H-3′), 7.27–7.32 (m, 10 H, Ph); ^{13}C NMR δ 53.62 and 53.71 (0.3 and 0.7 Me), 63.38 and 63.75 (0.7 and 0.3 C-6′), 69.07 and 69.26 (0.3 and 0.7 C-4′), 70.25 and 71.17 (0.3 and 0.7 C-1′), 71.59 (OCH_2Ph), 72.32 and 72.96 (0.7 and 0.3 C-5′), 73.3 and 73.4 (OCH_2Ph), 88.09 and 89.94 (0.7 and 0.3 C-2), 124.12 and 124.85 (0.7 and 0.3 C-2′), 131.07 and 131.32 (0.7 and 0.3 C-3′), 127.52, 127.57, 127.61, 127.65, 127.83, 127.91, 128.34, 128.43, 137.68, 137.71, and 137.92 (Ph), 162.37 and 162.47 (0.3 and 0.7 C=O); CI MS (NH_3) m/z 445 (M + NH_4^+). Anal. Calcd for $C_{23}H_{25}NO_7$: C, 64.63; H, 5.90; N, 3.28. Found: C, 64.37; H, 5.91; N, 3.51.

Ethyl 2-(4′,6′-Di-*O*-benzyl-2′,3′-dideoxy-D-*erythro*-hex-2′-enopyranosyl)-2-nitro-2-(ethoxycarbonyl)acetate, 11. α Anomer: oil; TLC R_f 0.61 (25% AcOEt/hexane); $[\alpha]^{20}_D$ +15.3° (*c*, 1, CH_2Cl_2); ^{1}H NMR δ 1.28 (t, 3 H, *J* = 7.1 Hz, Me), 1.29 (t, 3 H, *J* = 7.1 Hz, Me), 3.60 (dd, 1 H, *J* = 10.8 and 3.2 Hz, H-6′), 3.67 (dd, 1 H, *J* = 10.8 and 4.4 Hz, H-6″), 4.03 (dddd, 1 H, *J* = 6.7, 2.4, 2.3, and 1.8 Hz, H-4′), 4.17 (ddd, 1 H, *J* = 6.7, 4.4, and 3.2 Hz, H-5′), 4.32 (q, 4 H, *J* = 7.1 Hz, OCH_2CH_3), 4.47 and 4.56 (2 d, 2 × 1 H, *J* = 12.2 Hz, OCH_2Ph), 4.49 and 4.60 (2 d, 2 × 1 H, *J* = 11.7 Hz, OCH_2Ph), 5.20 (ddd, 1 H, *J* = 2.4, 2.4, and 2.4 Hz, H-1′), 6.07 (ddd, 1 H, *J* = 10.6, 2.4, and 1.8 Hz, H-2′), 6.19 (ddd, 1 H, *J* = 10.6, 2.4, and 2.3 Hz, H-3′), 7.26–7.30 (m, 10 H, Ph); ^{13}C NMR δ 13.63 (Me), 13.74 (Me), 63.60 (OCH_2), 63.63 (OCH_2), 68.78 (C-6′), 68.84 (C-4′), 70.75 (OCH_2Ph), 72.64 (C-1′), 72.85 (C-5′), 73.19 (OCH_2Ph), 98.58 (C-2), 123.64 (C-2′), 131.03 (C-3′), 127.60, 127.70, 127.74, 127.80, 128.31, 128.33, and 138.07 (Ph), 160.76 (C=O), 161.03 (C=O); CI MS (NH_3) m/z 531 (M + NH_4^+). Anal. Calcd for $C_{27}H_{31}NO_9$: C, 63.15; H, 6.08; N, 2.73. Found: C, 63.01; H, 6.29; N, 2.71.

β Anomer: oil; TLC R_f 0.64 (25% AcOEt/hexane); $[\alpha]^{20}_D$ +98.6° (*c* 1.3, CH_2Cl_2); ^{1}H NMR δ 1.26 (t, 3 H, *J* = 7.2 Hz, Me), 1.27 (t, 3 H, *J* = 7.2 Hz, Me), 3.69 (dd, 1 H, *J* = 10.7 and 4.5 Hz, H-6′), 3.70 (dd, 1 H, *J* = 10.7 and 3.6 Hz, H-6″), 3.67 (ddd, 1 H, *J* = 8.6, 4.5, and 3.6 Hz, H-5′), 4.04 (dddd, 1 H, *J* = 8.6, 2.9, 1.9, and 1.5 Hz, H-4′), 4.31 (q, 4 H, *J* = 7.2 Hz, OCH_2CH_3), 4.52 and 4.64 (2 d, 2 × 1 H, *J* = 11.6 Hz, OCH_2Ph), 4.58 and 4.62 (2 d, 2 × 1 H, *J* = 12.1 Hz, OCH_2Ph), 5.17 (ddd, 1 H, *J* = 2.8, 2.3, and 1.8 Hz, H-1′), 6.02 (ddd, 1 H, *J* = 10.6, 2.3, and 2.0 Hz, H-2′), 6.14 (ddd, 1 H, *J* = 10.6, 2.0, and 1.8 Hz, H-3′), 7.30–7.34 (m, 10 H, Ph); ^{13}C NMR δ 13.64 (Me), 13.74 (Me), 63.60 (2 OCH_2), 69.15 (C-6′), 69.37 (C-4′), 71.50 (OCH_2Ph), 73.26 (OCH_2Ph), 75.24 (C-1′), 78.14 (C-5′), 98.13 (C-2), 123.96 (C-2′), 132.26 (C-3′), 127.41, 127.54, 127.64, 127.70, 128.26, 128.41, 137.75, and 138.53 (Ph), 160.52 (C=O), 160.86 (C=O); CI MS (NH_3) m/z 531 (M + NH_4^+). Anal. Calcd for $C_{27}H_{31}NO_9$: C, 63.15; H, 6.08; N, 2.73. Found: C, 63.27; H, 6.03; N, 2.64.

