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Terpenoidal Metabolites Obtained from Saudi Red Sea Soft Coral Sarcophyton Sp.

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Abstract. Chemical investigation of the soft coral Sarcophyton sp. collected from the Saudi territorial Red Sea waters, led to isolation of five terpenoidal metabolites (1-5). Three known sesquiterpenoid derivative; guaiacophine (1), guaia-5, 11(12)-dien (2) and calamenene (3), along with two known cembranoidal diterpenes, 2S*,11S*,12R*-isosarcophytoxide (4) and ent-sarcophine (5) were obtained. The structures of the compounds were established based on their NMR, MS, IR and UV spectral data.

Keywords: Red sea, soft coral, sesquiterpenes, cembranoids.

1. Introduction

Marine ecosystems are often characterized by harsh atmosphere which lead to high diversity with archetype of metabolites comparable with those originated from terrestrial organisms. Huge numbers of compounds are discovered from marine origin every year.[1]

Marine invertebrate, particularly, soft-corals are considered potential sources of a diversity of natural products with different biological effects; anti-bacterial, anti-tumor, anti-viral, anti-inflammatory and analgesics.[2] The Red Sea serves as an epicenter for marine bio-diversity with a high endemic biota. Indeed of the 180 soft corals species identified world-wide, approximately 40% are native to the Red Sea.[3]

Soft corals constitute an important group of marine invertebrates widely distributed in the coral reefs of the world oceans and have proven to be a biochemical warehouse for terpenes.[4] Of them, the animals belonging to the genus *Sarcophyton* (Phylum, Cnidaria; Class, Anthozoa; Subclass, Octocorallia; Order, Alcyonacea; Family, Alcyoniidae) are very prolific.

Sesquiterpenes are terpenes that consist of three isoprene units, and their structures are derived from geranylfarnesyldiphosphate. They form a large group with widespread distribution, having been isolated from terrestrial fungi, higher plants, insects, and various marine organisms, such as soft corals.[5] Several sequiterpenes with six skeletons (one is a novel skeleton) were isolated from six species of this genus, i.e., *Sarcophyton buitendijki, S. elegans, S. acutangulum, S. glaucum, S. ehrenbergi, and S. trocheliophorum.*

The cembranes skeleton is isoprenoid and consists of a fourteen-membered carbocyclic ring substituted by an isopropyl residue at position 1, and by three symmetrically disposed methyl groups at positions 4, 8, and 12. Natural cembranoids range in functional complexity from hydrocarbons and alcohols to polyfunctional lactone derivatives. These compounds typically contain nuclear unsaturation at one or more of the methyl substitution.[6-13]

A soft coral, identified as *Sarcophyton* sp., was found to produce several known metabolites, guaiacophine (**1**); guaia-5,11(12)-dien (**2**) calamenene (**3**), 2*S**,11*S**,12*R**-isosarcophytoxide (**4**) and ent-sarcophine (**5**). The structures were determined based on spectroscopic measurements (NMR, UV, IR and MS).

2. Experimental Section

2.1. General

1D and 2D NMR spectra were recorded on Bruker AVANCE III WM 600 MHz spectrometers and ^{13}C NMR at 150 MHz. Chemical shift values are given in δ (ppm) relative to TMS as internal standard. EI/MS analyses were carried out on a Shimadzu-QP 2010. GC/MS analyses were carried out using RTX-1 column (30 m, 0.25mm). Optical rotations were measured on ATAGO POLAX-L 2 polarimeter. Thin layer chromatography was performed on silica gel (Kieselgel 60, F_{254}, Fluka, Germany) of 0.25 mm layer thickness. Gel filtration was carried out using Sephadex LH-20 (Pharmacia Fine Chemicals, AB Uppsala, Sweden). Spots were detected by using ethanol /sulfuric acid as spray reagent.

