, d, J=16 Hz; 5.6—5.8, 1H, m; 5.95, 6.17, 2H, ABq, J=11 Hz) suggesting a structural analogy to IIIa and IV. The presence of a 1,1,4,4-tetrasubstituted conjugated diene in VIIIa was implied by the presence of ^{1}H-NMR signals at δ 5.95 and 6.17 as an AB system (J=11 Hz), and IR (1670 and 1610 cm^{-1}) and UV (248 nm, ε 23600) absorptions. The conformation of the diene was deduced as *s-trans* on the basis of the similarity of the ^{1}H-NMR, IR, and UV

data between VIIIa and IIIa or IV.[1] deshielded vinylic methyl signal at δ 1.75 is linked to the conjugated diene and the slightly broadened nature of the signal at δ 5.95 suggests allylic coupling with the methyl signal at δ 1.75. The presence of an isolated *trans*-disubstituted double bond which is vicinal to a quaternary carbon in VIIIa was indicated by its ^{1}H-NMR signals at δ 5.56 (1H, d, J=16 Hz) and δ 5.6—5.8 (1H, m), and IR absorption at 975 cm^{-1}. The degenerated nature of the olefinic proton signal at δ 5.0 (1H, br. m) together with the methyl signal at δ 1.64 (3H, d, J=1 Hz) implied the existence of an isolated trisubstituted double bond carrying a methyl group. The remaining ^{1}H-NMR signals of VIIIa were those of allylic protons (δ 2.15, 4H, br. s) and of the protons due to two isolated methylenes (δ 1.97, 2H, d, J=7 Hz; 2.66, 2H, d, J=5 Hz). The signal at δ 2.66 (2H, d, J=5 Hz) was attributed to a methylene group flanked by two double bonds, in view of the chemical shift. Compound VIIIa could be oxidized by manganese dioxide (MnO_2) into an $\alpha,\beta,\gamma,\delta$-diunsaturated ketone (VIIIc), as judged from the UV (294 nm, ε 6500) and the IR (1670 cm^{-1}) absorptions. Since these UV and IR data are similar to those of IIIc (UV, 294 nm, ε 6040; IR, 1680 cm^{-1}), which was obtained from IIIa by oxidation with chromic trioxide (CrO_3)-C_5H_5N, it was suggested that the locations of the secondary hydroxyl group in VIIIa and IIIa are the same. This was confirmed by the detection of isobutyric acid on ozonolysis of VIIIa. The ^{13}C-NMR signal at δ 50.9 (t) of VIIIa showed a significant downfield shift as compared with the signal at δ 46.2 (t) assigned to C-13 in IIIa, so that it is reasonable to locate another carbinyl carbon at C-12. Thus, the structure VIIIa, having a cembrane skeleton, was proposed for sarcophytol-D. This was further supported by the detection of levulinic acid on ozonolysis of VIIIa in the manner described above.

Sarcophytol-E (IXa), also an oil, $[\alpha]_D$ +160°, exhibited a molecular formula of $C_{20}H_{32}O_2$ (M^+, m/e 304), and a hydroxyl absorption at 3400 cm^{-1} in its IR spectrum. The ^{1}H-NMR spectrum of IXa indicated the presence of an isopropyl group (δ 1.08, 3H, d, J=7 Hz; 1.10, 3H, d, J=7 Hz; 2.64, 1H, sept, J=7 Hz), two vinylic methyl groups (δ 1.51, 3H, s; 1.75, 3H, s), and five olefinic protons (δ 4.95, 1H, br. s; 5.1—5.2, 1H, br. m; 5.16, 1H, br. s; 5.93, 6.04, 2H, ABq, J=10.5 Hz), also suggesting a structural analogy to IIIa, IIIb, IV, and VIIIa. The UV absorption (251 nm, ε 19600) and the ^{1}H-NMR signals (δ 5.93 and 6.04, 2H, ABq, J=10.5 Hz) of IXa indicated the presence of an *s-trans*-1,1,4,4-tetrasubstituted diene system. The existence of a terminal methylene group was also implied by the presence of ^{1}H-NMR signals at δ 4.95 and 5.16 (each 1H, br. s) and IR absorptions (1650 and 910 cm^{-1}). The two oxygen atoms of IXa were assigned to two isolated secondary hydroxyl groups, whose hydroxy-methine signals were observed at δ 4.12 (1H, d.d, J=8,3 Hz) and at δ 5.0 overlapped with an olefinic signal due to a trisubstituted olefin. Acetylation of IXa gave a diacetate (IXb), whose acetoxy-methine signals appeared at δ 6.04 (1H, d.d, J=6,3 Hz) and at δ 5.0 (1H, d.d, J=8, 3 Hz). Since the ^{13}C-NMR spectrum of IXa (Table I) showed no signal due to sp^3 quaternary carbons, both secondary hydroxyl groups in IXa were implied to be flanked by sp^2 quaternary centers and methylene groups. The remaining signals were ascribed to methylene protons, which occurred as a broad singlet centered at δ 2.1 (10H) including allylic protons.

