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# Marine Terpenes and Terpenoids. VII.1) Minor Cembranoid Derivatives, Structurally Related to the Potent Anti-tumor-Promoter Sarcophytol A, from the Soft Coral *Sarcophyton glaucum*

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**Eight new cembranoids, sarcophytol M (3), sarcophytol N (9a), sarcophytol J (11a), sarcophytol H and its diacetate (15a and 15b), sarcophytol O (18), sarcophytol I (19a) and sarcophytol G (24a), and known cembranoids nephthenol (7) and sinulariol D (8), were isolated from the soft coral *Sarcophyton glaucum*. Their structures were determined from the spectroscopic properties and by chemical conversion. Sarcophytol M (3) was found to be the enantiomer of the known compound cembrenol from a terrestrial plant. Sarcophytol N (9a) and sarcophytol J (11a) were the geometrical isomers at C-3 of the major components sarcophytol A (1a) and sarcophytol B (2a), which are potent anti-tumor-promoters. Sarcophytol H and sarcophytol O were identical with the diols 15a and 18, respectively, which were previously synthesized from 1a. Sarcophytol I (19a) and sarcophytol G (24a) were the diastereoisomers of the known compounds sarcophytol E (22a) and sarcophytol D (21), respectively, and their absolute configurations were determined by chemical conversion of two 11,12*E*-epoxides (20 and 23).**

**Keywords** soft coral; *Sarcophyton glaucum*; cembranoid; sarcophytol G, H, I, J, M, N, O; Alcyonacea

The occurrence of abundant production and accumulation of cembranoids in soft corals is intriguing, and it is not yet clear whether these metabolites serve simply as repellents of predators. The cembranoids may play another as yet unknown physiological role in these benthic animals. The abundance of cembranoids contrasts with the minimal contents of such common lipids as triglycerides or wax esters2) which are of vital importance in evolutionarily higher animals. Among the various soft corals, *Sarcophyton glaucum* is one of the most intensively studied species because of its wide distribution in the coral reefs of Indo-Pacific coastal waters, but its major cembranoids have been found to vary according to the localities where the corals were collected.3) The predominant component of *S. glaucum* we collected at Ishigaki Island, Okinawa, is sarcophytol A (**1a**), which is associated with the minor component sarcophytol B (**2a**) and its congeners4); this represented nearly a quarter of the total lipids obtained by Folch partition5) of the crude extract.

Recently, Fujiki and co-workers found that sarcophytol A and sarcophytol B inhibit the activity of the powerful tumor-promoter teleocidin,6) in a two-stage carcinogenesis experiment on the mouse dorsal skin using dimethylbenzanthracene as an initiator.7,8) The effects on the growth and average number of tumors were observed even in experiments using amounts of **1a** equimolar with those of teleocidin, in contrast to other known natural anti-tumor-promoters (flavonoids,9) pentagalloyl glucose,10) dihydroxycembranoids from tobacco leaves,11) *etc.*) which generally require the application of one thousand times or more of the promoter quantity. In view of this unexpected activity of **1a** and **2a**, and also the fact that they are virtually the first examples of natural anti-tumor-promoters that are as effective as retinoids but lacking their severe toxicity (hypervitaminosis A),12) we re-investigated the cembranoids of *S. glaucum*. As a result, we obtained eight new compounds (**3**, **9a**, **11a**, **15a**, **15b**, **18**, **19a**, and **24a**) which are structurally related to **1a** or **2a**, along with the known cembranoids (−)-nephthenol (**7**) and sinulariol D (**8**).

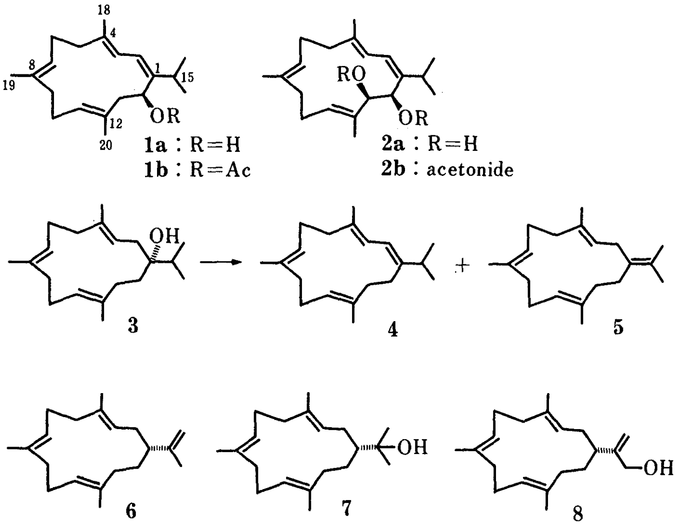

Chart 1

Compound **3** (sarcophytol M) was found to be a monohydroxycembratriene. The proton and carbon-13 nuclear magnetic resonance ($^{1}$H- and $^{13}$C-NMR) spectra of **3** showed typical signals due to the simple 3*E*,7*E*,11*E*-triunsaturated cembrane ring as found in nephthenol (**7**)13) and sinulariol D (**8**),1) which were simultaneously isolated, and in cembrene A (**6**),14,15) which is generally assumed to be the common precursor of natural cembranoids. The hydroxyl group is linked to C-1 ($^{13}$C-NMR, $\delta$ 76.9) and exerts the $\beta$-substituent effect on C-15 ($\delta$ 34.7), the signal of which is shifted by 6 ppm down-field relative to that of **1a**. The signals of C-16 and C-17 were, in turn, shifted up-field by the $\gamma$-effect of the hydroxyl group and were indistinguishable from those of the ring methyl groups ($\delta$ 15.2—16.9). Treatment of **3** with SOCl$_2$ in pyridine gave cembrene C [**4**, $^{1}$H-NMR, $\delta$ 5.93, br d, $J$ = 11.5 Hz; 6.02, d, $J$ = 11.5 Hz; 1.74, 3H, s. Ultraviolet (UV) spectrum, 253 nm ($\varepsilon$ 19000)],16) and its isopropylidene isomer (**5**). The spectral properties of **3** agreed well with those of 1-hydroxy-3*E*,7*E*,11*E*-cembratriene (cembrenol), which was isolated from the resin of the terrestrial plant *Boswellia carteri*.17) The absolute configuration at C-1 of cembrenol has been shown to be *S* by correlation with 4*S*-terpinenol. The reported specific rotation of cembrenol (−150°, in EtOH)

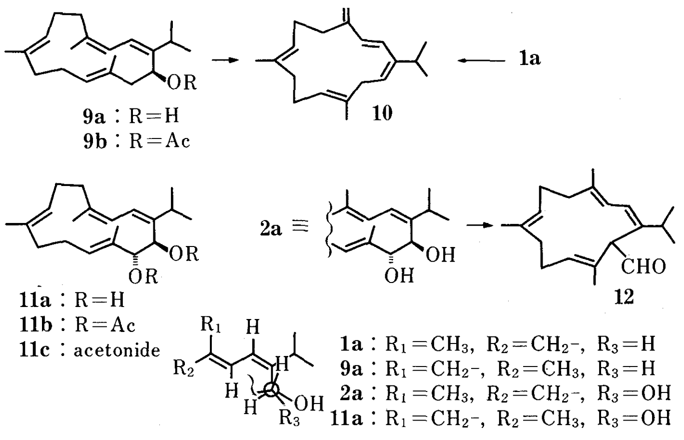

Chart 2

is opposite in sign to that of **3** (+160°) so that **3** is the enantiomer of cembrenol.