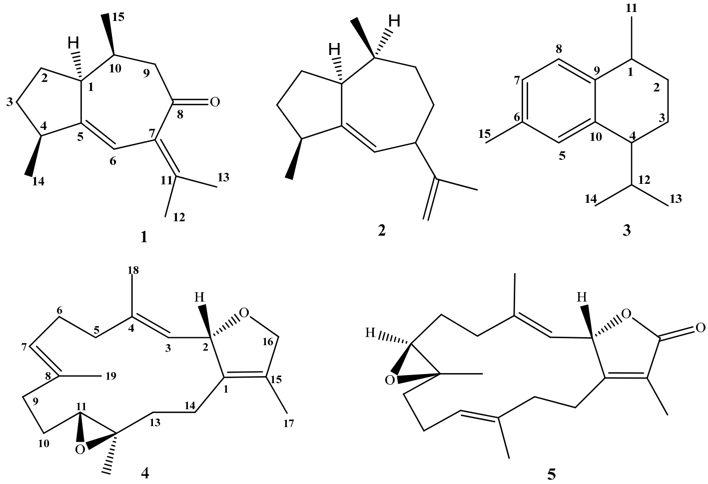

Fig. 1. Compounds isolated form *Sarcophyton* sp.

2.2 Marine animal

Soft coral *Sarcophyton* sp. (Order Alcyonacea, Family Alcyoniidae) was collected from the Red Sea coast (21°29′33″N 39°11′25″E) in Jeddah, at a depth of 5-15 m (January, 2014). A voucher specimen (SC-2014-1) was deposited in the Faculty of Marine Sciences, King Abdulaziz University, Jeddah, Saudi Arabia.

2.3 Extraction and isolation

The fresh Soft coral *Sarcophyton* sp. (5.0 kg) was minced and exhaustively extracted with a mixture of CH_2Cl_2:MeOH (2:1 v/v, 24 hours for each batch, 22 ºC, 10 L X 3), and then the combined extracts were concentrated under vacuum yielding viscous blackish residue. The residue was partitioned between diethyl ether and water. The organic layer was dried (35 g) and then fractionated on normal phase silica gel

(NP-Silica), eluted stepwise with *n*-hexane containing increasing amounts of diethyl ether and then increasing polarity with EtOAc. 100 Fractions (F 1-100), were collected. The fractions were investigated by TLC pattern using UV lamp and/or 50%-sulfuric acid in methanol as spraying reagent. The fraction F-3 eluted with *n*-hexane: diethyl ether (9.5:0.5, 300.00 mg) was purified by preparative TLC using solvent system *n*-hexane: diethyl ether (9.5:0.5). The band with R_f= 0.60 (violet-red color with sulfuric acid - methanol) was taken to give **1** as colorless oil (9 mg), that with R_f= 0.40 (pink color with sulfuric acid/ methanol) was taken to give **4** as colorless oil (160 mg) and the third with R_f= 0.17 (UV active and exhibited dark violet color with sulfuric acid - methanol) resulted in **5** as colorless oil (110 mg). The fraction F-13 eluted with *n*-hexane: diethyl ether (9:1, 120.00 mg) was purified by preparative TLC using the solvent system *n*-hexane: diethyl ether (10: 0), to give two bands. The first one with R_f = 0.8 (violet color with sulfuric acid-methanol) was taken to give colorless oil (10 mg) **3**, while the second with R_f =0.5 (violet color with sulfuric acid-methanol) gave a pale yellow oil of **2** (4.5 mg).

Guaiacophine (1)

Colorless oil (9 mg); R_f= 0.6 (*n*-hexane: diethyl ether, 9.5:0.5); EIMS *m/z* (rel. int.): 218 $[M]^+$ ($C_{15}H_{22}O$), 203 $[M\text{-}CH_3]^+$, 200 $[M\text{-}H_2O]^+$, 175, 178 (30), 157, 118, 90, 63, 55 . HRESI-MS data *m/z* 218.1674 $[M]^+$ (calculated for $C_{15}H_{22}O$, 218.1671); ^1H, ^{13}C NMR (Table 1).