Pd(0)-Catalyzed Isomerization of Phenyl 4,6-Di-*O*-benzyl-2,3-dideoxy-α-D-*erythro*-hex-2-enopyranoside, 4. The α-phenyl glycoside **4** (251 mg, 0.62 mmol) was dissolved in CH_3CN (2.5 mL), $Pd(dba)_2$ (18 mg, 0.031 mmol) and 1,4-bis(diphenylphosphino)butane (15 mg, 0.035 mmol) in 2.5 mL of CH_3CN were added, and the mixture was stirred at 70 °C for 6 h. After concentration and column chromatography, the product was shown by ^{1}H NMR analysis to consist of only the starting material **4α**. The same procedure was used for the β anomer **5**, and the starting material was also recovered.

Denitration of Compound 11α. To a stirred solution of Bu_3SnH (400 mg, 1.3 mmol) in 0.3 mL of toluene was added a solution of **11α** (34 mg, 0.066 mmol) and AIBN (8 mg, 0.05 mmol) in 0.7 mL of toluene at 110 °C, and the resulting mixture was stirred at this temperature for 90 min. Column chromatography (silica gel; hexane/ethyl acetate, 3:1) gave **6α**: 30 mg (90%).

Registry No. **1**, 2873-29-2; **2**, 62398-09-8; **3**, 113019-34-4; **4**, 113019-35-5; **5**, 113019-36-6; **α-6**, 119366-97-1; **β-6**, 119366-98-2; **α-7**, 119366-99-3; **β-7**, 119367-00-9; **α-8**, 119367-01-0; **β-8**, 119434-14-9; **α-9**, 113019-37-7; **β-9**, 113084-95-0; **α-10**, 119367-02-1; **α-11**, 119367-03-2; **β-11**, 119367-04-3; $CH_2(CO_2Et)_2$, 105-53-3; $CH_2(COCH_3)_2$, 123-54-6; $CH_3COCH_2CO_2CH_3$, 105-45-3; $O_2NCH_2CO_2Et$, 626-35-7; $O_2NCH_2CO_2CH_3$, 2483-57-0; $O_2NCH(CO_2Et)_2$, 603-67-8.

Supplementary Material Available: NMR spectra for compounds **6β**, **9β**, **11α**, and **11β** (4 pages). Ordering information is given on any current masthead page.

Sclerophytin C–F: Isolation and Structures of Four New Diterpenes from the Soft Coral *Sclerophytum capitalis*

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The marine soft coral *Sclerophytum capitalis* was found to contain four new diterpenes, which were isolated and identified as sclerophytins C–F. The structures of the isolated compounds were determined by spectroscopic and/or by X-ray crystallographic methods. The absolute configuration of sclerophytin C was determined by X-ray crystallography and constitutes the first absolute configuration determined in this family of diterpenes.

In a survey conducted, almost a decade ago, under the auspices of the National Cancer Institute, a number of marine invertebrates were found to have promising cytotoxic activity against a variety of cancerous cell lines. One such invertebrate, *Sclerophytum capitalis*, has been a subject of investigation in our laboratory. We recently reported the isolation and structures of two novel tetracyclic diterpenes, sclerophytins A and B (I and II), from this coral.[1] Sclerophytin A was found to be active against L1210 cell line at a 1×10^{-6} mg/mL level. Both sclerophytin A and B were suggested to have been derived from a deacetylation product of the diterpene cladiellin (III),[2] which in turn has been proposed to have been derived from an isocembrene.[3] In this communication we report the isolation and structures of four new diterpenes (sclero-