Compound **9a** (sarcophytol N) is the geometrical isomer of sarcophytol A (**1a**) and its spectroscopic properties were very similar to those observed for **1a**.[4a] The $^1$H-NMR spectrum of **9a** exhibited the signals of an isopropyl group ($\delta$ 1.07 and 1.09, each d, $J$=7.0 Hz), a 1,1,4,4-tetrasubstituted diene (6.09 and 6.18, each d, $J$=11.5 Hz), three olefinic methyl groups (1.51, 1.58, 1.77), two olefinic protons centered at $\delta$ 4.85, and one hydroxymethine proton at $\delta$ 5.06 (t, $J$=7.5 Hz). The hydroxyl group is located at C-14 and upon addition of europium trisdipivaloylmethanate the signals of the isopropyl group were moved to a lower field. The absolute configuration at C-14 was shown to be *S*, the same as that of **1a**, by Horeau determination.[18] The UV spectrum (250 nm, $\varepsilon$ 20000) and the mass spectrum (MS) of **9a** were also indistinguishable from those of **1a**. The prominent difference found between **1a** and **9a** was that in the $^{13}$C-NMR, the signal of one of the three methyl groups linked to olefin bonds is shifted to a lower field ($\delta$ 23.4 or 23.6 or 26.3). This indicates that one of these olefin bonds is *Z*-oriented in **9a**.[19] This and the up-field-shifted C-5 signal ($\delta$ 31.1; **1a**, $\delta$ 38.8 or 39.6) are almost the same as those of 3*Z*-cembrene A, isolated from the frontal gland of a termite,[15,20] and its C-17 dimethylallyl homolog cericerene, isolated from a scale insect.[21] Treatment of **9a** with *p*-toluenesulfonic acid (TsOH) in benzene caused dehydration and gave a conjugated triene **10** [$^1$H-NMR: $\delta$ 5.03 (1H, d, $J$=1.5 Hz), 5.08 (1H, d, $J$=2.0 Hz), 6.34 and 6.40 (each 1H, d, $J$=16.5 Hz); UV 267 ($\varepsilon$, 19000), 277 (25000), 288 (20000) nm]. This triene was also obtained from **1a** by the same acid treatment. The $^{13}$C-NMR of **10** showed two methyl signals at $\delta$ 14.8 and 17.3 and indicated them to be linked to *E*-trisubstituted double bonds,[19] so that the *Z*-double bond in **9a** corresponds to that at C-3. The signals of H-2 and H-3 are distinguishable from the broad H-3 signal by allylic coupling. The nuclear Overhauser effect (NOE) differential spectrum of **9a** showed the presence of NOEs between H-3 ($\delta$ 6.09, br d, $J$=11.5 Hz) and the hydroxymethine proton (H-14), and between H-3 and H-18, while irradiation at H-2 ($\delta$ 6.18, d, $J$=11.5 Hz) caused NOE at H-16,17. Prominent NOE was observed between H-2 and a signal at $\delta$ 2.68 (dt, $J$=3.5, 13.0 Hz), which is attributable to one of the C-5 methylene protons. These results show sarcophytol N (**9a**) to be the 3*Z* isomer of **1a**.

Compound **11a** (sarcophytol J) is a 3*Z* isomer of sarcophytol B (**2a**)[4a] and showed common spectroscopic properties (Experimental) with **2a** except for those related to the C-3 double bond. NOE enhancement was observed between H-2 and H-16,17, and between H-3 and H-14,18. A double triplet signal at $\delta$ 2.66 (H-5, dt, $J$=3.5, 13.0 Hz) showed marked NOE, as in **9a**, on irradiation of H-2. The down-field-shifted olefinic methyl ($\delta$ 23.2 or 23.5 or 26.4) and the up-field-shifted C-5 carbon ($\delta$ 31.0) were observed again in **11a**. The stereochemistry at C-13 and C-14, and the geometry of the C-1 double bond of **2a** were not clarified in the previous report.[4a] The results of the $^1$H-NMR examination of **2a** were in fact quite similar to those of **1a**[22] and showed NOE between H-2 and H-16,17,18, and between H-3 and H-14. This and the NOEs observed in **9a** and **11a** indicate that the relative dispositions of carbons in **1a**, **2a**, **9a** and **11a** are common regarding C-1 to C-4 and C-14 (Chart 2).[23] The large NOE enhancement (13—17%) observed between H-14 and H-3 in these compounds is the result of this arrangement; this forces H-14 to be exposed in the deshielding portion of the magnetic field induced by the 1,3-diene. As a result, the protons at C-14 of these systems (*vide infra*) occur at unusually low-field ($\delta$ 4.73—5.12) for allylic hydroxymethine protons. Another common feature between **2a** and **11a** is their chemical shifts and coupling constants of H-13 and H-14 (**2a**, $\delta$ 3.93 and 4.73, each dd, $J$=8.0 and 2.0 Hz; **11a**, $\delta$ 3.94 and 4.79, each dd, $J$=9.5 and 2.0 Hz). They showed NOE between H-13 and H-15 but none between H-13 and H-14. Compounds **2a** and **11a** gave acetonides (**2b** and **11c**) whose 13,14-vicinal coupling constants (**2b**, $\delta$ 4.01, 4.91, each d, $J$=8.5 Hz; **11c**, $\delta$ 3.96, 4.91, each d, $J$=9.0 Hz) were almost unchanged. Both **2a** and **11a** have, therefore, partially eclipsed glycol groups and undergo only minor conformational changes in the cembrane ring on going from the glycol to the acetonide. These results and the NOE observations obtained above indicate the nearly opposite spatial arrangement of H-13 and H-14 and lead to the partial conformation given in Chart 2 for **2a** and **11a**.[23] This was supported by the fact that **2a** underwent alkyl bond migration and gave the ring-contracted aldehyde **12** (53% yield) on brief treatment in benzene with TsOH. Thus, the configurations of **2a** and **11a** were concluded to be 13*R*,14*R* or 13*S*,14*S*. Formation of **9a** and **11a** from **1a** and **2a** by photo-isomerization was ruled out by serial $^1$H-NMR and thin-layer chromatographic (TLC) examinations of the purified and stored samples. Recent studies on the biosynthesis of cyclic monoterpenes using acyclic precursors showed that linalyl pyrophosphate is a more efficient precursor than geranyl or neryl derivatives,[24] though in that case only the *Z*-double bond is possible. Although the majority of natural cembranoids bear a 3*E*-double bond, the discovery of 3*Z*-cembranoids (3*Z*-cembrene A,[15] **9a**, **11a**, and those from an *Eremophila* plant[25]) indicates that geranyllinalyl pyrophosphate is an apparent precursor in the biosynthesis of both 3*E*- and 3*Z*-cembranoids.

Sarcophytols H (**15a**), O (**18**), I (**19a**), and G (**24a**) are isomers having the same molecular formula, $C_{20}H_{32}O_2$. The diacetate **15b** was isolated simultaneously. Their common UV spectra (249—251 nm) and the $^1$H-NMR chemical shifts (Experimental), especially that of the strongly deshielded hydroxymethine protons ($\delta$ 4.79—5.12), showed