The structure of the C-1 to C-7 segment in IXa, which is common in IIIa, IIIb, IV, and VIIIa, was confirmed by the ^{13}C-NMR data (Table I) and the detection of levulinic acid on ozonolysis of IXa. The formation of isobutyric acid on ozonolysis of IXa showed that the hydroxyl group in IXa is located at C-14. The methylene carbon signal at δ 43.6 (t) in its ^{13}C-NMR spectrum was ascribed to C-13, which is located between a carbinyl carbon and an sp^2 quaternary carbon as in the case of IIIa and IIIb. These results led us to propose a cembrane skeleton for IXa. The remaining hydroxyl group in IXa was deduced to be located at C-11 on the ground that the ^{13}C-NMR signals at δ 134.9 (s) and 135.0 (s) in IXa, assignable to either C-4 or C-8, were both devoid of β-effects[9] of hydroxyl groups. Thus the structure IXa was proposed for sarcophytol-E. The absolute configuration of each compound (VI, VIIIa, and IXa) is currently under investingation.

Experimental

Melting points were determined on a Kofler hot stage apparatus and are uncorrected. IR spectra were recorded on a Hitachi 215 spectrometer, UV spectra on a Shimadzu UV-220 spectrometer in ethanol solution, and ^{1}H-NMR and ^{13}C-NMR spectra on a JEOL FX-100 spectrometer operating at 100 (^{1}H-NMR in $CDCl_3$ solution) and 25.00 (^{13}C-NMR in C_5D_5N solution) MHz with tetramethylsilane (TMS) as an internal standard. Mass spectra were determined with a JMS D-300 mass spectrometer.

Isol tion of Each Compound (VI, VIIIa, and IXa)——Minced and partly dried *S. glaucum* (12.5 kg), which had been collected at the same place as before on Ishigaki Island in September 1978, was extracted exhaustively first with methanol (MeOH) and then with chloroform ($CHCl_3$)–MeOH (2: 1). The dried residue amounted to 7.3 kg. The combined extract was concentrated and partitioned by Folch's method,[10] giving 1.6 kg of lipids as a viscous dark brown oil. A part of the lipids (400 g) was dissolved in hexane–$CHCl_3$ (4: 1), and passed through a column of silica gel (HF_{254}, Merck). Elution with the same solvent and later with $CHCl_3$ removed most of the nonpolar lipids which contained major cembrane-type diterpenes (IIIa, IIIb, and IV). Further elution with a hexane–ethyl acetate (AcOEt) gradient of increasing polarity (4: 1 to 2: 1) gave viscous brown lipids (90 g), which contained IV, VI, VIIIa, and IXa. This product in turn was rechromatographed with the same solvent system. Hexane–AcOEt (4: 1)-eluted fractions, which contained mainly VI, were rechromatographed with benzene–(Et_2O) (4: 1) to give a pure sample of VI (420 mg) as an oil. Hexane–AcOEt (3: 1)-eluted fractions containing VIIIa were concentrated to yield a crystalline precipitate, which, after recrystallization from acetone ($(CH_3)_2CO$), gave a pure sample of VIIIa (280 mg) in a crystalline state. Further elutions with hexane–AcOEt (2: 1) then AcOEt gave fractions containing IXa, which were rechromatographed with benzene–Et_2O (4: 1), and further rechromatographed with $CHCl_3$–$(CH_3)_2CO$ (15: 1) to afford a pure sample of IXa (520 mg) as an oil.

