Supplementary Material

New cytotoxic isoprenoid derivatives from the red sea soft coral *Sarcophyton glaucum*

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Abstract

Chemical investigation of the soft coral *Sarcophyton glaucum* collected from the Red Sea waters, led to isolation of eleven isoprenoidal metabolites (**1-11**). A new sesquiterpenoid, 6-oxo-germacra-4(15),8,11-triene (**1**); a new natural cembranoids, **sarcophinediol**; along with two known sesquiterpenoids (**2** and **3**) and seven known cembranoids (**5-11**) were obtained. The structures of the compounds were established based on their NMR, MS, IR and UV spectral data. All compounds were evaluated for their cytotoxic activities employing three different cancer cell lines (HepG2, MCF-7 and HCT116). Compounds **4**, and **6** showed significant cytotoxicity towards HepG2 with IC₅₀ values of 18.8±0.07, and 19.9 ±0.02 µM; respectively. Compounds **5**, **6** and **7** exhibited potent cytotoxicity against MCF-7 cells with IC₅₀ values of 9.9±0.03, 2.4 ±0.04, and 3.2±0.02 µM, respectively. Compounds **1**, **4**, and **5** showed significant activities towards HCT116 cells with IC₅₀ values of 29.4 ±0.03, 19.4 ±0.02 and 25.8±0.03 µM, respectively. The observed cytotoxic activity warrants further investigations.

Keywords: *Sarcophyton glaucum*; cembranes; cytotoxic; HepG2; MCF-7

Palustrol (3)

Colorless oil, ^1H NMR (CDCl_3 , 600 MHz): δ = 1.84 (1H, m, H_a -2), 1.37 (1H, m, H_b -2), 1.82 (2H, m, H_2 -3), 2.15 (1H, m, H-4), 1.60 (1H, dd, J = 10.2, 10.2 Hz, H-5), 0.51 (1H, dd, J = 10.8, 9 Hz, H-6), 0.68 (1H, ddd, J = 10.8, 9, 6.6 Hz, H-7), 1.88 (1H, m, H_a -8), 1.06 (1H, m, H_b -8), 1.47 (1H, m, H_a -9), 1.35 (1H, m, H_b -9), 1.27 (1H, m, H-10), 1.03 (3H, s, H_3 -12), 1.06 (3H, s, H_3 -13), 0.98 (3H, d, J = 6.6 Hz, H_3 -14), 0.92 (3H, d, J = 6.6 Hz, H_3 -15); ^{13}C NMR (CDCl_3 , 150 MHz): δ = 85.7 (CH, C-1), 47.2 (CH, C-5), 46.1 (CH, C-10), 38.9 (CH_2 , C-2), 35.0 (CH, C-4), 32.8 (CH_2 , C-3), 32.3 (CH_2 , C-9), 28.9 (CH_3 , C-13), 27.1 (CH, C-7), 24.5 (CH_2 , C-8), 22.0 (CH, C-6), 19.9 (C, C-11), 18.7 (CH_3 , C-14), 17.7 (CH_3 , C-15), 15.6 (CH_3 , C-12).

Sarcophine diol (4)

