

BISABOLANE SESQUITERPENES FROM BARBADIAN  
*PSEUDOPTEROGORGIA* SPP.

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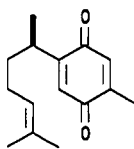
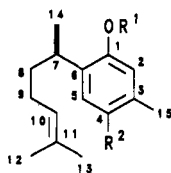
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ABSTRACT.—A new bisabolane sesquiterpene, (–)-curcuhydroquinone-1-monoacetate [1], was isolated from Barbadian *Pseudopterogorgia americana* along with the known (–)-curcuhydroquinone [2], (–)-curcuphenol acetate [3], and (–)-curcuquinone [4]. Compound 2 was also isolated from *P. acerosa*. The structures of all compounds were confirmed by the use of HMQC and HMBC nmr experiments.

In the course of our continuing investigation of marine organisms from the southern Caribbean Sea (1), we have examined extracts of the gorgonians *Pseudopterogorgia americana* Gmelin and *P. acerosa* Pallas (Octocorallia, Coelenterata), collected off the west coast of Barbados. The extracts of *P. americana* yielded the new bisabolane sesquiterpene, (–)-curcuhydroquinone-1-monoacetate [1], as well as the known compounds, (–)-curcuhydroquinone [2], (–)-curcuphenol acetate [3], and (–)-curcuquinone [4]. This is the first report of the direct isolation of 3; it was previously isolated by acetylation of the corresponding phenol [5], that was carried out in order to facilitate purification (2,3). Compounds 2–4 were first isolated from *P. rigida* collected off the coasts of Belize

and Tobago, West Indies (4,5). Very recently, (+)-curcuphenol was isolated from sponges and shown to possess anti-tumor activity and to inhibit H,K-ATPase (6,7). Three groups have now reported syntheses of these bisabolane sesquiterpenes (8–10). The current interest in these compounds has prompted us to report the results of our own investigations.

Compound 1,  $C_{17}H_{24}O_3$ , was isolated as a pale yellow oil and had ir absorptions characteristic of hydroxyl ( $3440\text{ cm}^{-1}$ ) and ester ( $1740\text{ cm}^{-1}$ ) functionalities. An examination of the  $^1\text{H}$ -nmr spectrum revealed the presence of two broad aromatic singlets at  $\delta$  6.64 and  $\delta$  6.75 which were reminiscent of a bisabolane sesquiterpene related to 2 (see below) but containing one acetate ( $\delta$  2.29). Two olefinic methyl groups resonated at  $\delta$  1.54 and  $\delta$  1.68, while an aromatic methyl had a broad singlet at  $\delta$  2.18. A fifth methyl group was evident from the presence of a doublet at  $\delta$  1.14 ( $J=7.0\text{ Hz}$ ). An HMQC experiment showed the direct connectivity involving all protonated carbons, while an HMBC experiment was used for the assignment of the non-protonated carbons. In the HMBC experiment, a phenolic hydroxyl proton



- 1  $R^1 = \text{Ac}$ ,  $R^2 = \text{OH}$
- 2  $R^1 = \text{H}$ ,  $R^2 = \text{OH}$
- 3  $R^1 = \text{Ac}$ ,  $R^2 = \text{H}$
- 5  $R^1 = \text{H}$ ,  $R^2 = \text{H}$

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with a broad singlet at  $\delta$  4.71 showed a two-bond correlation with a carbon at  $\delta$  151.8, which was assigned to C-4. Consequently, the acetate group must be at C-1. The foregoing evidence revealed that compound **1** is (-)-curcuhydroquinone-1-monoacetate. These nmr results are summarized in Table 1.

Compounds **2-4** were isolated from *P. americana* as viscous oils and had spectroscopic data in accord with literature values (2-5). However, because the nmr data reported in the literature for these compounds were incomplete (2-5), we have carried out a series of 2D nmr experiments, which included COSY, HMQC, and HMBC sequences, in order to complete their characterization (see Table 2).

An investigation of the extracts of *P. acerosa* gave **2** as white crystals, mp 86-87°; it was isolated previously on two occasions as a colorless oil (4,5). The spectroscopic properties of **2** were identical to literature values (4,5) and to the sample isolated from *P. americana*. Previous investigations of *P. americana* gave aristolane, maaliane, elemene, and

germacrane sesquiterpenes (11,12), while *P. acerosa* collected in Tobago and the Florida Keys yielded cembrane and pseudopterane diterpenes (13-17).

## EXPERIMENTAL

GENERAL EXPERIMENTAL PROCEDURES.—Mps were determined on a Thomas-Kofler micro hot stage. Infrared spectra were obtained on a Nicolet 5DX Ft-ir spectrometer. Uv spectra were recorded on a Cary 14 uv instrument, and nmr spectra were recorded on a Varian Unity 500 spectrometer in CDCl<sub>3</sub> solution with TMS as internal standard. A VG 70-250S mass spectrometer (70 eV) was used to obtain mass spectra.

ANIMAL MATERIAL.—The samples of *Pseudopterogorgia americana* and *P. acerosa* were collected off the west coast of Barbados in June 1994, and were identified by Mr. Richard Laydo of the Institute of Marine Affairs, Trinidad and Tobago, where voucher specimens have been deposited.

