Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supporting Information

Asymmetric Total Synthesis of Cephanolide B

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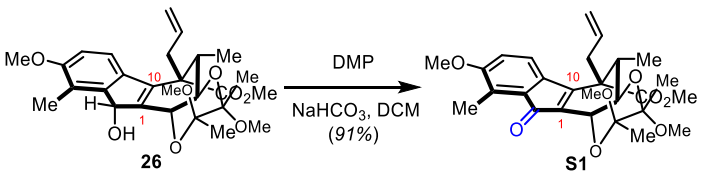
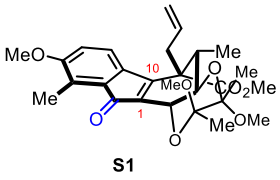
1. Experimental Procedures and Spectroscopic Data of Compounds

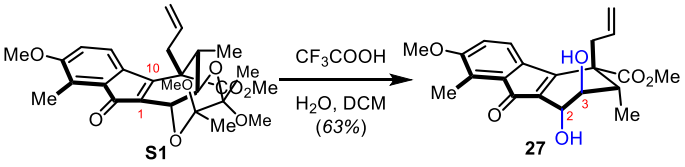
General Experimental Procedures. All reactions were carried out under nitrogen except noted. Anhydrous dichloromethane, toluene, acetonitrile and dimethylformamide were purified by the PS-MD-5 (Innovative Technology) solvent purification system. Anhydrous tetrahydrofuran and diethyl ether were distilled from sodium-benzophenone ketyl. All other commercial reagents were used as received. Flash column chromatography was performed as described by Still[1], employing SiliCycle UltraPure Silica Gels: SilicaFlash® P60 40 – 63 μm (230 – 400 mesh). TLC analysis were performed on EMD 250 μm Silica Gel HSGF$_{254}$ plates and visualized by quenching of UV fluorescence (λ_{max} = 254 nm), or by staining ceric ammonium molybdate, phosphomolybdic acid, or potassium permanganate. ^{1}H and ^{13}C NMR spectra were recorded on a Bruker-500, 400 spectrometer. Chemical shifts for ^{1}H and ^{13}C NMR spectra are reported in ppm (δ) relative to residue protium in the solvent ($CDCl_3$: δ 7.26, 77.0 ppm, $CO(CD_3)_2$: δ 2.05, 29.84 ppm, and the multiplicities are presented as follows: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, brs = broad single). High-resolution mass spectra (HRMS) were acquired on Waters Micromass GCT Premier or Bruker Daltonics, Inc. APEXIII 7.0 TESLA FTMS. Mass spectra were acquired on Agilent 5975C. The $[\alpha]_D$ was recorded using Anton Paar MCP 5500. Infrared (IR) spectra was obtained using a Shimatzu IRTracer-100 fourier transform infrared spectroscopy (FTIR).

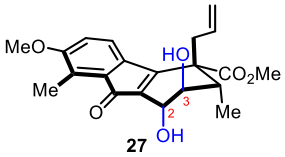




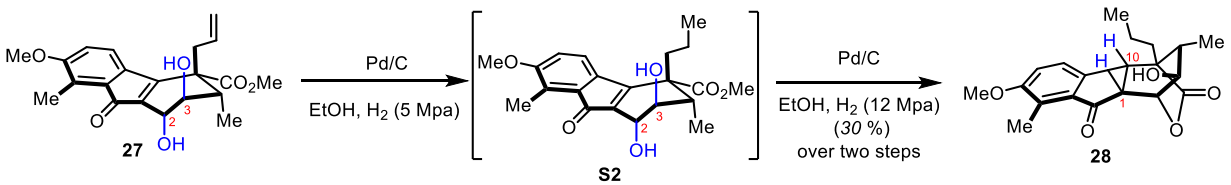
To a solution of **26** (214 mg, 0.438 mmol, 1.0 equiv.) in dichloromethane (2.00 mL) at 0 °C were added sodium hydrogen carbonate (74.0 mg, 0.876 mmol, 2.0 equiv.) and Dess-Martin periodinane reagent (279 mg, 0.657 mmol, 1.5 equiv.). The resulting suspension was warmed to room temperature. After 15 min, TLC analysis indicated that **26** had been completely consumed. An aqueous solution of 1:1 10% sodium thiosulfate/saturated sodium hydrogen carbonate was added carefully and the reaction mixture was diluted with water. The mixture was transferred to a separatory funnel and the aqueous layer was extracted with dichloromethane (3×20 mL). The combined organic layer was washed with brine (3×5 mL), dried over sodium sulfate, filtered, concentrated, and purified by silica gel column chromatography (10% ethyl acetate – petroleum ether) to give compound **S1** as an orange solid (191 mg, 91%), R_f = 0.51 (20% ethyl acetate – petroleum ether). M.p. 223 – 224 °C. $[\alpha]_D^{20}$ = +3.7×10² (c = 0.20 in CH_2Cl_2). ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.74 (d, *J* = 8.0 Hz, 1H), 6.52 (d, *J* = 8.0 Hz, 1H), 5.47 – 5.38 (m, 1H), 5.04 (d, *J* = 2.1 Hz, 1H), 5.04 (d, *J* = 2.1 Hz, 1H), 4.48 (d, *J* = 8.5 Hz, 1H), 4.00 (dd, *J* = 11.9, 8.5 Hz, 1H), 3.79 (s, 3H), 3.67 (s,