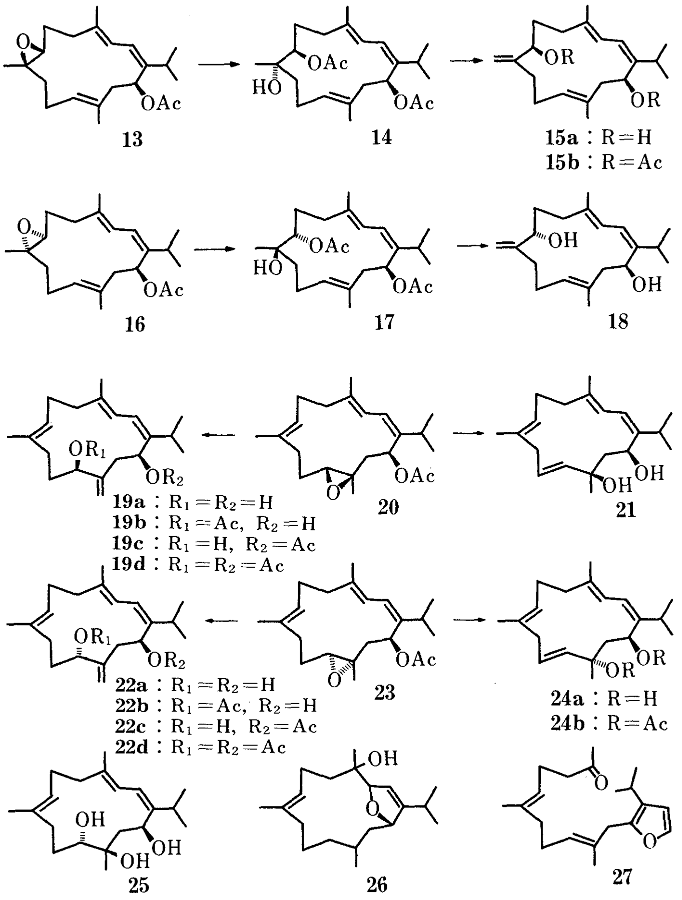

Chart 3

the presence of 1,3-diene and 14-hydroxyl groups. Compounds **15a**, **18** and **19a** each bear one terminal methylene group, and **24a** has one tertiary hydroxyl group and one *E*-disubstituted double bond (Experimental). Compounds **19a** and **24a** are the diastereoisomers of the previously isolated sarcophytol E (**22a**) and sarcophytol D (**21**), respectively, whose absolute configuration was not reported.[4b] Unlike **21**, **24a** was resistant to acetylation and only after prolonged heating ($Ac_2O$ in pyridine, 70 °C, 2 d), did it give the diacetate **24b**.

*m*-Chloroperbenzoic acid oxidation of **1b** gives two 7,8*E*-epoxides (**13** and **16**) as the major products,[22] and small amounts of a 3,4- and two 11,12- (**20** and **23**) epoxides. The lack of NOE between the methyl group and the vicinal oxymethine proton of the epoxide rings indicated that the latter three compounds are also *E*-epoxides. The ratio of the major 7*E*-epoxides (**13**:**16**=*ca.* 4.5:3)[22] reflects the markedly flexible nature of the cembranoid system. This indicates that the seemingly homogeneous $^1$H-NMR spectrum of **1b**, even at −50 °C, is in fact the result of at least two stable conformers having opposite spatial arrangements of C-19, with respect to the gross plane of the ring. Both of the 7*E*-epoxides have previously been converted to the corresponding olefins **15a** and **18**,[22] and sarcophytols H and O were found to be identical with **15a** and **18**, respectively. Thus, sarcophytol H (**15a**) is 7*R*,14*S*-dihydroxycembra-1*Z*,3*E*,8(19),11*E*-tetraene and sarcophytol O (**18**) is its C-7 diastereomer. The absolute configuration at C-11 of **19a** was shown to be *R*, and that of **22a** to be *S*, by application of micro Horeau determination[26] to each of the 14-monoacetates (**19c** and **22c**), which were prepared in low yields by mild alkaline hydrolysis of the diacetates **19d** and **22d**. The 11*E*-epoxide **20** was treated in the same way, by hydrolysis ($HClO_4$ in acetone), acetylation, dehydration ($SOCl_2$–pyridine), and hydrolysis. The resultant major product **19a** was identical with sarcophytol I, and the stereochemistry of the starting epoxide was accordingly shown to be 11*R*,12*R*. Similar treatment of the other 11*E*-epoxide **23** gave **22a**, with a small amount of unreacted triol **25**, which was identical with sarcophytol E. Treatment of each of the epoxides **20** and **23** with diphenyl diselenide–$NaBH_4$ followed by $H_2O_2$[27] gave sarcophytol D (**21**) and sarcophytol G (**24a**) respectively. It was thus established that sarcophytol I (**19a**) is 11*R*,14*S*-dihydroxycembra-1*Z*,3*E*,7*E*,12(20)-tetraene and sarcophytol E (**22a**) is its C-11 diastereomer, and sarcophytol G (**24a**) is 12*S*,14*S*-dihydroxy-1*Z*,3*E*,7*E*,10*E*-cembratetraene and sarcophytol D (**21**) is its C-12 diastereomer.

Two additional compounds (**26** and **27**), simultaneously isolated, are artefacts derived from **1a**, which were referred to in the preceding report. Their formation has been reported in the autoxidation of **1a**.[22]

## Experimental

Melting points were determined on a Kofler hot-stage melting point apparatus and are uncorrected. Infrared (IR) spectra were determined on a JASCO A102 spectrometer. UV spectra were determined on a Hitachi EPS-3T spectrometer. Optical rotations were determined in $CHCl_3$ on a JASCO DIP-4 digital polarimeter. NMR spectra were determined in $CDCl_3$ on a JEOL JMS GX-270 spectrometer at 270 MHz ($^1$H) and on a JEOL JNM FX-90Q spectrometer at 22.5 MHz ($^{13}$C) with tetramethylsilane as an internal standard. $^{13}$C-NMR signals were assigned by using INEPT and by comparison of chemical shift data with those in the literature. MS were determined on a JEOL JMS D300 mass spectrometer. Chromatography was done by flash chromatography[28] using silica gel (Wako gel C-300, 200—300 mesh, Wako Pure Chemical Industries).

**Fractionation and Separation of *S. glaucum* Extract** Partially dried and minced material of *S. glaucum* (30 kg), collected at Ishigaki Island, was extracted exhaustively first with MeOH and then $CHCl_3$–MeOH (2:1). The combined extract was concentrated and mixed with $CHCl_3$–MeOH (2:1, 12 l). The precipitated inorganic salts were removed by filtration and the filtrate was concentrated to afford crude extract. This was submitted in portions to Folch partition.[5] Each 200 g of the extract was shaken with a mixture of $CHCl_3$–MeOH–$H_2O$ (8:4:3, 2 l) and the lower extracts were combined. Evaporation of the solvent gave 3.2 kg of crude lipid. The crude lipid (970 g) was partitioned in portions (200 g each) with a mixture of hexane–MeOH–$H_2O$ (20:10:2, 2 l) and the upper layer and lower layer were separated. The upper layer was washed with the lower layer of the same solvent mixture as above. Similarly, the lower layer of the extract was washed with the upper layer of the solvent mixture. Evaporation of the combined two upper extracts gave 164 g of a mixture of less polar lipids. Also, evaporation of the combined two lower layer extracts gave 35 g of a mixture of more polar components containing polyhydroxysterols. The less polar lipid mixture (600 g) was charged on a column of silica gel (2 kg) and eluted (1 l/fraction) with a mixture of hexane–benzene (1:1, frs. 1—20), benzene (frs. 21—53), $CHCl_3$ (frs. 54—80) and a gradient of MeOH in $CHCl_3$ (0 to 10%, 81—120).

Fractions 2—8 contained **1a** and compounds having similar polarities to **1a**. Chromatography of this mixture with ethyl acetate–hexane (1:19) gave 180 g of **1a** and a mixture containing **1a**, **3**, **15b** and **27**. Repeated chromatography of a portion (700 mg) of this mixture over 7% $AgNO_3$-impregnated silica gel with ethyl acetate–hexane (1:19 and then 1:12) gave **15b** (280 mg), **27** (150 mg) and **3** (120 mg) in that order.