Colorless oil (8.0 mg, 0.0084%); $[\alpha]_{\text{D}}^{22} + 10.0$ (c 0.02, CHCl_3); IR λ_{max} (film) cm^{-1} : 3713 (O-H), 3423 (O-H), 2937 (C-H), 1645 (C=C), 1378, 1221, 1045; ^1H NMR (CDCl_3 , 600 MHz) δ = 6.43 (1H, d, 10.8 Hz, H-1), 5.96 (1H, dd, 10.8, 1.8 Hz, H-3), 2.02 (1H, m, H-5), 1.30 (1H, m, H-5), 1.90 (1H, m, H-6), 1.66 (1H, m, H-6), 2.86 (1H, dd, 6.6, 4.8 Hz, H-7), 2.40 (1H, m, H-9), 1.29 (1H, m, H-9), 2.33 (1H, m, H-10), 2.20 (1H, m, H-10), 5.12 (1H, dd, 6.6, 12.6 Hz, H-11), 1.92 (2H, m, H-13), 2.30 (1H, m, H-14), 2.05 (1H, m, H-14), 3.66 (1H, d, 7.8 Hz, H-16), 3.46 (1H, d, 7.8 Hz, H-16), 1.33 (3H, s, H_3 -17), 1.80 (3H, s, H_3 -18), 1.25 (3H, s, H_3 -19), 1.60 (3H, s, H_3 -20); ^{13}C NMR (CDCl_3 , 150 MHz) δ = 143.99 (s, C-1), 120.03 (d, C-2), 120.99 (d, C-3), 138.01 (s, C-4), 38.46 (t, C-5), 23.18 (t, C-6), 62.29 (d, C-7), 59.98 (s, C-8), 25.85 (t, C-9), 26.26 (t, C-10), 125.33 (d, C-11), 135.65 (s, C-11), 35.56 (d, C-13), 41.22 (t, C-14), 76.23 (s, C-15), 68.91 (t, C-16), 16.10 (q, C-17), 17.83 (q, C-18), 24.30 (q, C-19), 4, 38.46 (t, C-5), 23.18 (t, C-6), 62.29 (d, C-7), 59.98 (s, C-8), 25.85 (t, C-9), 26.26 (t, C-10), 125.33 (d, C-11), 135.65 (s, C-11), 35.56 (d, C-13), 41.22 (t, C-14), 76.23 (s, C-15), 68.91 (t, C-16), 16.10 (q, C-17), 17.83 (q, C-18), 24.30 (q, C-19), 17.03 (q, C-20); NMR data of compound (4a); ^1H NMR (CDCl_3 , 600 MHz) δ = 6.40 (1H, d, 10.8 Hz, H-1), 5.94 (1H, dd, 10.8, 1.8 Hz, H-3), 2.02 (1H, m, H-5), 1.30 (1H, m, H-5), 1.90 (1H, m, H-6), 1.66 (1H, m, H-6), 2.84 (1H, dd, 6.6, 4.8 Hz, H-7), 2.40 (1H, m), 1.29 (1H, m), 2.33 (1H, m), 2.20 (1H, m), 5.12 (1H, dd, 6.6, 12.6 Hz, H-11), 1.92 (2H, m, H-13), 2.30 (1H, m, H-14), 2.05 (1H, m, H-14), 3.65 (1H, d, 7.8 Hz, H-16), 3.45 (1H, d, 7.8 Hz, H-16), 1.36 (3H, s, H_3 -17), 1.78 (3H, s, H_3 -18), 1.25 (3H, s, H_3 -19), 1.60 (3H, s, H_3 -20); ^{13}C NMR (CDCl_3 , 150 MHz) δ = 144.18 (s, C-1), 120.03 (d, C-2), 120.99 (d, C-3), 138.03 (s, C-4), 38.36 (t, C-5), 23.10 (t, C-6), 62.22 (d, C-7), 59.95, 25.91 (t, C-9), 26.38 (t, C-10), 125.23 (d, C-11), 135.70 (s, C-11), 35.46 (d, C-13), 41.09 (t, C-14), 76.23 (s, C-15), 69.02 (t, C-16), 16.13 (q, C-17), 17.87 (q, C-18), 24.44 (q, C-19), 17.12 (q, C-20); HRESIMS (Positive-ion-mode) m/z 321.2420 $[\text{M}+\text{H}]$. (Calculated m/z = 320.2351, for $\text{C}_{20}\text{H}_{32}\text{O}_3$).