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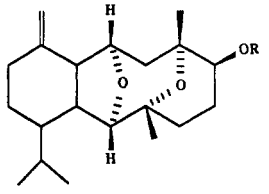
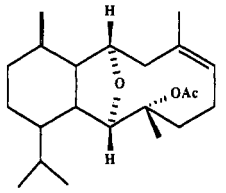
Table I. ^1H and ^{13}C NMR Assignments of Sclerophytin A and C–F

carbon no.	sclerophytin A (I)		C (IV)		D (V)		E (VI)		F (VII)	
	^{13}C δ	^1H δ (J, Hz)	^{13}C δ	^1H δ (J, Hz)	^{13}C δ	^1H δ (J, Hz)	^{13}C δ	^1H δ (J, Hz)	^{13}C δ	^1H δ (J, Hz)
1 (CH)	45.1	2.19 (dd, J = 6.7)	45.0	2.25 (m)	45.3	2.22 (m)	45.2	2.22 (m)	45.4	2.26 (m)
2 (CH)	90.4	3.63 (b s)	91.4	3.58 (s)	91.4	3.60 (s)	92.0	3.60 (s)	91.9	3.54 (s)
3 (C)	74.8	–	86.2	–	86.2	–	86.3	–	86.6	–
4 (CH_2)	39.9	1.27 (m)	34.5	2.44 (dd, J = 15.5, 8.3, βH) 1.72 (dd, J = 15.6, 8.4 αH)	35.2	2.42 (dd, J = 16.2, 8.2, βH)	36.1	2.35 (dd, J = 15.5, 8.3, βH) 1.90 (dd, J = 15.4, 8.4, αH)	35.9	2.41 (dd, J = 16.2, 8.4, βH) 1.90 (dd, J = 15.8, 8.2, αH)
5 (CH_2)	29.3	1.75, 1.98 (m)	29.5	1.80 (dd, J = 14.4, 9.2, βH)	29.6	1.82 (dd, J = 15.1, 9.0, βH)	30.4	1.89 (m)	30.5	1.90 (m)
6 (CH)	79.9	4.55 (d, J = 6.5)	77.0	4.61 (d, J = 6.4)	77.0	4.65 (d, J = 6.4)	80.1	4.55 (d, J = 6.5)	80.1	4.55 (d, J = 6.5)
7 (C)	77.0	–	79.6	–	79.6	–	77.0	–	77.0	–
8 (CH/CH_2)	45.3	1.71, 2.23 (m)	79.5	3.54 (d, J = 8.7)	79.8	3.56 (d, J = 8.3)	45.7	2.25 (m) and 1.80 (m)	45.8	2.25 (m) and 1.80 (m)
9 (CH)	78.1	4.12 (m)	81.1	3.86 (dd, J = 8.8, 6.3)	81.1	3.86 (dd, J = 8.7, 6.4)	78.2	4.11 (ddd, J = 10.3, 8.5, 8.0)	78.2	4.11 (ddd, J = 10.5, 8.4, 8.0)
10 (CH)	52.5	2.98 (dd, J = 13.4, 6.7)	52.5	3.25 (dd, J = 6.5, 6.4)	53.0	3.25 (dd, J = 6.6, 6.4)	52.9	2.95 (dd, J = 6.5, 6.4)	52.9	2.95 (dd, J = 6, 6.4)
11 (C)	147.9	–	148.6	–	149.0	–	147.6	–	147.6	–
12 (CH_2)	31.5	2.05, 2.25 (m)	31.6	2.26 (2 H, m)	31.6	2.27 (2 H, m)	31.4	2.30 (2 H, m)	31.4	2.30 (2 H, m)
13 (CH_2)	24.8	1.70 (m)	24.8	1.81 (2 H, m)	24.9	1.80 (2 H, m)	24.8	1.80 (2 H, m)	24.7	1.80 (2 H, m)
14 (CH)	43.6	1.25 (m)	43.7	1.41 (m)	43.9	1.40 (m)	43.9	1.23 (m)	43.9	1.23 (m)
15 (CH_3)	16.0	0.80 (d, J = 6.7)*	16.2	0.80 (d, J = 6.5)	16.0	0.79 (d, J = 6.5)	16.1	0.73 (d, J = 6.4)	15.7	0.75 (d, J = 6.5)
16 (CH_3)	21.9	0.96 (d, J = 6.7)*	21.9	0.96 (d, J = 6.5)	21.9	0.95 (d, J = 6.5)	21.9	0.95 (d, J = 6.5)	21.9	0.94 (d, J = 6.5)
17 (CH)	29.1	1.78 (m)	29.0	1.78 (m)	29.0	1.75 (m)	29.0	1.79 (m)	29.1	1.78 (m)
18 (CH_3)	30.3	1.16 (s)	23.0	1.40 (s)	23.0	1.40 (s)	23.2	1.23 (s)	23.2	1.14 (s)
19 (CH_3)	23.0	1.20 (s)	17.7	1.23 (s)	17.6	1.21 (s)	24.6	1.43 (s)	22.3	1.38 (s)
20 (CH_2)	109.0	4.64, 4.67 (s)	109.9	4.87 (s), 4.48 (s)	109.9	4.86 (s), 4.50 (s)	109.3	4.86 (s), 4.49 (s)	109.3	4.87 (s), 4.48 (s)
21 (C=O)			169.5	–	–	–	170.1	–	–	–
22 (CH_3)			22.7	2.01 (s)	–	–	22.7	2.02 (s)	–	–

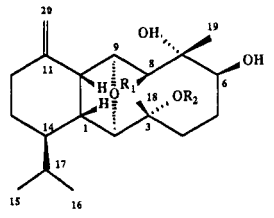
phytins C–F), related to cladiellin, from the soft coral *S. capitalis*.