Fractions 9—13 contained **1a**, **7**, **8**, **9a** and **26** and an unidentified compound designated sarcophytol F. A portion of this fraction (6.6 g) was separated by chromatography with ethyl acetate–hexane (1:9) to give **1a** (3 g), a mixture (2.2 g) containing **7**, **9a** and **26**, and a mixture (3 g) mainly composed of sarcophytol F, sterols, and a very small amount of **8**. Compound **8** was separated in small amounts by the same chromatography as above. Chromatography of the mixture containing **7**, **9a** and **26** with ethyl acetate–hexane (1:9) and ethyl acetate–hexane–$CHCl_3$ (1:19:5) gave a mixture (350 mg) containing **7**, and a mixture (1.78 g) containing **9a** and **26**. Compound **7** was purified by chromatography with ethyl acetate–hexane (1:13). Chromatography of the mixture (1.26 g) containing **9a** and **26** with ethyl acetate–hexane (1:9) gave 400 mg of **26** and a mixture (380 mg) of **9a** and **26**. Chromatography of this mixture over 7% $AgNO_3$-impregnated silica gel with ethyl acetate–hexane (1:13) gave 137 mg of **9a**.

Fractions 63—64 contained **2a**, **11a**, **15a**, **19a**, **21**, **24a** and unidentified compounds including sarcophytol K. Chromatography of a portion (7.5 g) of this mixture with ethyl acetate–hexane (2:8) gave first **24a** (2 g), then **2a** (2 g) and a mixture (3 g) containing **11a**, **15a**, **19a**, **21** and sarcophytol K, and unknown compounds. Chromatography of the mixture with MeOH–$CHCl_3$ (1:99) gave a mixture (2.5 g) containing **15a** and **19a**, and a mixture (500 mg) containing **11a**, **21**, and sarcophytol K. Crystallization of the mixture containing **15a** from $CHCl_3$–hexane gave 780 mg of **15a**. Separation of the mother liquor with $CHCl_3$–MeOH (99:1) and $Et_2O$–hexane (1:15) gave **19a** (120 mg). Chromatography of the mixture containing **11a** with ethyl acetate–hexane (3:7) gave **11a** (170 mg), **21** (90 mg) and sarcophytol K (80 mg).

Fractions 72—93 contained **22a** as the major component, with smaller amounts of **18** and unidentified compounds. Chromatography of a portion (1.5 g) of this mixture with $Et_2O$–$CHCl_3$ (5:4) gave first a mixture of two unidentified compounds (30 mg), and a mixture (388 mg) containing **18**, and then pure **22a** (1.0 g). Chromatography of the mixture containing **18** over 7% $AgNO_3$-impregnated silica gel with MeOH–$CHCl_3$ (1:19) gave **18** (40.7 mg).

**Sarcophytol M (3)** $[\alpha]_D$ +57° ($c=0.94$), +160° ($c=0.68$, EtOH). $^1$H-NMR $\delta$: 0.92, 0.94 (each 3H, d, $J=7.0$ Hz), 1.55, 1.56, 1.59 (3H, s each), 4.89 (1H, br t, $J=6.6$ Hz), 5.00 (1H, br t, $J=7.0$ Hz), 5.24 (1H, br t, $J=7.5$ Hz). $^{13}$C-NMR $\delta$: C-1 (76.9), C-2,13,14 (33.5, 34.7, 35.0), C-3 (121.0), C-4,8,12 (133.3, 135.6, 136.6), C-5,9 (39.6, 39.9), C-6,10 (23.8, 24.9), C-7,11 (123.3, 126.0), C-15 (34.7), C-16,17,18,19,20 (15.2, 16.4, 16.7 (2C), 16.9). IR $\nu_{max}^{neat}$ cm$^{-1}$: 3470. MS $m/z$: 290 ($M^+$), 247, 229, 153, 127, 81, 71. High-resolution MS [Found (Calcd)] $m/z$: $C_{20}H_{34}O$ ($M^+$), 290.25981 (290.26091).

**$SOCl_2$ Treatment of 3** A solution of **3** (22 mg) in pyridine (0.2 ml) was treated with $SOCl_2$ (30 $\mu$l) at room temperature for 1 h. The mixture was diluted with $Et_2O$ and the $Et_2O$ solution was washed with $H_2O$, 5% HCl solution and saturated NaCl solution, then the solvent was evaporated off. The residue was submitted to preparative TLC and developed three times with hexane. Two major bands were detected by spraying with $H_2O$, and after drying they were extracted with ethyl acetate. Evaporation of the solvent gave **4** (9.3 mg) from the lower band, and **5** (6.6 mg) from the upper band. **4**: $^1$H-NMR $\delta$: 1.04 (6H, d, $J=6.6$ Hz), 1.51, 1.58, 1.74 (3H each, s), 4.99, 5.01 (1H each, br t, $J=7.0$ Hz), 5.93 (1H, br d, $J=11.5$ Hz, H-3), 6.02 (1H, d, $J=11.5$ Hz, H-2). UV $\lambda_{max}^{EtOH}$ nm ($\varepsilon$): 253 (19000). MS $m/z$: 272 ($M^+$), 257, 229, 136, 121, 93. **5**: $^1$H-NMR $\delta$: 1.56, 1.64, 1.67 (each 3H, s), 1.59 (6H, s), 2.70 (2H, d, $J=6.5$ Hz, H-2), 4.9—5.1 (3H, m). MS $m/z$: 272 ($M^+$), 257, 229, 121, 107, 93.

**Nephthenol (7)** $[\alpha]_D$ −37° ($c=0.43$) (lit.,[13] −36°). $^1$H-NMR $\delta$: 1.20 (6H, s), 1.57 (9H, s), 4.95, 5.01, 5.11 (each 1H, t, $J=6.5$—$7.5$ Hz). IR $\nu_{max}^{neat}$ cm$^{-1}$: 3370. MS $m/z$: 290 ($M^+$), 272, 257, 229.

**Sinulariol D (8)** Compound **8** was identical with sinulariol D previously obtained from *S. mayi*,[1] by direct comparisons of their $^1$H-NMR spectra and behavior in several TLC systems.

**Sarcophytol N (9a)** $[\alpha]_D$ −280° ($c=0.77$). $^1$H-NMR $\delta$: 1.07, 1.09 (each 3H, d, $J=7.0$ Hz), 1.51, 1.58, 1.77 (each 3H, s), 2.52 (1H, sept, $J=7.0$ Hz, H-15), 2.68 (1H, dt, $J=3.5$, 13.0 Hz), 4.85 (2H, m), 5.06 (1H, t, $J=7.5$ Hz, H-14), 6.09 (1H, br d, $J=11.5$ Hz, H-3), 6.18 (1H, d, $J=11.5$ Hz, H-2). $^{13}$C-NMR $\delta$: C-1 (144.7), C-2,3 (121.7, 122.3), C-4 (137.0), C-5 (31.1), C-6,10 (25.0, 26.3), C-7 (124.1), C-8 (134.3), C-9 (39.5), C-11 (126.8), C-12 (130.1), C-13 (44.9), C-14 (68.3), C-15 (26.3), C-16,17,18 (23.4, 23.6, 26.3), C-19,20 (15.4, 17.2). UV $\lambda_{max}^{EtOH}$ nm ($\varepsilon$): 250 (20000). IR $\nu_{max}^{neat}$ cm$^{-1}$: 3350, 1660, 1610, 1005, 870, 835. MS $m/z$: 288 ($M^+$), 273, 270, 255, 245, 227, 203, 137, 109. High-resolution MS [Found (Calcd)] $m/z$: $C_{20}H_{32}O$ ($M^+$), 288.24411 (288.24521). Acetylation ($Ac_2O$–pyridine) of **9a** gave **9b**, $[\alpha]_D$ −150° ($c=0.42$). $^1$H-NMR $\delta$: 1.02, 1.09 (each 3H, d, $J=7.0$ Hz), 1.51, 1.60, 1.78, 2.02 (each 3H, s), 2.47 (1H, sept, $J=7.0$ Hz), 2.65 (1H, dt, $J=3.5$, 13.0 Hz), 4.82—4.93 (2H, m), 6.06 (1H, dd, $J=11.5$, 3.5 Hz, H-14), 6.21 (2H, s, H-2,3). MS $m/z$: 330 ($M^+$), 315, 270, 255, 245, 227, 137, 109.