Guaia-5, 11(12)-dien (2)

Pale yellow oil (4.5 mg); R_f= 0.5 (*n*-hexane: diethyl ether, 10:1); EIMS *m/z* (rel. int.): 204 $[M]^+$ ($C_{15}H_{24}$), 189 $[M\text{-}CH_3]^+$ 174 $[M\text{-}2CH_3]^+$, 146,118, 41. HRESI-MS data *m/z* 204.1870 $[M]^+$ (calculated for $C_{15}H_{24}$, 204.1878); ^1H, ^{13}C NMR (Table 1).

Calamenene (3)

Yellow oil (10 mg); R_f= 0.8 (*n*-hexane: diethyl ether, 10:1); UV (*n*-hexane) (λ_{max}) 221, 273, 289 nm. IR (film) 3080, 3045, 2925, 2861, 1510, 1020, 950, 935, 898, 813 cm^{-1}. EIMS *m/z* (rel. int.): 202 $[M]^+$ ($C_{15}H_{22}$), 187 $[M\text{-}CH_3]^+$ 157 $[M\text{-}C_3H_7]^+$, 144, 129, 157, 90, 63, 55, 43 . HRESI-MS data *m/z* 202.1714 $[M]^+$ (calculated for $C_{15}H_{22}$, 202.1722); ^1H, ^{13}C NMR (Table 1).

2S,11S*,12R*-isosarcophytoxide (4)*

Colorless oil (160 mg); $[\alpha]_{22}^{D}$ -60 (*c* 0.01, $CHCl_3$); IR ($CHCl_3$) λ_{max}1710, 1677 cm^{-1}; ^{1} H NMR and ^{13}C NMR (Table 2); HREIMS *m*/*z* 302.2232 (calc 302.2246).

ent-sarcophine (5)

Yellow oil (90 mg); R_f= 0.86 (Pet. Ether : diethyl ether (9: 1),); EIMS *m/z* (rel. int.): 316 ([M, $C_{20}H_{28}O_3$] $^{+}$, 298 (2) [M- H_2O] $^{+}$, 283 (3), 270 (1), 248 (3), 221 (5), 215 (7), 201 (11), 164 (60), 149 (45), 107 (55), 91 (75), 81 (100), 53 (70). ^{1} H NMR and ^{13}C NMR (Table 2).

3. Results and discussion

Compound **1** was designated guaiacophine (**1**). It showed an HREI-MS [M^{+}] *m*/*z*=218.1674 for a molecular formula of $C_{15}H_{22}O$ and therefore, possessed five degrees of unsaturation. The NMR (^{13}C and DEPT NMR experiments) data (Table 1) indicated the presence of two double bonds (a trisubstituted one, δ_C 151.7 and 116.9 ppm, and a tetra-substituted one, δ_C 137.8 and 136.9 and a ketone (δ_C 207.6 and λ_{max} 1710 cm^{-1}); therefore **1** had to be bicyclic. Two-dimensional NMR experiments, including COSY, HMQC and especially HMBC were mainly used for the structure elucidation and established its structure as guaia-5,7(11)-dien-8-one structure.[16] Furthermore, on the basis of NOEs the stereochemistry of **1** with both CH -14 and -15 on one side of the molecule, opposite H-1, was established. NOEs were seen between CH_3 -14 and H-3β and H-6; between CH_3-15 and H-2β, H-3 β, and H-9β on one side of the molecule, and between H-1α and H-10α on the other side.