I. R = H
II. R = Ac



III



IV. R_1 = OH, R_2 = Ac
V. R_1 = OH, R_2 = H
VI. R_1 = H, R_2 = Ac
VII. R_1 = H, R_2 = H

The residue from the MeOH extract of the coral was extracted first with hexane followed by $CHCl_3$. The residue from the $CHCl_3$ extract upon chromatography gave a group of fractions containing one major and one minor metabolite. These were separated by repeated HPLC to yield sclerophytin A (I, major) and sclerophytin C (IV) as a minor metabolite. The ^1H NMR spectrum of IV exhibited resonances due to an exocyclic methylene [δ 4.87 and 4.78 (1 H each, s)], a carbinylic proton [δ 4.61 (1 H, d, J = 6.7 Hz)], three oxymethine protons [δ 3.86 (1 H, dd, J = 8.8, 6.8 Hz), 3.58 (1 H, s), and 3.54 (1 H, d, J = 8.8 Hz)], a methine proton [δ 3.25 (1 H, apparent t, J = 6.3 Hz)], a proton resonating at δ 2.44 (1 H, dd, J = 15.9, 8.2 Hz), along with an acetyl methyl [δ 2.01 (3 H, s)], four methyls [δ 1.40 (3 H, s), 1.23 (3 H, s), 0.95 (3 H, d, J = 6.5 Hz), and 0.80 (3 H, d, J = 6.5 Hz)]. The ^1H NMR spectrum of IV was similar to that which has been reported for I.[1] The only differences are the multiplicity and downfield shift of the H9 proton (Table I) (in IV it appears as a dd at δ 3.86 while in I it appeared as a ddd at δ 4.12) and the appearance of a methine doublet at δ 3.54; suggesting the presence of an electron-withdrawing substituent at C8 of a sclerophytin type of molecule. The ^{13}C NMR spectrum was also similar to that of I, with the exception of the appearance of additional resonances at δ 169.5, 79.66, and 22.73 and the absence of the resonance at δ 45.3. The EIMS gave the highest mass peak at m/z 378, suggesting that IV could be acetylation product of I possibly with a hydroxy substituent at C8. However, the acetylation of I gave II, which had a oxymethine proton (H6) resonating at δ 5.62; this resonance was absent in IV. The ^1H NMR spectrum of the acetylation product of IV showed the presence of three acetyl methyl groups [δ 2.03, 2.13, and 2.14 (3 H each, s)], thereby inferring the presence of two secondary hydroxyls in IV. Fortuitously IV, after repeated attempts, gave crystals that were found suitable for an X-ray crystallographic analysis.

The final positional parameters for non-hydrogen atoms of IV are available as supplementary materials and a view[4] is shown in Figure 1. The latter indicates the atomic numbering scheme and also shows the experimentally determined absolute configuration of the compound. The

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Table II. Absolute Configuration for Sclerophytin C. Relative Configuration for Eunicillin Dibromide,[5] Acetoxycladeillin,[2] and Dihydroxyasbestinin 1[6]

	absolute configuration:	relative configuration		
atom	sclerophytin C	eunicellin dibromide	acetoxycladiellin	dihydroxyasbestinin 1
C1	*R*	*R*	*R*	*R*
C2	*R*	*R*	*R*	*R*
C3	*R*	*R*	*R*	*R*
C9	*S*	*R*	*R*	*R*
C10	*R*	*S*	*S*	*R*
C14	*R*	*R*	*R*	*R*

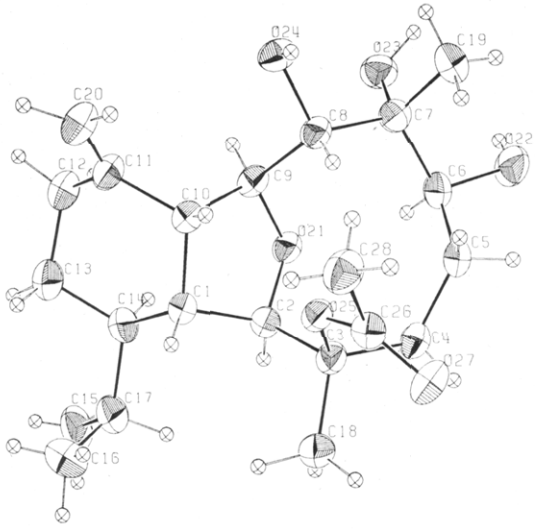

Figure 1. Perspective view of a single molecule and atom numbering scheme for sclerophytin C.