**TsOH Treatment of Sarcophytol A (1a) and Sarcophytol N (9a)** A solution of **1a** (230 mg) in benzene (5 ml) was treated with 5 mg of TsOH at 40 °C for 1 h. The mixture was diluted with $Et_2O$ and the $Et_2O$ solution was washed with saturated $NaHCO_3$ solution, $H_2O$, and saturated NaCl solution, then the solvent was evaporated off. Column chromatography of the residue with hexane gave **10** (139 mg). Similarly, sarcophytol N (**9a**, 50 mg) was treated in this way, giving 32 mg of **10**. $^1$H-NMR $\delta$: 1.12 (6H, d, $J=7.0$ Hz), 1.54, 1.63 (each 3H, s), 2.75 (2H, d, $J=8.0$ Hz, H-13), 2.76 (1H, sept, $J=7.0$ Hz, overlapped), 4.83 (1H, br t, $J=7.0$ Hz), 5.03 (1H, d, $J=1.5$ Hz, H-18), 5.08 (1H, d, $J=2.0$ Hz, H-18), 4.98—5.07 (1H, m), 5.55 (1H, t, $J=8.0$ Hz, H-14), 6.34, 6.40 (each 1H, d, $J=16.5$ Hz, H-2,3). $^{13}$C-NMR $\delta$: C-1,4 (146.1, 149.0), C-2,3,7,11 (122.2, 124.5, 125.4, 126.3), C-5,6 (30.8, 30.9), C-8,12 (132.3, 132.6), C-9,13 (36.4, 39.8), C-10 (24.8), C-14 (130.1), C-15 (28.7), C-16,17 (22.8 (2C)), C-18 (116.5), C-19,20 (14.8, 17.3). UV $\lambda_{max}^{EtOH}$ nm ($\varepsilon$): 267 (19000), 277 (25000), 288 (20000). IR $\nu_{max}^{neat}$ cm$^{-1}$: 1605, 1580, 955. MS $m/z$: 270 ($M^+$), 255, 227, 199, 187, 185.

**Sarcophytol J (11a)** mp 115—116 °C, $[\alpha]_D$ −277° ($c=1.50$). $^1$H-NMR $\delta$: 1.08, 1.09 (each 3H, d, $J=7.0$ Hz), 1.54, 1.59, 1.76 (each 3H, s), 2.53 (1H, sept, $J=7.0$ Hz, H-15, overlapped), 2.66 (1H, dt, $J=3.5$, 13.0 Hz, H-5), 3.94 (1H, dd, $J=9.5$, 2.0 Hz, H-13), 4.79 (1H, dd, $J=9.5$, 2.0 Hz, H-14), 4.84 (1H, m), 5.15 (1H, m), 6.00 (1H, br d, $J=11.0$ Hz, H-3), 6.19 (1H, d, $J=11.0$ Hz, H-2). $^{13}$C-NMR $\delta$: C-1 (142.2), C-2,3,7 (122.0, 123.4, 123.8), C-4 (137.0), C-5 (31.0), C-6,10 (25.0, 26.1), C-9 (38.8), C-11 (131.0), C-8,12 (132.6, 134.1), C-13 (71.5), C-14 (79.9), C-15 (27.4), C-16,17,18 (23.2, 23.5, 26.4), C-19 (15.8), C-20 (11.7). UV $\lambda_{max}^{EtOH}$ nm ($\varepsilon$): 250 (14000). IR $\nu_{max}^{neat}$ cm$^{-1}$: 3330, 1660, 1610, 880, 855, 825. MS $m/z$: 304 ($M^+$), 286, 137, 109. High-resolution MS [Found (Calcd)] $m/z$: $C_{20}H_{32}O_2$ ($M^+$), 304.24131 (304.24021). Acetylation ($Ac_2O$–pyridine) of **11a** gave **11b**, $[\alpha]_D$ −233° ($c=0.49$). $^1$H-NMR $\delta$: 1.00, 1.10 (each 3H, d, $J=7.0$ Hz), 1.53, 1.58, 1.80, 2.02, 2.04 (each 3H, s), 2.53 (1H, sept, $J=7.0$ Hz, H-15), 2.64 (1H, dt, $J=3.5$, 13.0 Hz), 4.85 (1H, m), 5.31 (1H, m), 5.46 (1H, d, $J=10.5$ Hz, H-13), 6.12 (1H, d, $J=10.5$ Hz, H-14), 6.22 (2H, s, H-2,3). MS $m/z$: 388 ($M^+$), 328, 303, 285, 177, 135, 109.

**Acetonides of 2a and 11a** A solution of **2a** (60 mg) in acetone (2 ml) was treated with a trace of concentrated HCl. The solution was diluted with $Et_2O$, and washed with $H_2O$ and saturated NaCl solution, then the solvent was evaporated off. The residue was purified by chromatography eluting with hexane to give 60 mg of **2b**. The acetonide **11c** (17.8 mg) was prepared from 21.2 mg of **11a** in a similar way. **2b**: $^1$H-NMR (100 MHz) $\delta$: 1.10 (6H, d, $J=7.0$ Hz), 1.47 (6H, s), 1.55 (3H, s), 1.69 (6H, s), 2.64 (1H, sept, $J=7.0$ Hz), 4.01 (1H, d, $J=8.5$ Hz, H-13), 4.84 (1H, m), 4.91 (1H, d, $J=8.5$ Hz, H-14), 5.36 (1H, m), 5.76 (1H, br d, $J=11.5$ Hz, H-3), 6.22 (1H, d, $J=11.5$ Hz, H-2). IR $\nu_{max}^{neat}$ cm$^{-1}$: 1240, 1167, 1050, 890, 855, 840. MS $m/z$: 344 ($M^+$), 329, 301, 287, 286, 269, 261, 179. **11c**: $^1$H-NMR $\delta$: 1.07, 1.10 (each 3H, d, $J=7.0$ Hz), 1.46, 1.48, 1.53, 1.63, 1.73 (each 3H, s), 2.55 (1H, sept, $J=7.0$ Hz, overlapped), 2.60 (1H, dt, $J=3.5$, 13.0 Hz), 3.96 (1H, d, $J=9.0$ Hz, H-13), 4.75 (1H, m), 4.91 (1H, d, $J=9.0$ Hz, H-14), 5.11 (1H, br dd, $J=10.5$, 3.5 Hz), 5.98 (1H, br d, $J=10.5$ Hz, H-3), 6.25 (1H, d, $J=10.5$ Hz, H-2). IR $\nu_{max}^{neat}$ cm$^{-1}$: 1240, 1170, 1055, 885, 850. MS $m/z$: 344 ($M^+$), 329, 301, 287, 286, 269, 261, 179.