Deoxosarcophine (5)

Colorless oil; ^1H NMR (CDCl_3 , 600 MHz): δ = 5.54 (1H, brd, J = 9 Hz, H-2), 5.23 (1H, brd, J = 9 Hz, H-3), 2.35 (1H, m, H-5), 1.90 (1H, m, H-6), 1.63 (m), 2.7 (2H, t, 7.2 Hz, H2-7), 2.10 (1H, m, H-9), 1.00 (1H, m, H-9), 2.25 (1H, m, H-10a), 1.9 (1H, m, H-10b), 5.10 (1H, dd, J = 6, 4.8 Hz, H-11), 1.91 (1H, m, H-13), 2.55 (1H, m, H-14), 1.66 (1H, m, H-14), 4.50 (1H, m, H-16), 1.65 (3H, s, H3-17), 1.61 (3H, s, H3-18), 1.27 (3H, s, H3-19), 1.83 (3H, br s, H3-20); ^{13}C NMR (CDCl_3 , 150 MHz): δ = 128.0 (C, C-1), 83.7 (CH, C-2), 126.3 (CH, C-3), 139.5 (C, C-4), 38.0 (CH, C-5), 25.3 (CH₂, C-6), 62.0 (CH₂, C-7), 60.0 (C, C-8), 39.9 (CH₂, C-9), 23.5 (CH₂, C-10), 123.6 (CH, C-11), 136.8 (CH, C-12), 36.9 (CH, C-13), 26.1 (CH₂, C-14), 131.4 (C, C-15), 78.3 (CH, C-16), 10.2 (CH₃, C-17), 15.1 (CH₃, C-18), 16.9 (CH₃, C-19), 15.6 (CH₃, C-20).

Sarcotrocheliol acetate (6)

Colorless oil; ^1H NMR (CDCl_3 , 600 MHz): δ = 1.26 (1H, m, H-1), 4.52 (1H, dd, J = 10.8, 5.4 Hz, H-2), 5.50 (1H, d, J = 10.8 Hz, H-3), 2.15 (1H, m, H-5_a), 2.10 (1H, m, H-5_b), 2.30 (1H, m, H-6_a), 2.07 (1H, m, H-6_b), 5.05 (1H, dd, J = 10.2, 4.8 Hz, H-7), 1.97 (1H, m, H-9_a), 1.63 (1H, m, H-9_b), 1.66 (1H, m, H-10_a), 1.50 (1H, m, H-10_b), 5.37 (1H, d, J = 10.2 Hz, H-11), 1.51 (1H, m, H-13_a), 1.23 (1H, m, H-13_b), 1.77 (1H, m, H-14_a), 1.28 (1H, m, H-14_b), 1.17 (1H, m, H-15), 0.69 (3H, d, J = 6.6 Hz, H₃-16), 0.82 (3H, d, J = 6.6 Hz, H₃-17), 1.62 (3H, s, H₃-18), 1.56 (3H, s, H₃-19), 1.04 (3H, s, H₃-20), 2.06 (3H, s, CH₃CO); ^{13}C NMR (CDCl_3 , 150 MHz): δ = 171.0 (C, C=O), 139.0 (C, C-4), 135.0 (C, C-8), 125.3 (CH, C-3), 124.5 (CH, C-7), 73.7 (C, C-12), 73.5 (CH, C-11), 71.4 (CH, C-2), 46.5 (CH, C-1), 39.8 (CH₂, C-5), 34.4 (CH₂, C-9), 34.3 (CH₂, C-14), 29.0 (CH₂, C-10), 29.0 (CH, C-15), 25.4 (CH₃, C-20), 25.3 (CH₂, C-6), 20.7 (CH₃, C-17), 20.3 (CH₃, C-16), 19.0 (CH₂, C-14), 17.0 (CH₃, C-19), 15.0 (CH₃, C-18), 21.3 (CH₃, CH₃CO); EIMS (70 eV) m/z 348 (1) [M , $\text{C}_{22}\text{H}_{36}\text{O}_3$] $^+$, 330 (2) [M -H₂O] $^+$, 305 (5) [M -C₃H₇] $^+$, 288 (17) [M -CH₃COOH] $^+$, 245 (13), 177 (85), 120 (70), 92 (100), 80 (50), 54 (45).