bond distances and angles clearly show the hydroxyl groups on C6, C7, and C8, the exocyclic methyl groups on C3 and C7, the acetate group on C3, the exocyclic double bond (C11–C20), and the ether bridge between C2 and C9. The six-membered ring (C1–C10–C11–C12–C13–C14) is in the chair conformation and is cis-fused to the ten-membered ring (C1–C10). The root mean square deviation of the plane through C1 to C14 is only 0.498 Å, indicating that the backbone of this diterpene is relatively flat. A similar flatness is observed in eunicellin dibromide,[5] acetoxycladiellin,[2] and dihydroxyasbestinin 1.[6] They all have a similar backbone (C1–C14) and have ether bridge between C2 and C9. The six-membered ring (C1–C10–C11–C12–C13–C14) is cis-fused to the ten-membered ring (C1–C10) in all four compounds.

The absolute configuration determined for sclerophytin C is shown in Figure 1. This is the first absolute configuration determined in this family of diterpenes. A comparison can be made between this absolute configuration and the relative ones determined for eunicellin dibromide,[5] acetoxycladiellin[2] and dihydroxyasbestinin 1.[6] The common chiral centers for the four compounds are C1, C2, C3, C9, C10, and C14. All of them basically assume the *R* configuration. The differences for C9 and C10, shown in

Table III. Calculated and Observed Bijvoet Difference

			del[a]		esf[a]	
h	*k*	*l*	calcd	obsd	calcd	obsd
0	4	0	−46.8	−19.1	−9.5	−6.1
1	2	6	−38.3	−40.2	−5.6	−5.7
1	5	3	43.8	27.3	6.3	5.8
−2	2	5	25.6	36.8	5.1	13.8
3	4	0	31.0	20.4	5.3	5.1
3	7	0	−29.0	−39.3	−6.0	−15.4
4	2	1	44.1	55.2	7.0	10.8
4	4	3	−31.3	−60.4	−5.0	−21.3
−5	2	6	−29.6	−15.9	−5.7	−5.8
−6	1	1	−23.0	−37.8	−5.1	−12.4
−6	1	2	34.1	35.1	5.6	13.4
−6	1	3	56.7	36.8	9.5	7.4
−6	3	4	−34.9	−24.5	−5.1	−4.3
8	3	0	39.1	12.6	5.1	2.5
−9	2	4	−37.2	−42.5	−6.6	−15.7

[a] del = $[[F^2(+) - F^2(-)]/0.5[F^2(+) + F^2(-)] \times 100$. esf = $[F^2(+) - F^2(-)]/\sigma(F^2)$. $F^2(+) = F^2(hkl)$; $F^2(-) = F^2(h\bar{k}\bar{l})$.

Table II, are only apparent ones due to the substitutions on the atoms adjacent to C9 and C10. If the OH on C8 in sclerophytin C and the OAc on C11 in both eunicellin dibromide and acetoxycladiellin are eliminated, C9 and C10 will have the *R* configuration in all the compounds (Table III and drawing therein). The iterative strain-energy calculation using the molecular mechanics program MM2[7,8] shows that the crystal structure of sclerophytin C is closed to the true energy minimum.

The hexane extract upon chromatography on silica gel 60 (E. Merck), followed by repeated HPLC of the desired fractions, gave sclerophytin B as the major and sclerophytins D (V), E (VI), and F (VII) as minor metabolites. The ^{1}H NMR spectrum of V was very similar to that of IV, the only exception being the absence of the acetyl methyl resonance at δ 2.01. The EIMS gave the highest mass peak at m/z 336 with fragments representing the loss of one (m/z 318) and two (m/z 300) molecules of water. The ^{13}C NMR spectrum showed the presence of 20 carbons. An APT[9] spectrum was used to determine the number of proton attached to each carbon, while a ^{1}H–^{13}C COSY spectrum[10] was used to identify individual protonated carbons. The ^{13}C assignments for C1, C4, C5, C12,

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C13, C14, and C17 could not be made unequivocally by a ^1H–^{13}C correlation spectrum,[11] thus necessitating the use of a reverse-detected long-range heteronuclear correlation (HMBC) spectrum, optimized for 7 Hz, for these assignments.[12] The proton-detected HMBC experiment was used in lieu of heteronucleus-detected variants because of its substantially greater sensitivity, allowing access to long-range correlation data overnight on 10–30-mg samples at an observation frequency of 300 MHz. The HMBC spectrum established the connectivities between exocyclic methylene protons and two carbons (53.0 and 31.6 ppm). Since H10 (δ 3.25, ^{13}C δ 53.0) was coupled to H9 (δ 3.86, ^{13}C δ 81.1), as determined by the ^1H–^1H COSY spectrum, the resonance at δ 53.0 was assigned to C10 while that at δ 31.6 was assigned to C12. As expected the proton at δ 3.56 showed transfer of magnetization to carbons resonating at δ 23.0 (C18), 43.9 (C14), 45.3 (C1), 53.0 (C10), 81.1 (C9, through oxygen), and 86.1 (C3). The assignment of C5 (δ 35.2) was supported by the connectivities observed between the C18-Me (δ 23.0) and the proton at δ 4.47 (H6). On the basis of spectral data V was identified as deacetylsclerophytin C. The acetylation products of both sclerophytin C (IV) and sclerophytin D (V) had superimposable ^1H and ^{13}C NMR spectra.