**TsOH Treatment of Sarcophytol B (2a)** A solution of **2a** (60.0 mg) in benzene (15 ml) was treated with 8 mg of TsOH at 40 °C for 15 min. The mixture was worked up as done for **1a** and **9a** above. Column chromatography of the residue with ethyl acetate–hexane (1:19) gave **12** (32.9 mg) as an oil. **12**, $[\alpha]_D$ −35° ($c=2.66$). $^1$H-NMR $\delta$: 1.01, 1.05 (each 3H, d, $J=7.0$ Hz), 1.50, 1.71, 1.72 (each 3H, s), 2.40 (1H, sept, $J=7.0$ Hz), 3.49 (1H, br s, H-13), 4.92 (1H, br t, $J=6.6$ Hz), 5.10 (1H, m), 5.64 (1H, br d, $J=11.5$ Hz, H-3), 6.33 (1H, d, $J=11.5$ Hz, H-2), 9.60 (1H, d, $J=2.0$ Hz, H-14). $^{13}$C-NMR $\delta$: C-1,4 (136.8, 137.2), C-2,3,7,11 (124.0, 124.6, 126.0, 128.2), C-5,9 (39.2, 39.5), C-6,10 (24.4, 25.9), C-8 (134.0), C-12 (129.0), C-13 (63.7), C-14 (199.5), C-15 (38.3), C-16,17 (21.2, 21.8), C-18,19,20 (14.8, 16.5, 16.9). MS $m/z$: 286 ($M^+$), 268, 257, 243, 215. High-resolution MS [Found (Calcd)] $m/z$: $C_{20}H_{30}O$ ($M^+$), 286.2292 (286.2296).

**Sarcophytol H (15a)** mp 143—145 °C, $[\alpha]_D$ +147° ($c=0.86$). $^1$H-NMR, UV and IR spectra: see ref. 22. $^{13}$C-NMR $\delta$: C-1 (147.5), C-2,3 (120.0 (2C)), C-4 (135.6), C-5,9 (34.0, 34.6), C-6 (31.1), C-7,14 (68.9, 71.9), C-8 (150.1), C-10 (24.9), C-11 (126.9), C-12 (132.2), C-13 (45.7), C-15 (27.2), C-16,17 (24.1, 25.9), C-18,20 (16.9, 18.4), C-19 (110.6). High-resolution MS [Found (Calcd)] $m/z$: $C_{20}H_{32}O_2$ ($M^+$), 304.24114 (304.24024). It was shown to be identical with **15a** prepared from **1a** by direct comparisons of their $^1$H-NMR and MS spectra, and behavior in several TLC systems.

**Sarcophytol H Diacetate (15b)** $[\alpha]_D$ +195° ($c=0.85$). $^1$H-NMR $\delta$: 1.03 (3H, d, $J=6.6$ Hz), 1.14 (3H, d, $J=7.0$ Hz), 1.55, 1.78, 2.02, 2.04 (each 3H, s), 2.50 (1H, sept, $J=7.0$ Hz), 5.11 (1H, m), 5.13, 5.15 (each 1H, s), 5.22 (1H, t, $J=6.6$ Hz), 5.90 (1H, dd, $J=10.5$, 4.0 Hz, H-14), 6.05 (1H, br d, $J=11.5$ Hz, H-3), 6.24 (1H, d, $J=11.5$ Hz, H-2). $^{13}$C-NMR $\delta$: C-1,8 (142.8, 145.3), C-2,3 (121.1, 121.8), C-4 (136.0), C-5,9 (34.1, 35.6), C-6 (28.2), C-7,14 (71.2, 73.7), C-10 (24.4), C-11 (127.2), C-12 (131.2), C-13 (42.3), C-15

(28.0), C-16,17 (23.6, 25.3), C-18,20 (16.2, 18.7), C-19 (113.2), OAc (21.2, 21.4, 170.1, 170.5). UV $\lambda_{\max}^{\mathrm{EtOH}}$ nm ($\varepsilon$): 251 (17000). IR $\nu_{\max}^{\mathrm{neat}}$ cm$^{-1}$: 1740, 1650, 960, 910, 895. MS *m/z*: 388 (M$^+$), 328, 286, 268. High-resolution MS [Found (Calcd)] *m/z*: $C_{24}H_{36}O_4$ (M$^+$) 388.26210 (388.26140).

**Sarcophytol O (18)** Oil, $[\alpha]_D$ +124° ($c$ = 1.02). $^1$H-NMR, UV and MS: see ref. 22. High-resolution MS [Found (Calcd)] *m/z*: $C_{20}H_{32}O_2$ (M$^+$), 304.2399 (304.2403). It was shown to be identical with **18** prepared from **1a** by direct comparisons of their $^1$H-NMR spectra and MS, and behavior in several TLC systems.

**Sarcophytol I (19a)** Oil, $[\alpha]_D$ −31° ($c$ = 1.30). $^1$H-NMR $\delta$: 1.07, 1.10 (each 3H, d, $J$ = 7.0 Hz), 1.74, 1.70 (each 3H, s), 2.49 (1H, sept, $J$ = 7.0 Hz, H-15), 4.11 (1H, m, H-11), 4.79 (1H, t, $J$ = 7.5 Hz, H-14), 4.91, 5.15 (each 1H, br s, H-20), 5.24 (1H, m, H-7), 6.10 (1H, br d, $J$ = 11.5 Hz, H-3), 6.15 (1H, d, $J$ = 11.5 Hz, H-2). $^{13}$C-NMR $\delta$: C-1 (147.1), C-2,3 (120.2, 120.5), C-4 (136.7), C-5 (38.5), C-6 (24.9), C-7 (126.8), C-8 (133.8), C-9 (35.0), C-10 (33.1), C-11,14 (69.8, 71.0), C-12 (150.3), C-13 (41.3), C-15 (29.2), C-16,17 (23.3, 24.7), C-18,19 (16.4, 17.2), C-20 (111.0). UV $\lambda_{\max}^{\mathrm{EtOH}}$ nm ($\varepsilon$): 250 (14000). IR $\nu_{\max}^{\mathrm{neat}}$ cm$^{-1}$: 3350, 1640, 970, 890. MS *m/z*: 304 (M$^+$), 286, 271, 268, 261, 243, 225, 215, 137, 109. High-resolution MS [Found (Calcd)] *m/z*: $C_{20}H_{32}O_2$ (M$^+$), 304.2398 (304.2402). Compound **19a** (25 mg) was acetylated in $Ac_2O$–pyridine (1 : 3, 0.2 ml) at room temperature overnight. The mixture was worked up as usual and the acetate was dissolved in 0.5 ml of 2.5% KOH in MeOH at room temperature and monitored by TLC. After 30 min the mixture was diluted with $H_2O$ and extracted with $Et_2O$. The extract was washed with $H_2O$ and saturated NaCl solution, and the solvent was evaporated off. Chromatography of the residue with ethyl acetate–hexane (1 : 19 and 1 : 9) gave **19d** (5.8 mg), **19c** (1.8 mg), **19b** (5.6 mg) and **19a** (6.5 mg) in that order.

**Sarcophytol I 11-Monoacetate (19b)** Oil, $[\alpha]_D$ −105° ($c$ = 0.36). $^1$H-NMR $\delta$: 1.06 (3H, d, $J$ = 7.0 Hz), 1.09 (3H, d, $J$ = 6.6 Hz), 1.63, 1.74 (each 3H, s), 2.11 (3H, s), 2.39 (1H, sept, $J$ = 7.0 Hz, H-15), 2.54 (1H, dd, $J$ = 14.0, 10.5 Hz, H-13), 4.35 (1H, ddd, $J$ = 10.5, 3.5, 2.0 Hz, H-14), 4.93, 5.00 (each 1H, s, H-20), 5.06 (1H, dd, $J$ = 6.5, 6.0 Hz, H-11), 5.21 (1H, m, H-7), 6.10 (1H, d, $J$ = 10.5 Hz, H-2), 6.53 (1H, br d, $J$ = 10.5 Hz, H-3).