Compound **2** was isolated as pale yellow oil. It showed an HREI-MS [M^{+}] m/z=204.1870 for a molecular formula of $C_{15}H_{24}$ and therefore, possessed four degrees of unsaturation. The NMR (^{1}H, ^{13}C and DEPT NMR experiments) data (Table 1) indicated the presence of two carbon-carbon double bonds (a trisubstituted one, δ_C150.8 and 122.4 ppm, and a 1,1-disubstituted one, δ_C147.2 and 110.8), two doublet methyls (δ_H 0.81, d, 6.6 Hz and 0.64, d, 7.2 Hz), a singlet methyl (δ_H 1.52, s) and two methyledine protons (δ_H4.57 and 4.56); therefore **2** had to be bicyclic. Two-dimensional NMR experiments, including COSY, HMQC and especially HMBC established its structure as guaia-5,7(12)-dien structure. Furthermore, on the basis of NOEs the stereochemistry of **2** with both CH -14, -15 and H-7 on one side of the molecule, opposite H-1, was established. NOEs were seen between CH_3 -14 and H-3β and H-6; between CH_3-15 and H-2β, H-7, H-3 β, and H-9β on one side of the molecule, and between H-1α, H-10α on the other side.

Compound **3** was isolated as yellow oil. It showed an HREI-MS $[M^+]$ m/z=202.1714 for a molecular formula of $C_{15}H_{22}$ and therefore, possessed six degrees of unsaturation. The NMR (^1H, ^{13}C and DEPT NMR experiments) data (Table 1) indicated the presence of three double bonds (δ_C 140.3, 140.1, 134.7, 129.0, 127.0 and 126.4), therefore **3** had to be bicyclic. The presence of a substituted benzene ring was concluded from the UV absorption spectrum, which showed maximum (λ_{max}) at 233, 275 and 287 nm, supported by IR absorption at 1510 cm^{-1}. The compound **3** has also an aromatic methyl protons resonating at δ_H 2.33 ppm and three secondary methyls at δ_H1.34 (d, 7.2 Hz), 1.03 (d, 7.2 Hz) and 0.75 (d, 7.2 Hz). The presence of *o*/*p*-trisubstituted benzene ring was shown from the presence of AB system of the aromatic system (δ_H7.16, d, 7.8 Hz and 6.99, d, 7.8 Hz) and a singlet aromatic proton at δ_H 7.05 (s). The H-H COESY established the proton system H-1/H_2-2/H_2-3/H-4/H-10/H_3-11(H_3-11). Two-dimensional NMR experiments, including COSY, HMQC and especially HMBC established the structure of **3** as of calamenene.[16].

Compound **4** was isolated as colorless oil (8.0 mg) with $[\alpha]_D^{22}$ + 80.0 (*c* 0.02, $CHCl_3$). The structure elucidation commenced when the molecular formula of **4**, $C_{20}H_{30}O_2$ was established by LCESIMS *m/z* = 302.2 $[M]^+$ and 287.1 $[M-H_2O]^+$. This result was validated by HREIMS *m/z* = 302.2245 $[M]^+$. The ^{13}C (^1H decoupled) and DEPT NMR spectra of **1**, showed 20 resonances attributable to four methyls, seven methylenes, four methines and five quaternary carbons (Table 2).

Two of the six elements of unsaturation, as indicated by the molecular formula of **4**, are attributed to three C=C double bonds; thus, the molecule is tricyclic. It was possible to deduce the planar structure of **4** by interpretation of the ^1H-^1H COSY and ^1H–^{13}C HMBC spectra. From the ^1H–^1H COSY spectrum of **4**, there is coupling between H-2 resonating at δ_H 5.55 (d, *J* = 10.2 Hz) and H-3 at δ_H 5.25 (d, 10.2 Hz); and correlations between H_3-18 at δ_H 1.67 (s) and H-3 and H-5 (δ_H 2.2 (m) and 1.2 (m)). Long-range C-H correlations observed between the resonances of H_3-18 and those of C-4 (δ_C 139.5 ppm), C-3 (δ_C 123.8), and C-5 (δ_C 40.1), between H-2 and C-1(δ_C 137.1), C-3 (δ_C 123.8), C-4(δ_C 139.5), C-14 (δ_C 37.8) and C-15 (δ_C 128.1).