Column chromatography of the hexane extract on silica gel gave a group of fractions (fractions 10–17) with only two compounds, which were separated as colorless, gummy residues by repeated HPLC on a silica gel cartridge.

Sclerophytin E (VI), eluting after VII, was isolated as a gummy colorless residue, which failed to give M^+ in the EIMS. The highest mass peak was observed at m/z 337 along with fragments representing loss of one (m/z 319) and two (m/z 301) molecules of water. The ^1H NMR spectrum of VI, in $CDCl_3$, was similar to that of I with the exception that VI has an acetyl methyl resonance (δ 2.03, ^{13}C δ 22.69 and 170.1). The ^1H NMR spectrum in DMSO-d_6, on the other hand, showed the presence of two hydroxyl (one tertiary and one secondary) groups, suggesting the possibility that the ether linkage between C3 and C7 in I has undergone hydration to give 8-dehydroxysclerophytin C. The presence of a secondary hydroxyl group was also evident from the ^1H NMR spectrum of the acetylation product of VI. The ^{13}C NMR spectrum of VI showed the presence of 22 carbons, 20 of which were unequivocally assigned by ^1H–^{13}C COSY and HMBC spectra. On the basis of spectral similarity with IV, the acetate was fixed at C3, and VI was identified as 6,7-dihydroxycaldiellin.

Sclerophytin E (VII), isolated as a colorless gummy residue, gave M^+ at m/z 338 (EIMS), with fragments at m/z 320 (M – H_2O), 302 (M – $2H_2O$). The ^1H NMR spectrum of VII, in $CDCl_3$, was similar to that of VI, the exception being the absence of the acetyl methyl resonance (Table I). The ^1H NMR spectrum in DMSO-d_6 showed the presence of three (two tertiary and one secondary) hydroxyls, indicating that VII is the deacetylation product of VI. This assumption was also supported by the ^{13}C NMR spectrum. Assignment of the 18 out of 20 carbons was accomplished by the use of APT, ^1H–^{13}C COSY, and HMBC spectra.

It has been proposed that compounds such as cladiellin, ophirin, and eunicillin, and sclerophytin A and B (metabolites of the coral *Cladiella* sp., *Muricella* sp., and *Eunicella stricta* and *Sclerophytum capitalis*, respectively) could have been derived from a cyclization product involving C1 and C10 of the geranylgeraniol.[1-3] Sclerophytin F could then, on one hand, serve as a precursor of cladiellin, which in turn gives rise to sclerophytin C–E or dehydrates to give sclerophytin A and B. It was surprising that both acetyl and hydroxy compounds were present in the extract of this coral. In order to eliminate the possibility of sclerophytin B, D, and E being artifacts, generated during chromatography, since ethyl acetate was used as a solvent in HPLC, a crude MeOH extract of the coral was analyzed by HPLC using pure sclerophytins A–F as standards and $CHCl_3$–MeOH as mobile phase. The presence of sclerophytins A–F were detected in the crude MeOH extract.

Experimental Section

The melting point was recorded on a Fisher-Johns melting point apparatus and was uncorrected. The rotation were recorded on a Perkin-Elmer Model 141 polarimeter. The IR spectra were recorded on a Perkin-Elmer Model 283 instrument, while the mass spectra were recorded on a Finnigan Model 1020 mass spectrometer equipped with an Incos data system and operating at 70 eV. The NMR spectra were recorded on a Nicolet NT 300 wide-bore spectrometer operating at 300.042 and 75.455 MHz for ^1H and ^{13}C observations, respectively. The instrument was controlled by a Model 293C pulse programmer and was equipped with a 5-mm $^1H/^{13}C$ dual tuned probe. ^1H–^1H and ^1H–^{13}C correlation (COSY) spectra were recorded as described elsewhere.[13] The long-range reverse detected heteronuclear multiple quantum (HMBC) spectrum was recorded by using the pulse sequence described by Bax and Summers.[12] Details of the modifications performed to allow the execution of this experiment using the NT-300 spectrometer have been described elsewhere.[14] HPLC were carried out by utilizing a Waters LC1200 system equipped with a differential refractometer (Model 440) and a radial compression module (RCM 100) containing a 5 μm silica gel cartridge.

Sclerophytin C, compound IV, cocrystallized with chloroform in the monoclinic crystal system. Space group is $P2_1$. Cell dimensions are a = 12.952 (2) Å, b = 10.519 (3) Å, c = 10.187 (2) Å, β = 109.09 (2)°; V = 1311.6 Å, Z = 2 for $C_{22}H_{36}O_6 \cdot CHCl_3$. Calculated density ρ = 1.31 g cm^{-3}.