Sarcotrocheliol (7)

Colorless oil; ^1H NMR (CDCl_3 , 600 MHz): δ = 1.28 (1H, m, H-1), 4.51 (1H, dd, J = 10.2, 4.8 Hz, H-2), 5.24 (1H, d, J = 10.2 Hz, H-3), 2.15 (1H, m, H-5_a), 1.96 (1H, m, H-5_b), 2.31 (1H, m, H-6_a), 2.08 (1H, m, H-6_b), 4.96 (1H, dd, J = 10.2, 4.8 Hz, H-7), 2.07 (1H, m, H-9_a), 1.97 (1H, m, H-9_b), 1.72 (1H, m, H-10_a), 1.24 (1H, m, H-10_b), 3.83 (1H, d, J = 9.6 Hz, H-11), 1.60 (1H, m, H-13_a), 1.40 (1H, m, H-13_b), 2.36 (1H, m, H-14_a), 1.22 (1H, m, H-14_b), 1.16 (1H, m, H-15), 0.70 (3H, d, J = 6.6 Hz, H₃-16), 0.85 (3H, d, J = 6.6 Hz, H₃-17), 1.62 (3H, s, H₃-18), 1.58 (3H, s, H₃-19), 0.99 (3H, s, H₃-20); ^{13}C NMR (CDCl_3 , 150 MHz): δ = 138.5 (C, C-4), 135.9 (C, C-8), 125.4 (CH, C-3), 123.9 (CH, C-7), 75.0 (C, C-12), 71.0 (CH, C-2), 69.9 (CH, C-11), 46.5 (CH, C-1), 39.9 (CH₂, C-5), 35.2

(CH₂, C-9), 33.6 (CH₂, C-14), 31.6 (CH₂, C-10), 28.9 (CH, C-15), 25.1 (CH₂, C-6), 24.2 (CH₃, C-20), 20.7 (CH₃, C-17), 20.2 (CH₃, C-16), 18.7 (CH₂, C-13), 17.6 (CH₃, C-19), 15.0 (CH₃, C-18).

Sarcophytolide B (8) (Al-Lihaibi et al., 2014)

Colorless oil; ¹H NMR (CDCl₃, 600 MHz): δ= 2.01 (1H, ddd, J=13.2, 10.8, 2.4 Hz H-2), 2.20 (1H, ddd, J=18.0, 12.6, 9.0 Hz H-2), 1.90 (1H, m, H-3), 1.70 (1H, m, H-3), 2.68 (1H, dd, J=4.8, 4.2 Hz, H-4), 1.10 (2H, m, H-6), 2.13 (1H, m, H-7), 5.17 (1H, dd, J= 9.6, 5.4 Hz, H2-9), 2.40 (1H, ddd, J= 10.8, 4.2, 3.0 Hz, H2-10), 2.10 (1H, ddd, J=13.2, 5.4, 2.4 Hz, H-11), 2.78 (1H, ddd, 18.0, 9.6, 7.8 Hz, H-11), 5.05 (1H, dd, J=10.2, 1.2 Hz, H2-13), 5.57 (1H, dd, J=10.2, 1.2 Hz, H-14), 1.65 (3H, s, H3-17), 1.28 (3H, s, H3-18), 1.91 (3H, s, H3-19), 1.88 (3H, s, H3-20); ¹³C NMR (CDCl₃, 150 MHz): δ = 162.2 (C, C-1), 36.4 (C, C-2), 25.2 (C, C-3), 61.4 (C, C-4), 59.9 (C, C-5), 39.0 (C, C-6), 23.3 (C, C-7), 144.1 (C, C-8), 124.9 (C, C-9), 37.4 (C, C-10), 27.6 (C, C-11), 135.6 (C, C-12), 122.9 (C, C-13), 78.8 (C, C-14), 120.6 (C, C-15), 174.0 (C, C-16), 15.4 (C, C-17), 17.1 (C, C-18), 16.1 (C, C-19), 8.92 (C, C-20).