Table 1. NMR spectral data of compounds 1-3 in $CDCl_3$ (δ, ppm, *J*, Hz).[a, b]

P.	**1**		**2**		**3**	
	δ_H (*J* in Hz)	**δ_C**	**δ_H (*J* in Hz)**	**δ_C**	**δ_H (*J* in Hz)**	**δ_C**
1	2.38 (1H, m)	45.2	2.70 (m)	45.7	2.26 (m)	30.8
2	1.78 (m, Ha) 1.70 (m, Hb)	29.2	1.50 (m, Ha) 1.35 (m, H_b)	30.2	1.98 (m, Ha) 1.36 (m, Hb)	30.5
3	1.87 (m, Ha) 1.34 (m, Hb)	34.0	1.50 (m, Ha) 1.00 (m, Hb)	34.0	1.85 (m, Ha) 1.65 (m, Hb)	22.0
4	2.54 (Sext., 7.2 Hz)	40.2	2.30 (dt, 13.2, 6.6)	41.0	2.34 (m)	43.0
5	-	151.7	-	150.8	7.05 (s)	129.0
6	6.13 (1H, s)	116.9	5.19 (dd, 7.2, 3.0)	122.4	-	134.7
7	-	137.8	2.62 (m)	47.4	7.16 (d, 7.8)	126.4
8	-	207.6	1.60 (m, Ha) 1.50 (m, Hb)	25.9	6.99 (d, 7.8)	127.0
9	2.50 (dd, 11.4, 6.6, Ha) 2.45 (dd, 11.4, 7.2, Hb)	51.1	1.64 (m, Ha) 1.20 (m, Hb)	33.4	-	140.3
10	2.35 (br sep., 6.6 Hz)	36.7	1.66 (m)	34.0	-	140.1
11	-	136.7	-	147.2	1.34 (d, 7.2)	22.3
12	1.76 (3H, s)	21.5	4.57 (s), 4.56 (s)	110.8	2.79 (m)	32.5
13	1.83 (3H, s)	22.7	1.52 (s)	21.6	0.75 (d, 7.2)	17.4
14	1.06 (3H, d, 6.6 Hz)	19.6	0.81(d, 6.6)	19.9	1.03 (d, 7.2)	21.3
15	0.83 (3H, d, 6.6 Hz)	16.8	0.64 (d, 7.2)	15.7	2.33 (s)	21.1

[a] The solvent is $CDCl_3$.

[b] All assignments are based on 1D and 2D measurements (HMBC, HSQC, COSY).

[c] Implied multiplicities were determined by DEPT (C = s, CH = d, CH_2 = t).

The existence of a furan ring in which C-1 is part, was concluded by studying the correlations observed between H-2 at δ_H 5.55 (d, J = 10.2 Hz), in addition to the long-range correlations. The presence of oxygen atom as part of a furan ring between C-2 (δ_C 83.9) and C-16 (δ_C 78.6) was evidenced from the down field δ_H of H-16 (δ_H 4.50, br s) and also the absence of absorption due to hydroxyl function in the IR spectrum. Furthermore, HMBC correlation between H-5 and, C-3 (δ_C 123.8 ppm), C-4 (δ_C 139.5 ppm), C-6 (δ_C 26.5 ppm), C-7 (δ_C 126.5 ppm) and C-18 (δ_C 15.3 ppm); also correlation between H_3-19 (δ_H 1.60, s) and C-7, C-8 (δ_C 133.5 ppm), and C-9 (δ_C 36.9), indicated the connection between C-7, C-8 and C-9 and positioning of CH_3-19 on C-8. On these bases the connections from C-2 to C-9 was established. NMR spectral data and molecular formula indicated that **4** has a tricyclic structure. The nature of the second ring was proved to be 14-membered ring based on the following: a) ^{13}C NMR signals δ_C 123.8 (C-3), 139.5 (C-4), 126.5 (C-7) and 133.5 (C-8) 137.1 (C-1), 128.1 (C-15), indicated the presence of two trisubstituted double bonds and tetra-substituted double bond without conjugation. This deduction supported by:a) absence of characteristic absorption in UV spectrum, b) ^{1}H-^{1}H COSY spectral data indicated the possibility of existence of three partial structures of consecutive proton systems extending from H_2-5 (δ_H 1.20, m and 2.20, m) to H-7 (δ_H 5.13, m) through H_2-6 (δ_H 2.30, m and 1.85, m); from H_2-9 (δ_H 2.4, m and 1.8 m) to H_2-11 (δ_H 2.5, m, and 1.8, m) to H_2-10 (δ_H 1.90, m and 2.20, m) . Finally interpretation of the HMBC correlations established the connection of the three partial structures. Thus, **4** represents the typical cembranoid-like structure which fitted with the published data.[7- 12] The location of the epoxide ring (third ring) at C11/C-12 was suggested to have resonances at δ_C 62.2 (CH) and δ_C 60.1 (C). This is confirmed by HMBC correlations, as there are clear connections between H-11 with C-9, C-10, C-12 and C-13, also correlation between H_3-20 with C-11, C-12 and C-13, and between H_2-10 and C-11 and C-12 establishing the connections from C-10 to C-13.

