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A NEW SESQUITERPENE FROM THE BROWN ALGAE *Sargassum polycystum*

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*A new sesquiterpene, named spheciospongone C (**1**), and a known compound fucosterol (**2**) were isolated from the brown algae* Sargassum polycystum*. The structure and absolute configuration of compound **1** were identified by comprehensive 1D, 2D NMR, HR-ESI-MS spectral data and compared the circular dichroism (CD) data with the literature.*

Keywords: brown algae, *Sargassum polycystum*, sesquiterpene.

The genus *Sargassum*, belonging to the Sargassaceae family, consists of 250 species in the world, widely distributed in tropical and temperate sea zones, there are 60 species found in China [1]. The species of *S. polycystum* has been used as traditional Chinese medicine to treat barbiers, edema, and indigestion [2]. *S. polycystum* can produce a great number of flavonoids and polyphenols with strong antioxidant activities [3], and steroids, phenols, tannins, saponins, flavonoids, terpenoids and glycosides were also isolated from *S. polycystum* [4]. The species of *S. polycystum* also has great development value in industrial raw material [5] in the fields of food [6], medicine [7–9], agriculture [10], and ecological restoration [11]. In our search for bioactive constituents from *S. polycystum*, a new sesquiterpene spheciospongone C (**1**), along with a known compound fucosterol (**2**) were isolated. Herein we describe the isolation and structural determination of the isolated compounds.

Compound **1** was obtained as a yellowish oil. Its molecular formula $C_{15}H_{22}O_5$ (five degrees of unsaturation) was determined by the HR-ESI-MS spectrum, and further supported by the evidence of ^{13}C NMR spectral data (Table 1). In the ^1H NMR spectrum (Table 1), the presence of five methyl groups at δ_H (0.81, 1.02, 1.38, 2.00, and 2.29), and an olefinic proton signal at δ (5.58, s), indicated that compound **1** has a sesquiterpene skeleton [12]. The combination of ^1H, ^{13}C NMR, and HSQC spectra data showed 15 carbon signals, including one ketone carbon at δ_C 208.2, one ester carbon at δ 172.3, two olefin carbon groups at δ 192.7 and 108.2, three oxygenated carbons at δ 93.9, 76.0, and 69.2, two methylene carbon groups at δ 42.9 and 42.3, one quaternary carbon at δ 40.0, and five methyl groups at δ 26.7, 25.9, 22.2, 21.2, and 16.4. The preceding NMR data indicated that compound **1** was similar to spheciospongone A [13], except for the presence of one acetyl group at C-14 (δ 172.3, C) and C-15 [δ 21.2 (CH_3) and δ_H (2.00, s)] in **1** in the ^1H and ^{13}C NMR spectra.

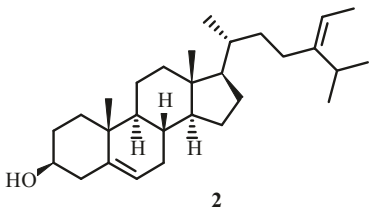

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TABLE 1. ^{1}H (600 MHz) and ^{13}C (125 MHz) NMR Data for Compound **1** (CD_3OD, δ, ppm, J/Hz)

C atom	δ_H	δ_C	C atom	δ_H	δ_C
1	–	40.0 (C)	8	5.58 (s)	108.2 (CH)
2	1.65 (m); 1.63 (m)	42.9 (CH_2)	9	–	192.7 (C)
3	5.24 (m)	69.2 (CH)	10	2.29 (s)	16.4 (CH_3)
4	1.96 (ddd, J = 1.3, 4.9, 13.1)	42.3 (CH_2)	11	0.81 (s)	26.7 (CH_3)
	1.68 (dd, J = 11.5, 13.1)		12	1.38 (s)	22.2 (CH_3)
5	–	76.0 (C)	13	1.02 (s)	25.9 (CH_3)
6	–	93.9 (C)	14	–	172.3 (C)
7	–	208.2 (C)	15	2.00 (s)	21.2 (CH_3)