The X-ray diffraction data of sclerophytin C were collected on an Enraf-Nonius CAD4 with Ni-filtered Cu Kα radiation (λ Cu Kα = 1.541 78 Å and μ = 34.46 cm^{-1}). A crystal of 0.13 × 0.30 × 0.30 mm^3 was used for the data collected at low temperature (–135 (2) °C); 72 reflections (15.1° < θ < 22.7°) and Cu Kα_1 wavelength (1.540 51 Å) were used for lattice constants. Systematic absences were $0k0$ ($k = 2n + 1$). All data with $1.0° \le 2\theta \le 150.0°$ in $-16 \le h \le 16$, $0 \le k \le 13$, $0 \le l \le 12$ were collected using $\theta - 2\theta$ scan techniques and a variable scan width calculated as (0.90 + 0.20 tan θ). The maximum scan time for a single reflection was 50 s. The receiving aperture, located 173 mm from the data crystal, had a variable width, which was calculated as (3.50 + 0.86 tan θ) mm, while the height of the aperture remained constant at 6 mm. Three orientation control monitors were measured every 200 reflections. Three intensity control monitors were measured every 7200 s of X-ray exposure time and they showed a maximum difference of 0.045 and an esd of 0.015. The profiles of all the collected reflections were observed and stored. Lorentz-polarization corrections were applied. No absorption correction was made.

Among 2852 unique data, there were 2390 observed ones [$I \ge 2\sigma(I)$]. The data set was processed by using Blessing's profile analysis method.[15] The structure was determined by the direct method with the program MITHRIL.[16] Instead of using the phase-permutation technique, the random phases for 250 unknown phases ($E \ge 1.479$) were used in the starting set and refined with the tangent formula. The theory of this technique was discussed by Yao.[17,18] The structure was refined with SHELX76,[19] utilizing

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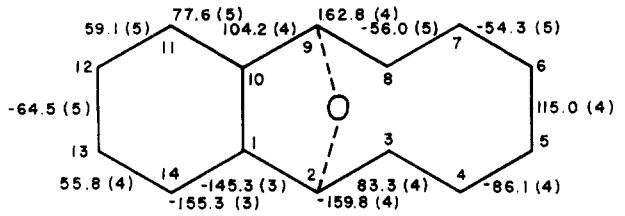
Table IV. Torsion Angles Around C-C Bonds from C1 to C10



	I[a]	II[b]
C14-C1-C2-C3	-145.3	-148.6
C1-C2-C3-C4	-159.8	-160.8
C2-C3-C4-C5	83.3	84.2
C3-C4-C5-C6	-86.1	-88.2
C4-C5-C6-C7	115.0	112.3
C5-C6-C7-C8	-54.3	-47.4
C6-C7-C8-C9	-56.0	-60.0
C7-C8-C9-C10	162.8	164.2
C8-C9-C10-C11	104.2	99.6

[a] I: The crystal structure. [b] II: The strain-energy minimized crystal structure.

2390 observed data, with anisotropic temperature factors for the non-hydrogen atoms. The locations of 37 hydrogen atoms were determined from successive difference Fourier syntheses and refined isotropically except for the fixed positional and temperature factor parameters of H(28)c. A final R of 0.046 and Rw of 0.052 were obtained by the full-matrix least-squares minimization of $\sum w(|F_o| - |kF_c|)^2$ where $w = 1/[\sigma^2(F) + 0.000\,400F^2]$. The maximum shift/sd = 0.038 for non-hydrogen atoms and 0.056 for hydrogen atoms. The largest and the smallest peaks in the final difference map were +0.44 and -0.36 e Å^3, located close to the Cl atoms of $CHCl_3$. The EOF = $[\sum w(F_o - F_c)^2/[(N - NP)]^{1/2}$ = 1.9, where N is the number of reflections used and NP is the number of parameters used. (Lists of positional and anisotropic thermal parameters of non-hydrogen atoms, positional and thermal parameters of hydrogen atoms, bond distances, and bond angles are available as supplementary materials.)

The absolute configuration of the molecule was determined by comparing the calculated and observed difference in the intensities of 15 Friedel pairs,[20,21] using the anomalous dispersion of Cu radiation by Cl atoms. The f' and f'' values for Cl atoms were taken from International Tables for X-ray crystallography.[22] The intensity differences of all the 15 reflections were in agreement with the absolute configuration shown in the figures. The Bijvoet parameters are listed in Table III.

The strain energy of sclerophytin C was minimized while using the crystal coordinates as the starting structure. The average difference for the nine most flexible endocyclic conformational angles was 3°. The results are listed in Table IV. Another set of energy calculations were carried out after driving each of the nine conformational angles separately, to set values in 10° increments, while relaxing all other angles. All these structures had a higher energy than the minimized crystal structure, indicating that the crystal structure is close to the energy minimum for the compound.