The *Rf* values of VI, VIIIa and IXa on thin-layer chromatography (TLC) (Silica gel HF_{254}, Merck) were 0.6, 0.4, and 0.25 (hexane–AcOEt=2: 1 as solvent), respectively.

Sarcophytol-C——Colorless oil, $[\alpha]_D$ +121° (c=1.4, $CHCl_3$). IR ν_{max}^{neat} cm^{-1}: 3300, 960, 840, 820. *Anal.* Calcd for $C_{20}H_{32}O_2$: C, 78.89; H, 10.59. Found: C, 78.73; H, 10.62. MS *m/e*: 304 (M^+), 286 (M^+-H_2O), 137, 109, 43 (base peak). ^{1}H-NMR: see the text. ^{13}C-NMR: see Table I.

$LiAlH_4$ Reduction of VI——A solution of 100 mg of VI in 3 ml of Et_2O was treated with an excess of $LiAlH_4$ and the mixture was stirred overnight at room temperature. Work-up in the usual manner gave a white powder, and which was crystallized from hexane–$(CH_3)_2CO$ as colorless needles, mp 102—104°. $[\alpha]_D$ −121° (c=0.48, $CHCl_3$). IR ν_{max}^{Nujol} cm^{-1}: 3300, 1100, 1000, 860, 830. *Anal.* Calcd for $C_{20}H_{34}O_2$: C, 78.38; H, 11.18. Found: C, 78.46; H, 11.20. MS *m/e*: 306 (M^+), 288 (M^+-H_2O), 270 ($M^+-2\times H_2O$), 137 (base peak), 109, 43. ^{1}H-NMR ($CDCl_3$) δ: 1.09 (6H, d, J=7 Hz, 16- and 17-CH_3), 1.14 (3H, s, 18-CH_3), 1.65 (6H, br.s, 19- and 20-CH_3), 2.55 (1H, sept, J=7 Hz, 15-CH), 4.66 (1H, t, J=7 Hz, 14-CH), 5.0 (2H, br.m, 7- or 11-CH), 5.25 (1H, d.d, J=8, 5 Hz, 2-CH). ^{13}C-NMR (C_5D_5N) δ: 15.6 (q), 17.1 (q), 23.5 (t), 24.4 (q), 25.4 (t), 26.2 (q), 27.1 (t), 29.1 (q), 38.4 (t), 39.7 (d), 40.4 (t), 47.4 (t), 69.5 (d), 72.9 (s), 120.4 (d), 127.2 (d), 128.7 (d), 132.5 (s×3).

Acetylation of VIIa——Compound VIIa (50 mg) was acetylated in the usual manner with Ac_2O–C_5H_5N at room temperature, and VIIb (41 mg) was obtained as a colorless oil, $[\alpha]_D$ −81° (c=1.0, $CHCl_3$). IR ν_{max}^{neat} cm^{-1}: 3300, 1720, 1240, 1020. *Anal.* Calcd for $C_{22}H_{36}O_3$: C, 75.81; H, 10.41. Found: C, 76.01; H, 10.51. MS *m/e*: 348 (M^+), 330 (M^+-H_2O), 288 (M^+−AcOH), 270 (M^+−AcOH−H_2O), 137, 43 (base peak). ^{1}H-NMR ($CDCl_3$) δ: 1.00, 1.11 (each 3H, d, J=7 Hz, 16- or 17-CH_3), 1.15 (3H, s, 18-CH_3), 1.57, 1.60 (each 3H, br.s, 19- or 20-CH_3), 2.03 (3H, s, –OC(O)CH_3), 5.0 (2H, br.m, 7- and 11-CH), 5.36 (1H, d.d, J=8.6, 5.4 Hz, 2-CH), 5.55 (1H, t, J=6 Hz, 14-CH).