EXTRACTION AND ISOLATION.—*Pseudopterogorgia americana* (33 g dry wt after extraction) was soaked in Me<sub>2</sub>CO (3×200 ml) and the solvent concentrated to a small volume (75 ml) and extracted with CH<sub>2</sub>Cl<sub>2</sub> (2×250 ml). The CH<sub>2</sub>Cl<sub>2</sub>-soluble material (6.2 g) was flash chromatographed on Si gel using hexane-Me<sub>2</sub>CO (3:1) as mobile phase, followed by prep. tlc of similar fractions using hexane/Me<sub>2</sub>CO mixtures to give **1** (230 mg),

TABLE 1. Nmr Characteristics of Compound **1**.<sup>a</sup>

Position	$\delta_c$	$\delta_H$ ( $J_{HH}$ ) <sup>b</sup>	HMBC
1 .....	141.5	—	
2 .....	124.3	6.75 (br s)	C-1, C-3, C-15
3 .....	122.0	—	
4 .....	151.8	—	
5 .....	113.2	6.64 (s)	C-1, C-3, C-4, C-7
6 .....	131.6	—	
7 .....	32.0	2.75 (m)	C-1, C-5, C-6, C-8, C-9, C-14
8 .....	37.5	<1.52> <sup>c</sup> (m)	C-6, C-7, C-9, C-10, C-14
9 .....	26.0	<1.88> (m)	C-7, C-8, C-10, C-11
10 .....	124.2	5.07 (7)	C-12, C-13
11 .....	131.5	—	
12 .....	17.7	1.54 (br s)	C-10, C-11, C-15
13 .....	25.7	1.68 (br s)	C-10, C-11, C-12
14 .....	21.1	1.14 (7)	C-6, C-7, C-8
15 .....	15.4	2.18 (br s)	C-2, C-3, C-4
CH <sub>3</sub> CO .....	170.1	—	
CH <sub>3</sub> CO .....	20.9	2.29 (s)	CO
OH-4 .....	—	4.71 (br s)	C-3, C-4, C-5

<sup>a</sup>Taken at 500 MHz (<sup>1</sup>H) and 125 MHz (<sup>13</sup>C) with TMS as internal standard.

<sup>b</sup>Multiplicity in Hz.

<sup>c</sup><> Average value for an incompletely resolved methylene group.

TABLE 2.  $^{13}\text{C}$ - and  $^1\text{H}$ -Nmr Assignments for Compounds 2-4.<sup>a</sup>

Position	Compound					
	2		3		4	
	$\delta_{\text{C}}$	$\delta_{\text{H}}$	$\delta_{\text{C}}$	$\delta_{\text{H}}$	$\delta_{\text{C}}$	$\delta_{\text{H}}$
1	146.6	—	148.2	—	187.4	—
2	117.8	6.55	122.7	6.83	133.8	6.59
3	121.6	—	136.4	—	145.1	—
4	147.7	—	127.1	7.03	188.5	—
5	113.2	6.58	126.9	7.17	131.1	6.50
6	131.6	—	135.9	—	154.2	—
7	31.4	2.94	31.9	2.82	31.3	2.92
8	37.3	1.29	37.6	1.58	37.8	1.60
		1.29		1.58		1.36
9	26.0	1.93	26.1	1.90	25.8	1.93
		1.93		1.90		1.93
10	124.5	5.12	124.3	5.09	123.8	5.05
11	132.1	—	131.5	—	132.1	—
12	17.7	1.54	17.7	1.55	17.5	1.55
13	25.7	1.68	25.8	1.69	25.7	1.66
14	21.1	1.20	21.2	1.19	19.5	1.11
15	15.4	2.17	20.9	2.31	15.4	2.04
CH <sub>3</sub> CO	—	—	169.6	—	—	—
CH <sub>2</sub> CO	—	—	20.9	2.32	—	—
OH-1	—	4.39	—	—	—	—
OH-4	—	4.36	—	—	—	—

<sup>a</sup>Taken at 500 MHz ( $^1\text{H}$ ) and 125 MHz ( $^{13}\text{C}$ ) with TMS as internal standard.

2 (23 mg), 3 (117 mg), and 4 (54 mg). The spectroscopic data of compounds 2-4 were in accord with literature data (2-5).

(-)-*Curcubydroquinone-1-monoacetate* [1].—

Pale yellow oil;  $[\alpha]_{\text{D}} - 3.8^\circ$  ( $c=0.94$ ,  $\text{CHCl}_3$ ); ir  $\nu$  max 3440, 3020, 1740  $\text{cm}^{-1}$ ; uv  $\lambda$  max 215 nm ( $\epsilon$  6460), 279 nm ( $\epsilon$  2600); eims  $m/z$  276 ( $\text{M}^+$ , 31), 234 (74), 191 (7), 177 (15), 164 (29), 151 (100), 137 (25), 124 (15), 95 (17), 69 (21); hreims  $m/z$  found 276.1723 (calcd for  $\text{C}_{17}\text{H}_{24}\text{O}_3$  276.1725).

*Pseudopterogorgia acerosa* (87 g dry wt) was extracted with  $\text{Me}_2\text{CO}$  ( $3 \times 500$  ml) and the solvent concentrated and extracted with  $\text{CH}_2\text{Cl}_2$  ( $3 \times 200$  ml). The crude extract (9.5 g) was chromatographed using hexane- $\text{Me}_2\text{CO}$  (3:1) to give compound 2 as a white solid (1.99 g), mp 86-87°. All spectroscopic data (uv,  $[\alpha]_{\text{D}}$ , nmr, ms) for 2 were in complete accord with those of an authentic sample and literature values (4,5).

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