Sarcophytolol (9) (Al-Lihaibi et al., 2014)

Colorless oil; ¹H NMR (CDCl₃, 600 MHz): δ= 1.32 (H, m, H-1), 4.53 (1H, dd, J= 10.2, 5.4 Hz, H-2), 5.27 (1H, d, 10.2 Hz, H-3) 2.19 (1H, m, H-5), 1.97 (1H, m, H-5) 2.32 (1H, m, H-6) 2.11 (1H, m, H-6) 5.00 (1H, dd, J= 10.2, 5.4 Hz, H-7), 2.40 (1H, m, H-9) 1.29 (1H, m, H-9) 1.77 (1H, m, H-5) 1.29 (1H, m, H-5) 1.77 (1H, m, H-5), 1.28 (1H, m, H-5), 2.13 (1H, m, H-5), 2.00 (1H, m, H-5)- 3.88 (1H, d, J=9.6 Hz), 1.18 (1H, m, H-5), 0.88 (3H, d, J= 6.6 Hz, H3-16), 0.73 (3H, d, J= 6.6 Hz, H3-17) 1.65 (3H, s, H3-18) 1.61 (3H, s, H3-19) 1.02 (3H, s, H3-20); ¹³C NMR (CDCl₃, 150 MHz): δ= 46.6 (CH, C-1), 71.1 (CH, C-2) 25.4 (CH, C-3) 138.6 (C, C-4), 39.9 (CH₂, C-5), 25.2 (CH₂, C-6), 124.1 (CH, C-7), 136.0 (C, C-8), 33.7 (CH₂, C-9), 18.7 (CH₂, C-10), 31.9 (CH₂, C-11), 35.2 (CH₂, C-12), 75.0 (C, C-13), 71.9 (C, C-14), 29.0 (CH, C-15), 20.8 (CH₃, C-16), 20.3 (CH₃, C-17), 24.2 (CH₃, C-18), 17.3 (CH₃, C-19), 15.1 (CH₃, C-20).

Cembrene (10)

Colorless oil, ¹H NMR (CDCl₃, 600 MHz): δ=6.06 (1H, d, 10.8 Hz, H-2), 5.99 (1H dd, 10.8, 1.2 Hz, H-3), 2.15 (1H, m, H-5), 2.21 (1H, m, H-6), 5.05 (2H, m, H2-7), 2.17 (2H, m, H2-9), 2.17 (2H, m, H2-10), 5.05 (H, m, H-11), 2.12 (2H, m, H2-13), 2.36 (2H, m, H2-14), 2.35 (2H, m, H2-7), 1.09 (1H, d, J= 6.6 Hz, H-16), 1.09 (3H, d, 6.6 H3-17), 1.63 (3H, s, H3-18), 1.55 (3H, d, J= 4.2, H3-19), 1.78 (3H, br s, H3-20); ¹³C NMR (CDCl₃, 150 MHz): δ=147.0 (C, C-1), 118.5 (CH, C-2), 121.9 (CH, C-3), 134.7 (C, C-4), 38.9, 25.3 (CH, C-5), 125.0 (CH₂, C-7), 134.5 (C, C-8), 38.6

(CH₂, C-9), 38.6 23.5 (CH₂, C-10), 124.5 (CH, C-11), 134.7 (CH, C-12), 39.1 (CH, C-13), 28.0 26.1 (CH₂, C-14), 33.8 (C, C-15), 22.3 (CH, C-16), 22.3 (CH₃, C-17), 17.1 (CH₃, C-18), 15.6 (CH₃, C-19), 17.0 (CH₃, C-20).