Sarcophytol-D (VIIIa)——Colorless needles, mp 131—134° $[\alpha]_D$ +125° (c=0.94, $CHCl_3$). IR ν_{max}^{Nujol} cm^{-1}: 3350, 1670, 1610, 1210, 975, 830. UV λ_{max}^{EtOH} nm: 248 (ε 23600). *Anal.* Calcd for $C_{20}H_{32}O_2$: C, 78.89; H, 10.59. Found: C, 78.65; H, 10.57. MS *m/e*: (M^+), 289 (M^+-CH_3), 286 (M^+-H_2O), 261 ($M^+-C_3H_7$), 43 (base peak). ^{1}H-NMR: see the text. ^{13}C-NMR: see Table I.

Acetylation of VIIIa——Compound VIIIa (40 mg) gave, on acetylation as described above, VIIIb (26 mg) as a colorless oil. $[\alpha]_D$ +254° (c=0.93, $CHCl_3$). IR ν_{max}^{neat} cm^{-1}: 3300, 1735, 1240, 1020, 980, 850. MS *m/e*: 346 (M^+), 286 (M^+−AcOH), 43 (base peak). ^{1}H-NMR ($CDCl_3$) δ: 1.02, 1.14 (each 3H, d, J=7 Hz, 16- or 17-CH_3), 1.26 (3H, s, 20-CH_3), 1.61 (3H, s, 19-CH_3), 1.73 (3H, s, 18-CH_3), 2.05 (3H, s, –OC(O)CH_3), 2.08 (2H, d, J=6 Hz, 13-CH_2), 2.15 (4H, br. s, 5- and 6-CH_2), 2.62 (2H, d, J=6 Hz, 9-CH_2), 5.09 (1H, br. m, 7-CH), 5.58 (1H, d, J=16 Hz, 11-CH), 5.6—5.8 (1H, m, 10-CH), 6.13, 6.22 (2H, ABq, J=11 Hz, 2- and 3-CH).

MnO_2 Oxidation of VIIIa——A solution of VIIIa (26 mg) in AcOEt (4 ml) was stirred overnight at room temperature in the presence of 1.3 g of MnO_2. The mixture was filtered and the products were purified by silica gel column chromatography. Elution with hexane–AcOEt (7: 1) gave 8 mg of VIIIc as a colorless oil, $[\alpha]_D$ −0.1° (c=0.89, $CHCl_3$). IR ν_{max}^{neat} cm^{-1}: 3300, 1670, 1635, 1580, 975, 860. UV λ_{max}^{EtOH} nm: 212 (ε 10500), 227 (ε 9500), 294 (ε 6500). MS *m/e*: 302 (M^+), 284 (M^+-H_2O), 269 ($M^+-H_2O-CH_3$), 173 (base peak), 135, 43. ^{1}H-NMR ($CDCl_3$) δ: 1.02, 1.17 (each 3H, d, J=7 Hz, 16- or 17-CH_3), 1.26 (3H, s, 20-CH_3), 1.53 (3H, d, J=1.2 Hz, 19-CH_3), 1.80 (3H, d, J=1.2 Hz, 18-CH_3), 2.16 (4H, d, J=4 Hz, 5- and 6-CH_2), 2.57,

3.01 (2H, ABq, $J=16$ Hz, 13-CH_2), 2.59 (2H, d, $J=3.4$ Hz, 9-CH_2), 5.0 (1H, br. m, 7-CH), 5.3—5.6 (2H, m, 10- and 11-CH), 6.12, 6.20 (2H, ABq, $J=12$ Hz, 2- and 3-CH).