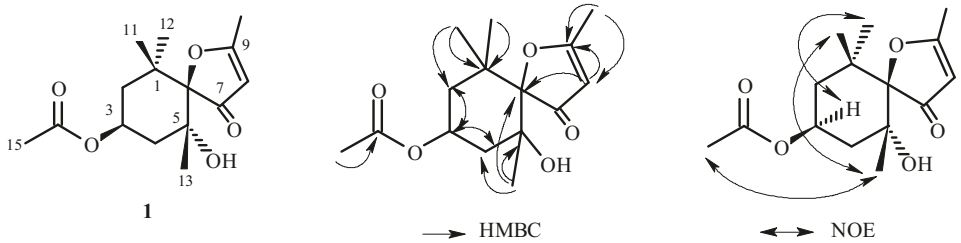

Fig. 1. The structure and key HMBC and NOE correlations of compound **1**.

The whole structure was further confirmed by the 2D NMR spectral (Fig. 1). The COSY correlations from H-3 to H-2a/H-2b/H-4a/H-4b established a moiety of CH_2(2)-CH(3)OH-CH_2(4). The HMBC correlations from CH_3-11 and CH_3-12 to C-1/C-2/C-6, CH_3-13 to C-4/C-5/C-6, disclosed a substructure of 1,1,5-trimethyl-cyclohexane [12]. Furthermore, the HMBC correlations from CH_3-10 to C-8/C-9, and from H-8 to C-6/C-7/C-9 enabled the formation of a 7-oxo-9-methyl-6,7-dihydrofuran ring to be located at C-6 in a spiro form (Fig. 1).

The relative configuration of **1** was based on the NOESY correlations as indicated in Fig. 1. The NOESY correlations of CH_3-11 to CH_3-13, CH_3-13 to CH_3-15, and CH_3-12 to H-3 indicated that CH_3-11, CH_3-13, and CH_3-15 were on the opposite side of the H-3 and CH_3-12. In addition, the CD spectrum of **1** was in good agreement with the literature CD spectrum [12], the negative Cotton effect (CE) ($\Delta\varepsilon_{271\ nm}$ –26.527) for the n–π* transition and the positive CE ($\Delta\varepsilon_{218\ nm}$ +5.004) for the π–π* transition when applying the right-handed helicity rule (Fig. 2). Accordingly, the chiral centers of C-3, C-5, and C-6 were determined to be 3*S*, 5*R*, and 6*R*; thus, the structure of **1** was established to be spheciospongone C. By comparing physical and spectroscopic data with values found in the literature, the known compound **2** was determined as fucosterol [14].

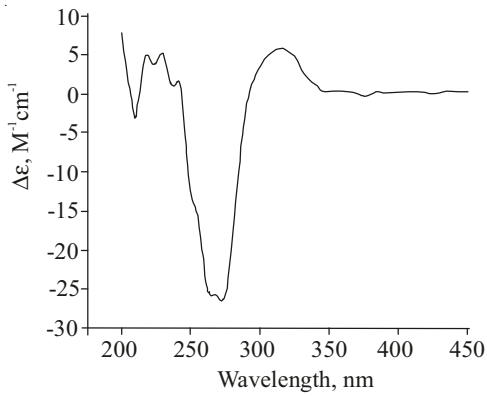

Fig. 2. CD spectrum of compound **1**.