Sarcophine (11)

White amorphous, ¹H NMR (CDCl₃, 600 MHz): δ= 5.57 (1H, dd, *J*= 10.2, 1.2 Hz, H-2), 5.05 (1H, dd, *J*= 10.2, 1.2 Hz, H-3), 2.37 (2H, m, H₂-5), 1.90 (1H, m, H_a-6), 1.69 (1H, m, H_b-6), 2.68 (1H, dd, *J*= 4.8, 4.2 Hz, H-7), 2.10 (1H, m, H_a-9), 1.10 (1H, m, H_b-9), 2.26 (1H, m, H_a-10), 1.93 (1H, m, H_b-10), 5.17 (1H, dd, *J*= 9.6, 5.4 Hz, H-11), 2.18 (1H, ddd, *J*= 18.0, 12.6, 9.0 Hz, H_a-13), 2.01 (1H, ddd, *J*= 13.2, 10.8, 2.4 Hz, H_b-13), 2.78 (1H, ddd, *J*= 13.2, 5.4, 2.4 Hz, H_a-14), 2.37 (1H, ddd, *J*= 18.0, 9.6, 7.8 Hz, H_b-14), 1.85 (3H, s, H₃-17), 1.89 (3H, s, H₃-18), 1.28 (3H, s, H₃-19), 1.61 (3H, s, H₃-20); ¹³C NMR (CDCl₃, 150 MHz): δ= 174.1 (C, C-16), 162.3 (C, C-1), 144.0 (C, C-4), 135.5 (C, C-12), 124.9 (CH, C-11), 122.9 (CH, C-15), 120.6 (CH, C-3), 78.2 (CH, C-2), 61.4 (CH, C-7), 59.9 (C, C-8), 39.0 (CH₂, C-9), 37.4 (CH₂, C-5), 36.4 (CH₂, C-13), 27.6 (CH₂, C-14), 25.2 (CH₂, C-6), 23.3 (CH₂, C-10), 17.1 (CH₃, C-19), 16.1 (CH₃, C-18), 15.4 (CH₃, C-20), 9.0 (CH₃, C-17).

Cytotoxicity assays and viability analysis

Compounds **1-11** were tested against three cancer cell lines; Human hepatocellular liver carcinoma (HepG2), human breast adenocarcinoma (MCF-7), human colon carcinoma (HCT116) by SRB assay as previously described (Tolba et al., 2013). Exponentially growing cells were collected using 0.25% Trypsin-EDTA and plated in 96-well plates at 1000-2000 cells/well. Cells were exposed to test compound for 48 h and subsequently incubated with MTT solution for 4 h in dark place and subsequently dissolved in DMSO. Color intensity was measured at 570 nm.

The dose response curve of compounds was analyzed using E_{max} model (Eq. 1).

$$\% \text{ Cell viability} = (100 - R) \times \left(1 - \frac{[D]^m}{K_d^m + [D]^m} \right) + R \quad \text{..... (Eq. 1)}$$

Where R is the residual unaffected fraction (the resistance fraction), D is the drug concentration used, K_d is the drug concentration that produces a 50% reduction of the maximum inhibition rate and m is a Hill-type coefficient. IC₅₀ was defined as the drug concentration required to reduce color intensity to 50% of that of the control (i.e., K_d = IC₅₀ when R=0 and E_{max}=100-R).

Statistical analysis of the data.

The results of experiments were expressed as means ± S.E.M. One-way analysis of variance (ANOVA) followed by Dunnett's test was used to determine significance when compared to the

control group. Graph Pad Prism5 was used for statistical calculations (Graph pad Software, San Diego California, U.S.A.).

References

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Table S1. Cytotoxic activities of the compounds **1-10**, against selected cancer cell lines

Compound		IC ₅₀ (μM)		
No.	HepG2	MCF-7	HCT116	
1	220.5±0.05	23.9±0.07	29.4±0.03	
2	-	-	24.6±0.03	
3	734.3±0.04	57.8±0.03	60.1±0.17	
4	18.8±0.07	15.1±0.17	19.4 ±0.02	
5	32.5± 0.15	9.9±0.03	25.8±0.03	
6	19.9±0.02	2.4 ±0.04	17.5 ±0.03	
7	23.6±0.16	19.1±0.07	21.5±0.03	
8^d	- ^a	-	73.8±0.07	
9^d	-	-	8.9±0.04	
10	83.2±0.04	33.6±0.01	60.2±0.04	
DOX	2.4 ±0.02	3.5 ±0.04	6.0±0.02	

HepG2 (human hepatocellular carcinoma), MCF-7 (human breast adenocarcinoma), HCT116 (colorectal carcinoma).