**Sarcophytol I 14-Monoacetate (19c)** Oil $[\alpha]_D$ +38° ($c$ = 1.12). $^1$H-NMR $\delta$: 1.04 (3H, d, $J$ = 6.6 Hz), 1.07 (3H, d, $J$ = 7.0 Hz), 1.74, 1.80 (each 3H, s), 2.02 (3H, s), 2.50 (1H, sept, $J$ = 7.0 Hz, H-15), 4.08 (1H, br d, $J$ = 12.0 Hz, H-11), 4.86, 5.13 (each 1H, br s, H-20), 5.04 (1H, br d, $J$ = 9.5 Hz, H-7), 5.91 (1H, dd, $J$ = 7.0, 6.5 Hz, H-14), 6.14 (1H, br d, $J$ = 11.0 Hz, H-3), 6.25 (1H, d, $J$ = 11.0 Hz, H-2).

**Sarcophytol I Diacetate (19d)** Oil $[\alpha]_D$ +3° ($c$ = 1.16). $^1$H-NMR $\delta$: 1.04, 1.07 (each 3H, d, $J$ = 7.0 Hz), 1.73, 1.75 (each 3H, s), 2.03, 2.07 (each 3H, s), 2.47 (1H, sept, $J$ = 7.0 Hz, H-15), 2.62 (1H, dd, $J$ = 14.5, 8.0 Hz, H-13), 4.87, 4.93 (each 1H, br s, H-20), 5.05 (1H, m, H-7), 5.18 (1H, br d, $J$ = 10.0 Hz, H-11), 5.74 (1H, dd, $J$ = 8.0, 6.5 Hz, H-14), 6.19 (2H, s, H-2,3).

**Sarcophytol G (24a)** mp 122—123 °C, $[\alpha]_D$ +109° ($c$ = 3.17). $^1$H-NMR $\delta$: 1.09 (3H, d, $J$ = 7.0 Hz), 1.10 (3H, d, $J$ = 6.6 Hz), 1.31 (3H, s, H-20), 1.69 (3H, s), 1.71 (3H, d, $J$ = 1.0 Hz), 2.02 (1H, dd, $J$ = 14.5, 10.0 Hz, H-13), 2.62 (1H, sept, $J$ = 7.0 Hz, H-15), 5.12 (2H, br d, $J$ = 10.0 Hz, H-7,14), 5.53 (1H, d, $J$ = 15.5 Hz, H-11), 5.81 (1H, ddd, $J$ = 15.5, 8.0, 6.5 Hz, H-10), 5.95 (1H, br d, $J$ = 12.5 Hz, H-3), 6.04 (1H, d, $J$ = 12.5 Hz, H-2). $^{13}$C-NMR $\delta$: C-1 (148.1), C-2,3 (119.9 (2C)), C-4 (137.8), C-5 (38.0), C-6 (24.9), C-7 (125.3), C-8 (134.3), C-9,13 (42.3, 46.4), C-10 (127.2), C-11 (137.2), C-12 (74.1), C-14 (68.5), C-15 (27.5), C-16,17 (24.3, 25.3), C-18,19 (17.0, 17.7), C-20 (30.7). UV $\lambda_{\max}^{\mathrm{EtOH}}$ nm ($\varepsilon$): 250 (16000). IR $\nu_{\max}^{\mathrm{Nujol}}$ cm$^{-1}$: 975, 930. MS *m/z*: 304 (M$^+$), 286, 271, 268, 258, 243, 225, 215, 175, 151, 137, 123, 107. High-resolution MS [Found (Calcd)] *m/z*: $C_{20}H_{32}O_2$ (M$^+$) 304.2414 (304.2402). Compound **24a** (13 mg) was dissolved in a mixture of $Ac_2O$ and pyridine (1 : 3, 0.2 ml). After 48 h at 70 °C, most of **24a** was consumed. Chromatography of the residue, after evaporation to dryness, with ethyl acetate–hexane (1 : 19) gave 6 mg of **24b** as an oil.

**Sarcophytol G Diacetate (24b)** $[\alpha]_D$ +250° ($c$ = 0.60). $^1$H-NMR $\delta$: 0.99, 1.10 (each 3H, d, $J$ = 7.0 Hz), 1.64 (3H, s), 1.73 (3H, d, $J$ = 1.0 Hz), 1.98, 1.99 (each 3H, s), 2.50 (1H, sept, $J$ = 7.0 Hz, H-15), 2.68 (2H, br d, $J$ = 7.5 Hz, H-9), 2.94 (1H, dd, $J$ = 15.0, 9.0 Hz, H-13), 5.13 (1H, br t, $J$ = 6.0 Hz, H-7), 5.54 (1H, d, $J$ = 15.5 Hz, H-11), 5.72 (1H, ddd, $J$ = 15.5, 7.5, 7.0 Hz, H-10), 6.10 (1H, H-14, overlapped with H-2), 6.09 (1H, d, $J$ = 11.5 Hz, H-2), 6.18 (1H, br d, $J$ = 11.5 Hz, H-3). MS *m/z*: 388 (M$^+$), 268, 253, 225. High-resolution MS [Found (Calcd)] *m/z*: $C_{24}H_{36}O_4$ (M$^+$), 388.2644 (388.2614).

**Sarcophytol E 11-Monoacetate (22b) and Sarcophytol E 14-Monoacetate (22c)** Sarcophytol E diacetate (**22d**, 500 mg) was dissolved in 3 ml of 2.5% KOH in MeOH and kept at room temperature for 40 min. The mixture was worked up and separated by chromatography as done for **19d**.

**22b**: Oil, $[\alpha]_D$ +210° ($c$ = 0.51). $^1$H-NMR (100 MHz) $\delta$: 1.10 (6H, d, $J$ = 7.0 Hz), 1.53, 1.74 (each 3H, s), 2.10 (3H, s), 2.70 (1H, sept, $J$ = 7.0 Hz, H-15), 4.91, 5.01 (each 1H, br s, H-20), 4.9—5.25 (3H, m, H-7,11,14), 5.99 (2H, s, H-2,3). MS *m/z*: 346 (M$^+$), 331, 301, 286, 271, 243, 137.

**22c**: Oil, $[\alpha]_D$ +210° ($c$ = 1.65). $^1$H-NMR (100 MHz) $\delta$: 1.05, 1.10 (each 3H, d, $J$ = 7.0 Hz), 1.55, 1.75 (each 3H, s), 2.04 (3H, s), 4.0—4.24 (1H, m, H-11), 4.87, 5.10 (each 1H, br s, H-20), 5.0—5.2 (1H, m, H-7), 6.03, 6.04 (each 1H, d, $J$ = 11.0 Hz, H-2,3), 6.16 (1H, dd, $J$ = 9.5, 5.0, H-14). MS *m/z*: 346 (M$^+$), 328, 286, 271, 243, 225.

**Sarcophytol A 11*R*,12*R*-Epoxide 14-Acetate (20) and Sarcophytol A 11*S*,12*S*-Epoxide 14-Acetate (23)** The chromatography fractions obtained previously by epoxidation of **1b** and kept at −30 °C[22] were used as the material. The mixture (0.6 g) which eluted immediately before **13** was composed of unreacted **1b**, an unidentified material and **20**. This was subjected to preparative TLC with $CHCl_3$–hexane (4 : 6) several times, giving **20** (160 mg). Compound **13**, obtained in the previous experiment, was homogeneous on TLC with ethyl acetate–hexane (1 : 9) but was found to contain small amounts of **23** and the 3,4-epoxide by TLC with $CHCl_3$ or acetone–benzene (1 : 50). A portion (2 g) of **13** was separated first by column chromatography with acetone–benzene (1 : 50) and then preparative TLC with $CHCl_3$, giving 200 mg of the 3,4-epoxy derivative of **1b**, and 104 mg of **23**.