The relative configuration of **4** assigned by 2D NOESY spectral data, which indicated the presence of cross peaks between the vinylic CH_3-18 and H_2-6 (δ_H 2.30, m and 1.85, m) suggested the *E* geometry for the C-3/C-4 double bond. This was also identified by the chemical shift of H-3 at δ_H 5.25 (d, 10.2 Hz). The geometry of the trisubstituted olefin at C-3/C-4 is *E* oriented owing to the values of chemical shifts of allylic methylene. Cross peaks assigned for the vinylic CH_3-19 (δ_H 1.61, s) and H_2-6 (δ_H 1.62, m and 1.42, m, ppm) suggested the E geometry for the C-7/C-8 double bond, which was also identified by the chemical shift of H-7 at δ_H 5.13 (m). The geometry of the trisubstituted olefin at C-7/C-8 was assigned as *E* based on the higher field chemical shift of the olefinic methyl signal for C-19 (δ_C 15.8). Furthermore, the NOE correlations between Me-18/H-2 (δ_H 5.25 ppm), and Me-19/H-11, demonstrated the existence of 2*S**, 11*S**, and 12R*[17] demonstrated for similar cembranoid structures that the absolute configuration at C-2 can be related to the sign of the specific optical rotation. Compounds with the *S* configuration have a large positive optical rotation and those with *R* configuration have a large negative optical rotation. Thus, the absolute configuration at C-2 of **4** was tentatively assigned as *S* based on the optical rotation ($[\alpha]^{20}_{D}$-80). A careful analysis of all the NMR spectroscopic data (COSY, HSQC, HMBC, and NOESY) confirmed **4** to be a cembranoid derivative with 2*S**, 11*S**, and 12*R** isosarcophytoxide. A computer survey was done employing Science Finder database has shown that compound **4** was extracted for the first time from *Sarcophyton* sp.

Compound **5** was isolated as a white amorphous powder. Its molecular formula, $C_{20}H_{28}O_3$ was established by using HREI-MS *m*/*z* = 316.2029 $[M]^+$, indicated seven degrees of unsaturation. The IR spectral data showed the presence of α, β-unsaturated-γ-lactone, carbon-carbon double bond, and an epoxide ring (*cf. exp.*). ^1H, ^{13}C (^1H decoupled) (Table 2) HSQC and DEPT NMR spectra, indicated the presence of the following features: a) tricyclic structure, b) trisubstituted epoxy ring resonating at δ_C 61.4 (C-7, d) and 59.9 ppm (C-8, s) assigned for C-7 and C-8, respectively, c) an α, β-unsaturated-γ-lactone based on characteristic signals resonating at δ_C 174.1 (C-16, s), 122.9 (C-15, s) and 162.3 ppm (C-1, s), d) two trisubstituted C=C bonds resonating at δ_C 120.6 (C-3, d), 144.0 (C-4, s), 124.9 (C-11, s) and 135.5 ppm (C-12, d) and e) an oxymethine carbon which appeared at δ_C 78.2 ppm (C-2).