S. capitalis was collected from the waters of Enewetak, Micronesia, and was soaked in methanol upon collection. The methanolic extract (40 L) upon concentration and lyophilization gave a residue (60 g), which was triturated first with hexane followed by $CHCl_3$ and MeOH. Evaporation of the hexane, $CHCl_3$, and MeOH extracts gave 12.52, 5.4, and 32.9 g of residues, respectively. Residue from the chloroform extract (2 g) was chromatographed on a silica gel (230–400 mesh, E. Merck) column (2.5 × 100 cm). The column was eluted with benzene (5 × 100 mL), benzene–$CHCl_3$ (5 × 100 mL), $CHCl_3$ (5 × 100 mL), and $CHCl_3$–MeOH (9:1 v/v, 10 × 100 mL). Fractions 17–22 [100 mL each, eluted with $CHCl_3$–MeOH (9:1 v/v)] were combined on the basis of TLC (silica gel, solvent system: ethyl acetate) and evaporated to give 510 mg of a residue, which was rechromatographed on a silica gel column with a silica gel column using a linear gradient of 5–10% MeOH in $CHCl_3$. The desired fractions were combined and subjected to repeated HPLC with use of a solvent consisting of hexane–EtOAc (1:1 v/v). The HPLC resulted in separation of sclerophytin A (I, 40 mg) and sclerophytin C (IV, 15.7 mg).

Residue from the hexane extract (5 g) was chromatographed on a silica gel 60 (230–400 mesh, E. Merck) column (2.5 × 100 cm), which was eluted with hexane (200 mL, F1), hexane–benzene (1:1 v/v, 200 mL, F2), benzene (200 mL, F3), benzene–$CHCl_3$ (200 mL, F4, F5), and $CHCl_3$–MeOH (9:1 v/v, F6-9, 200 mL each). Fraction F6 upon evaporation gave 103 mg of a residue, which was subjected to repeated HPLC on a silica gel cartridge and hexane–EtOAc (1:1 v/v, flow rate 1 mL/min) as mobile phase, to yield 32 mg of sclerophytin B (II, retention time 11 min) and 18 mg of sclerophytin D (V, retention time 16 min) as a gummy residue. Fraction 7 upon evaporation gave a residue (59.5 mg), which was rechromatographed on a silica gel 60 column (1 × 60 cm). The column was eluted with a linear gradient of MeOH in $CHCl_3$ (0–10%, total volume 500 mL). Fractions of 10-mL volume were collected and combined on the basis of TLC (silica gel, EtOAc as solvent). Fractions 27–35 upon evaporation gave 31 mg of a residue, which was subjected to HPLC [silica gel cartridge, hexane–EtOAc (2:1 v/v) as solvent] to give 16.0 mg of sclerophytin E (VI, retention time 11.2 min) and 20.6 mg of sclerophytin E (VII, retention time 9 min).

Sclerophytin C (IV): mp 87 °C; $[\alpha]_D$ = -104.8° ($CHCl_3$, c = 0.124); IR λ_{max} 3550, 2920 and 1720 cm^{-1}; EIMS m/z (relative intensity) 378 (30), 337 (45), 336 (62), 318 (53), 300 (25), 275 (25), 263 (24), 178 (25), 177 (35), 134 (40), 127 (90), 108 (70), and 84 (64). ^{1}H and ^{13}C NMR data are presented in Table I.

Sclerophytin D (V): gummy solid; $[\alpha]_D$ = -138° ($CHCl_3$, c = 0.150); IR λ_{max} 3550, 3500, 2960 cm^{-1}; EIMS m/z (relative intensity) 336 (18), 318 (60), 300 (29), 275 (25), 263 (29), 127 (60), 108 (50), and 84 (100). ^{1}H and ^{13}C NMR are presented in Table I.

Sclerophytin E (VI): gummy solid; $[\alpha]_D$ = +88° ($CHCl_3$, c = 0.42); IR λ_{max} 3540, 3050, 2950, 1735 cm^{-1}; EIMS m/z (relative intensity) 338 (27), 320 (30), 302 (20), 278 (10), 260 (19), 192 (42), 108 (60), and 84 (62). ^{1}H and ^{13}C NMR data are presented in Table I.

Sclerophytin F (VII): gummy solid; $[\alpha]_D$ = +55° ($CHCl_3$, c = 0.20); IR λ_{max} 3500, 2980 cm^{-1}; EIMS m/z (relative intensity) 363 (2), 320 (54), 319 (71), 302 (11), 278 (8), 259 (10), 84 (60). ^{1}H and ^{13}C NMR data are presented in Table I.

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Supplementary Material Available: Anisotropic thermal parameters, positional and isotropic thermal parameters, bond distances, bond angles, final coordinates and isotropic equivalent thermal parameters for sclerophytin C (9 pages); structure factors for sclerophytin C (15 pages). Ordering information is given on any current masthead page.

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