CrO_3-C_5H_5N Oxidation of IIIa——A solution of IIIa (200 mg) in C_5H_5N (1 ml) was treated with CrO_3–C_5H_5N complex (500 mg in 5 ml) at room temperature for 6 hr. The mixture was filtered and extracted with Et_2O, and the organic layer was washed with 2 N HCl then with saturated brine, and concentrated. Purification by silica gel column chromatography with hexane–$CHCl_3$ (1: 1) gave IIIc (17 mg) as a colorless oil, $[\alpha]_D$ 0° ($c=0.9$, $CHCl_3$). IR ν_{max}^{neat} cm^{-1}: 1680, 1650, 910, 850. UV λ_{max}^{EtOH} nm: 236 (ε 9300), 294 (ε 6040). MS *m/e*: 286 (M^+), 271 (M^+-CH_3), 243 ($M^+-C_3H_7$), 135 (base peak), 43. ^{1}H-NMR ($CDCl_3$) δ: 1.08 (6H, d, $J=$ 7 Hz, 16- and 17-CH_3), 1.48 (3H, s, 19-CH_3), 1.73 (3H, br. s, 18- or 20-CH_3), 1.78 (3H, d, $J=1$ Hz, 18- or 20-CH_3), 2.10 (8H, br. s, 5-, 6-, 9- and 10-CH_2), 2.68 (1H, sept, $J=7$ Hz, 15-CH), 3.15 (2H, s, 13-CH_2), 5.0 (2H, br. m, 7- and 11-CH), 5.89, 6.21 (2H, ABq, $J=12$ Hz, 2- and 3-CH).

Sarcophytol-E (IXa)——Colorless oil, $[\alpha]_D$ +160° ($c=1.0$, $CHCl_3$). IR ν_{max}^{neat} cm^{-1}: 3400, 1650, 1100, 910, 850. UV λ_{max}^{EtOH} nm: 251 (ε 19600). *Anal.* Calcd for $C_{20}H_{32}O_2$: C, 78.89; H, 10.59. Found: C, 78.55; H, 10.53. MS *m/e*: 304 (M^+), 268 ($M^+-2\times H_2O$), 243 ($M^+-C_3H_7$), 225 ($M^+-C_3H_7-H_2O$), 137, 109, 43 (base peak). ^{1}H-NMR: see the text. ^{13}C-NMR: see Table I.

Acetylation of IXa——Compound IXa (180 mg) gave, on acetylation as described above, IXb (120 mg) was obtained as a colorless oil. $[\alpha]_D$ +232° ($c=1.1$, $CHCl_3$). IR ν_{max}^{neat} cm^{-1}: 1740, 1650, 1240, 1050, 910, 860. *Anal.* Calcd for $C_{24}H_{36}O_4$: C, 74.19; H, 9.34. Found: C, 74.44; H, 9.32. MS *m/e*: 388 (M^+), 328 (M^+-AcOH), 268 ($M^+-2\times$AcOH), 43 (base peak). ^{1}H-NMR ($CDCl_3$) δ: 1.01, 1.06 (6H, d, $J=7$ Hz, 16- and 17-CH_3), 1.47 (3H, d, $J=1$ Hz, 19-CH_3), 1.74 (3H, d, $J=1$ Hz, 18-CH_3), 2.01, 2.07 (each 3H, s, $-OC(O)CH_3$), 2.50 (1H, sept, $J=7$ Hz, 15-CH), 4.91, 5.0 (each 1H, br. s, 20-CH_2), 5.0 (1H, d.d, $J=8$, 3 Hz, 11-CH), 6.04 (1H, d.d, $J=6.3$ Hz, 14-CH), 6.05, 6.29 (2H, ABq, $J=12$ Hz, 2- and 3-CH).

Ozonolyses of VI, VIIIa, and IXa——a) A solution of VI (30 mg) in 3 ml of $CHCl_3$ at −15° (MeOH-ice) was treated with O_3 (1.5% (v/v)), followed by oxidative work-up (15% (w/v) H_2O_2, warmed to 60°), as reported by Dauben *et al.*[11] Levulinic acid was identified by co-chromatography in GC (PEGS, at 130°) with an authentic sample, and also by TLC (*Rf* 0.6 solvent, $CHCl_3$–$Et_2O=5:1$) as the methyl ester.

b) Compound VIIIa was treated in the same way as in (a) and the product mixture was directly analyzed by GC (Sp-1200, at 110°). Isobutyric acid was identified by co-chromatography in GC with an authentic sample. Levulinic acid was identified similarly.

c) Compound IXa was treated in the same way as in (a) and isobutyric and levulinic acids were identified similarly.

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