**20**: Oil, $[\alpha]_D$ +150° ($c$ = 1.33). $^1$H-NMR $\delta$: 1.01, 1.08 (each 3H, d, $J$ = 7.0 Hz), 1.24 (3H, s, H-20), 1.27 (1H, dd, $J$ = 14.5, 2.0 Hz, H-13), 1.67, 1.71, 2.05 (each 3H, s), 2.43 (1H, sept, $J$ = 7.0 Hz, H-15), 2.48 (1H, dd, $J$ = 14.5, 8.0 Hz, H-13), 2.69 (1H, dd, $J$ = 7.0, 3.5 Hz, H-11), 5.18 (1H, m, H-7), 5.94 (1H, dd, $J$ = 8.0, 2.0 Hz, H-14), 6.09 (1H, d, $J$ = 11.0 Hz, H-2), 6.10 (1H, br d, $J$ = 11.0 Hz, H-3). $^{13}$C-NMR $\delta$: C-1 (144.3), C-2,3 (119.2, 120.8), C-4 (138.2), C-5 (38.2), C-6,10 (24.3, 24.8), C-7 (127.3), C-8 (133.1), C-9 (36.7), C-11 (61.9), C-12 (60.6), C-13 (43.7), C-14 (71.6), C-15 (28.2), C-16,17 (24.1, 24.6), C-18,19,20 (15.2, 17.7 (2C)), OAc (21.2, 170.2). MS *m/z*: 346 (M$^+$), 286, 243, 223, 215, 205, 203, 201, 187, 175. High-resolution MS [Found (Calcd)] *m/z*: $C_{22}H_{34}O_3$ (M$^+$), 346.2517 (346.2508).

**23**: Oil, $[\alpha]_D$ +270° ($c$ = 0.28). $^1$H-NMR $\delta$: 1.03, 1.06 (each 3H, d, $J$ = 7.0 Hz), 1.27 (3H, s, H-20), 1.49 (3H, br s, H-19), 1.75 (3H, s), 1.97 (3H, s), 2.13 (1H, dd, $J$ = 15.0 Hz, 3.5 Hz, H-13), 2.24 (1H, dd, $J$ = 15.0, 9.0 Hz, H-13), 2.47 (1H, sept, $J$ = 7.0 Hz), 2.93 (1H, dd, $J$ = 9.0, 3.5 Hz, H-11), 5.19 (1H, m, H-7), 5.67 (1H, dd, $J$ = 9.0, 3.5 Hz, H-14), 6.08 (1H, br d, $J$ = 11.5 Hz, H-3), 6.16 (1H, d, $J$ = 11.5 Hz, H-2). $^{13}$C-NMR $\delta$: C-1 (142.9), C-2,3 (121.1, 122.2), C-4 (137.7), C-5 (39.0), C-6,10 (24.6, 25.6), C-7 (126.2), C-8 (133.6), C-9 (36.2), C-11 (57.9), C-12 (58.4), C-13 (39.7), C-14 (67.9), C-15 (27.8), C-16,17 (24.4 (2C)), C-18,19,20 (14.9, 16.0, 19.6), OAc (20.9, 169.2). MS *m/z*: 346 (M$^+$), 286, 271, 261, 253, 243, 235, 225, 215, 187, 185. High-resolution MS [Found (Calcd)] *m/z*: $C_{22}H_{34}O_3$ (M$^+$), 346.2506 (346.2508).

**Conversion of 20 to Sarcophytol I (19a)** A solution of **20** (32 mg) in 1 ml of acetone was treated for 30 min at room temperature with 2 drops of $HClO_4$ solution made from 0.15 ml of 70% perchloric acid and 5 ml of $H_2O$. The mixture was diluted with $Et_2O$ and washed with $H_2O$ and saturated NaCl solution, then the solvent was evaporated off. The residue was dissolved in a mixture of $Ac_2O$ and pyridine (1 : 3, 0.7 ml) and left at room temperature overnight. After usual work-up, the crude product in 0.3 ml of pyridine was treated with 15 $\mu$l of thionyl chloride at room temperature for 30 min. After addition of $H_2O$, the mixture was extracted with $Et_2O$. The extract was washed with $H_2O$, 5% HCl solution, saturated $NaHCO_3$ solution, $H_2O$, and saturated NaCl solution, then the solvent was evaporated off. The residue was hydrolyzed with 2.5% KOH in MeOH (60 °C, 10 min) and the mixture was worked up as usual. Column chromatography of the residue with ethyl acetate–hexane (1 : 8) gave **19a** (12.9 mg), $[\alpha]_D$ −45° ($c$ = 0.92), which was identical with sarcophytol I as judged from the $^1$H-NMR spectrum and the behavior in several TLC systems.

**Conversion of 23 to Sarcophytol E (22a)** Compound **23** (50 mg) was treated in the same way as shown above and gave 7.2 mg of **22a**, $[\alpha]_D$ +158° ($c$ = 0.72), which was identical with sarcophytol E on the basis of comparisons of their $^1$H-NMR spectra, and behavior in several TLC systems. A small amount (2.5 mg) of unreacted triol (**25**) was isolated simultaneously. **25**, oil, $[\alpha]_D$ +96° ($c$ = 0.50). $^1$H-NMR $\delta$: 1.08 (3H, s, H-20), 1.13, 1.17 (each 3H, d, $J$ = 7.0 Hz), 1.43 (3H, s, H-19), 1.77 (3H, s, H-18), 2.65 (1H, sept, $J$ = 7.0 Hz, H-15), 3.49 (1H, br d, $J$ = 10.0 Hz, H-11), 5.09 (1H, br dd, $J$ = 10.0, 5.2 Hz, H-7), 5.17 (1H, dd, $J$ = 10.5, 4.0 Hz, H-14), 6.06 (1H, br d, $J$ = 11.5 Hz, H-3), 6.25 (1H, d, $J$ = 11.5 Hz, H-2). MS *m/z*: 322 (M$^+$), 304, 279, 261, 243, 221, 193, 175. High-resolution MS [Found (Calcd)] *m/z*: $C_{20}H_{34}O_3$ (M$^+$), 322.2495 (322.2508).

**Conversion of 20 to Sarcophytol D (21)** Compound **20** (30 mg) was hydrolyzed by 2.5% KOH in MeOH (0.5 ml) at room temperature for 1.5 h and the mixture was worked up as usual. The residue (20 mg) was dissolved in an isopropyl alcohol solution (3 ml) made by reducing diphenyl diselenide (21 mg) with $NaBH_4$ (5.5 mg) at room temperature. The mixture was refluxed under $N_2$ for 36 h. The mixture was diluted with tetrahydrofuran (2 ml) and 0.3 ml of 30% $H_2O_2$ was added dropwise at 0 °C. The mixture was stirred at room temperature for 4 h, diluted with $H_2O$, and then extracted with $Et_2O$. The extract was washed with $H_2O$ and saturated NaCl solution, and the solvent was evaporated off. Column chromatography of the residue with $CHCl_3$ gave 5.2 mg of **21**, $[\alpha]_D$ $+110°$ ($c=0.32$), which was identical with sarcophytol D on the basis of comparisons of their $^1H$-NMR spectra and behavior in several TLC systems.

**Conversion of 23 to Sarcophytol G (24a)** Compound **23** (50 mg) was treated in the same way as above and gave 15 mg of **24a**, $[\alpha]_D$ $+123°$ ($c=1.03$), which was shown to be identical with sarcophytol G by comparison of their $^1H$-NMR spectra and behavior in several TLC systems.

**Micro Horeau Determination** Brooks's modified micro Horeau determination[26)] was applied, using a combination of high-performance liquid chromatography (Senshu Pak, Silica-1251-S, 4.6 × 250 mm, ethyl acetate–hexane (15 : 85)) and gas chromatography (1.5% OV-17 on 80—100 mesh Shimalite W, 2 m, at 215 °C). The results were judged by the same (*R*) or opposite (*S*) increment of one of the two chiral amide peaks obtained by the reaction of (−)-menthol, relative to that obtained from cyclohexanol.

## References and Notes

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