EXPERIMENTAL

General. 1D and 2D NMR spectra were measured on an NMR spectrometer (JEOL, 600 MHz, Japan) and a Bruker AV-400 (Bruker Corporation, Switzerland) instrument with TMS as the internal standard ESI-MS and HR-ESI-MS spectra were obtained on a Bruker Daltonics Apex-Ultra 7.0 T (Bruker Corporation, Billerica, MA, USA) and a Q-TOF Ultima Global GAA076 LC mass spectrometer. For semipreparative HPLC, an Agilent 1100 prep-HPLC system with a Waters C18 semipreparative column (9.4 × 250 mm, 7 μm) was used. Sephadex LH-20 (Pharmacia Co. Ltd., Sandwich, UK) and silica gel

(200–300 and 300–400 mesh, Qingdao Marine Chemical Factory, Qingdao, China) were used for column chromatography (CC). Silica gel (GF254) for TLC were supplied by the Qingdao Marine Chemical Factory in China. All solvents used were of analytical grade (Guangzhou, China).

Plant Material. The plant material was collected from Danzhou, Hainan Province, China and was identified by Prof. Caijuan Zheng, College of Chemistry and Chemical Engineering, Hainan Normal University, Haikou, China. A voucher specimen (No. HZ202109) has been deposited at the key laboratory of tropical medicinal resource chemistry of ministry of education, college of chemistry and chemical engineering, Hainan Normal University.

Extraction and Isolation. The air-dried *Sargassum polycystum* (1.5 kg) were powdered and extracted three times with 95% EtOH (each for 7 days) at room temperature. The crude extract was suspended in water and extracted successively with petroleum ether (PE) and ethyl acetate (EtOAc). The petroleum ether extract (20.0 g) was subjected to column chromatography (CC) on silica gel, eluting with PE–EtOAc (40:1, 20:1, 15:1, 10:1, 8:1, 5:1, 2:1, 1:1) to yield eight fractions (Frs. 1–8). Fraction 6 (200 mg) was further subjected over silica gel column (PE–EtOAc, 8:1) and subjected to Sephadex LH-20 (PE–$CHCl_3$–MeOH, 2:1:1), and then purified by semipreparative HPLC eluted with MeOH–H_2O (70:30) to yield compound **1** (1.5 mg). Repeated chromatography of Fr. 3 (355 mg) was used over a silica gel column (PE–EtOAc, 10:1→1:10) to yield compound **2** (4 mg).

Spheciospongone C (1), yellowish oil; $[\alpha]_D^{20}$ –12.0° (*c* 1.0, CH_3OH). UV (MeOH, λ_{max}, nm): 272, 208. IR (KBr, ν_{max}, cm^{-1}): 3516, 2900, 1668, 1457, 1169. ^1H and ^{13}C NMR data (CD_3OD), see Table 1. HR-ESI-MS *m/z* 281.1392 $[M - H]^-$ (calcd for $C_{15}H_{21}O_5$, 281.1394).

Fucosterol (2), white powder. ^1H NMR (400 MHz, $CDCl_3$, δ, ppm, J/Hz): 5.34 (1H, br.d, J = 5.2, H-6), 5.17 (1H, q, J = 6.7, H-28), 3.51 (1H, m, H-3), 2.18 (1H, m, H-25), 1.60 (3H, d, J = 6.7, H-29), 1.00 (3H, s, H-19), 0.96 (3H, d, J = 1.4, H-21), 0.68 (3H, s, H-18). ^{13}C NMR (100 MHz, $CDCl_3$, δ, ppm): 37.4 (C-1), 31.9 (C-2), 71.9 (C-3), 42.40 (C-4), 140.8 (C-5), 121.8 (C-6), 31.6 (C-7), 32.0 (C-8), 50.3 (C-9), 36.6 (C-10), 21.2 (C-11), 39.9 (C-12), 42.5 (C-13), 56.9 (C-14), 24.5 (C-15), 28.4 (C-16), 55.9 (C-17), 12.0 (C-18), 19.5 (C-19), 36.5 (C-20), 18.9 (C-21), 35.4 (C-22), 25.8 (C-23), 147.1 (C-24), 34.9 (C-25), 22.3 (C-26), 22.4 (C-27), 115.7 (C-28), 13.3 (C-29). ESI-MS *m/z* 411.3 $[M - H]^-$ [14].

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