Data are presented as Mean ± standard error of the mean (SEM). ^aThe cytotoxicity of **2**, **8** and **9** against HepG2 and MCF-7 were previously published from our group (Al-Lihaibi et al., 2014).

^1H NMR Compound 1

^1H NMR Compound 1

^1H NMR Compound 1

^1H NMR Compound 1

^{13}C NMR Compound 1

^{13}C NMR Compound 1

^{13}C NMR Compound 1

^{13}C NMR Compound 1

COSY NMR Compound 1

COSY NMR Compound 1

COSY NMR Compound 1

HSQC NMR Compound 1

NOESY NMR Compound 1

NOESY NMR Compound 1

NOESY NMR Compound 1

NOESY NMR Compound 1

NOESY NMR Compound 1

HMBC NMR Compound 1

HMBC NMR Compound 1

HMBC NMR Compound 1

HMBC NMR Compound 1

HMBC NMR Compound 1

HMBC NMR Compound 1

^1H NMR of Compound 2

^1H NMR of Compound 2

^1H NMR of Compound 2

^1H NMR of Compound 2

^1H NMR of Compound 2

¹³C NMR of Compound 2

¹H NMR of Compound 2

^1H NMR of Compound 2

^1H NMR of Compound 2

^1H NMR of Compound 2

^1H NMR of Compound 2

^{13}C NMR of Compound 2

^1H NMR of Compound 3

^1H NMR of Compound 3

^1H NMR of Compound 3

¹H NMR of Compound 3

^1H NMR of Compound 3

¹³C NMR of Compound 3

^{13}C NMR Compound 4

^{13}C NMR Compound 4

^{13}C NMR Compound 4

^{13}C NMR Compound 4

^{13}C NMR Compound 4

^{13}C NMR Compound 4

^{13}C NMR Compound 4

COSY NMR Compound 4

COSY NMR Compound 4

COSY NMR Compound 4

COSY NMR Compound 4

COSY NMR Compound 4

HSQC NMR Compound 4

HSQC NMR Compound 4

HSQC NMR Compound 4

HSQC NMR Compound 4

HSQC NMR Compound 4

HSQC NMR Compound 4

HMBC NMR Compound 4

HMBC NMR Compound 4

HMBC NMR Compound 4

HMBC NMR Compound 4

HMBC NMR Compound 4

HMBC NMR Compound 4

^1H NMR Compound 5

^1H NMR Compound 5

¹H NMR Compound 5

¹H NMR Compound 5

^1H NMR Compound 5

^{13}C NMR of Compound 5

^1H NMR of Compound 6

^1H NMR of Compound 6

^1H NMR of Compound 6

^1H NMR of Compound 6

¹³C NMR of Compound 6

^1H NMR of Compound 7

¹H NMR of Compound 7

^1H NMR of Compound 7

^1H NMR of Compound 7

^1H NMR of Compound 7

^{13}C NMR of Compound 7

^1H NMR of Compound 8

^1H NMR of Compound 8

^1H NMR of Compound 8

^1H NMR of Compound 8

¹³C NMR of Compound 8

^1H NMR of Compound 9

^1H NMR of Compound 9

^1H NMR of Compound 9

^1H NMR of Compound 9

¹³C NMR of Compound 9

^1H NMR of Compound 10

¹³C NMR of Compound 10

^{13}C NMR of Compound 10

^{13}C NMR of Compound 10

^1H NMR of Compound 11

^1H NMR of Compound 11

^1H NMR of Compound 11

^1H NMR of Compound 11

^1H NMR of Compound 11

¹³C NMR of Compound 11