Interpretation of the ^1H-^1H COSY and HMBC spectral data and comparison with those reported in the literature indicated that **5** is identical to the previously known compound ent-sarcophine isolated from the genus *Sarcophyton*.[17]

Table 2. NMR spectral data of compounds 4 and 5in CDCl$_3$ (δ, ppm, *J*, Hz).[a]

Position	4		5	
	δ ^{1}H (m, *J*, Hz)	δ^{13}C[b]	δ ^{1}H (m, *J*, Hz)	δ^{13}C
1	-	137.1	-	162.3
2	5.55 (d, 10.2)	83.9	5.57 (dd, 10.2, 1.2 Hz)	78.2
3	5.25 (d, 10.2)	123.8	5.05 (dd, 10.2, 1.2 Hz)	120.6
4	-	139.5	-	144.0
5	2.20 (m, Ha) 1.20 (m, Hb)	40.1	2.37 (2H, m)	37.4
6	2.30 (m, Ha) 1.85 (m, Hb)	26.4	1.90 (m, Ha) 1.69 (m, Hb)	25.2
7	5.13 (m)	126.5	2.68 (dd, 4.8, 4.2 Hz)	61.4
8	-	133.5	-	59.9
9	2.40 (m, Ha) 1.80 (m, Hb)	36.6	2.10 (m, Ha) 1.10 (m, Hb)	39.0
10	2.20 (m, Ha) 1.90 (m, Hb)	23.8	2.26 (m, Ha) 1.93 (m, Hb)	23.3
11	2.73(dd, 10.2, 7.2)	62.2	5.17 (dd, 9.6, 5.4)	124.9
12	-	60.1	-	135.5
13	2.50 (m, Ha) 1.80 (m, Hb)	25.5	2.18(ddd, 18.0, 12.6, 9.0, Ha) 2.01(ddd, 13.2, 10.8, 2.4, Hb)	36.4
14	2.10 (m, Ha) 1.00 (m, Hb)	37.8	2.78 (ddd, 13.2, 5.4, 2.4, Ha) 2.37 (ddd, 18.0, 9.6, 7.8, Hb)	27.6
15	-	128.1	-	122.9
16	4.5 (br s)	78.6	-	174.1
17	1.85 (s)	10.4	1.85 (s)	9.0
18	1.67 (3H, s)	15.3	1.89 (3H, s)	16.1
19	1.60 (3H, s)	15.8	1.28 (3H, s)	17.1
20	1.29 (3H, s)	17.2	1.61 (3H, s)	15.4

[a] All assignments are based on 1D and 2D measurements (HMBC, HSQC, COSY).

[b] Implied multiplicities were determined by DEPT (C = s, CH = d, CH$_2$ = t).

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أيضات تربينية من عينة من مرجان البحر الاحمر الناعم (جنس الساركوفيتون)

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المستخلص. الفصل الكروماتوجرافى لعينة من المرجان الناعم من جنس الساركوفيتون التي تم جمعها من المياه الاقليمية للبحر الاحمر السعودي,أدت الي فصل خمس تيربينات **(1–5)**: ثلاث منها معروفة من مشتقات السيسكويترين, جواياكوفين **(6)**، جوايا–5,11(12)–دايبي **(8)** و كالامينين **(9)**, وايضا مركبين من مشتقات السمبران ثنائى تيربين 2إس*11إس*،12أر*– ايزوساركوفيتوكسيد **(1)** واينت–ساركوفين **(5)**. تم إثبات التركيب الكيميائى بإستخدام الطرق الطيفية المختلفة مثل الرنين النووى المغناطيسى وطيف الاشعة فوق البنفسجية و تحت الحمراء بالإضافة الى مطياف الكتلة.