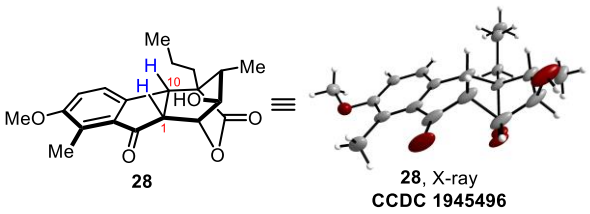
3H), 3.42 (s, 3H), 3.22 (s, 3H), 3.00 (dd, *J* = 14.5, 5.4 Hz, 1H), 2.64 (dd, *J* = 14.5, 9.4 Hz, 1H), 2.38 (s, 3H), 2.20 – 2.14 (m, 1H), 1.40 (s, 3H), 1.33 (s, 3H), 1.01 (d, *J* = 6.9 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 194.7, 172.7, 159.7, 156.1, 132.8, 132.0 (2C), 130.1, 129.1, 120.5, 118.3, 110.6, 100.1, 99.6, 69.5, 66.6, 55.7, 52.8, 52.2, 48.3, 47.5, 37.3, 35.5, 17.9, 17.8, 10.2, 9.6. IR (cm^{-1}) ν_{max} 2951, 2924, 1736, 1703, 1476, 1437, 1273, 1209, 1184, 1117, 1032, 1022, 932, 745. HRMS (m/z): ESI [M] calculated for $C_{27}H_{34}O_8$+Na [M+Na]$^+$: 509.2151, Found [M+Na]$^+$: 509.2141.



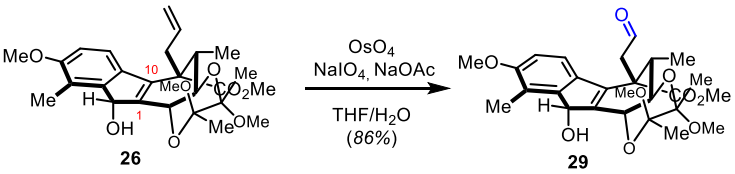


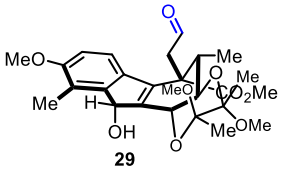
To a solution of compound **S1** (160 mg, 0.008 mmol, 1.0 equiv.) in dichloromethane (16.0 mL) at room temperature were treated with water (1.10 mL, 65.8 mmol, 200 equiv.) and trifluoroacetic acid (1.00 mL, 13.2 mmol, 40 equiv.). The resulting reaction mixture was stirred at room temperature for 12 h and cooled to 0 ºC. An aqueous solution of saturated sodium hydrogen carbonate was added until the pH of the aqueous layer reached 7 – 8. The layers were separated and the aqueous layer was extracted with dichloromethane (3×20 mL). The combined organic layer was washed with brine (3×5 mL), dried over sodium sulfate, filtered, concentrated, and purified by silica gel column chromatography (30% ethyl acetate – petroleum ether) to give diol **27** as a red solid (78.0 mg, 64%), R_f = 0.20 (30% ethyl acetate – petroleum ether). M.p. 84 – 85 °C. $[\alpha]_D^{20}$ = +3.3×10² (c = 0.19 in CH_2Cl_2). ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.80 (d, *J* = 8.0 Hz, 1H), 6.54 (d, *J* = 8.0 Hz, 1H), 5.49 – 5.41 (m, 1H), 5.07 (d, *J* = 3.8 Hz, 1H), 5.05 (s, 1H), 4.40 (d, *J* = 7.7 Hz, 1H), 3.85 (dd, *J* = 11.3, 7.7 Hz, 1H), 3.80 (s, 3H), 3.68 (s, 3H), 3.03 (dd, *J* = 14.6, 5.4 Hz, 1H), 2.67 (dd, *J* = 14.6, 9.4 Hz, 1H)., 2.39 (s, 3H), 2.08 – 2.01 (m,1H), 1.07 (d, *J* = 6.9 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 198.3, 172.6, 159.8, 155.2, 132.9, 132.5, 132.1, 129.9 (2C), 120.3, 119.1, 111.0, 77.2, 73.9, 71.0, 55.8, 52.5, 37.3, 37.0, 11.2, 9.9. IR (cm^{-1}) ν_{max} 3392, 2952, 2922, 2850, 1734, 1697, 1475, 1436, 1271, 1211, 1184, 742, 669. HRMS (m/z): EI [M] calculated for $C_{21}H_{24}O_6$ [M]$^+$: 372.1573, Found 372.1578.





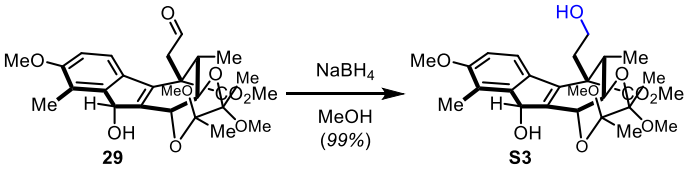
To a solution of diol **27** (10.0 mg, 0.027 mmol, 1.0 equiv.) in ethanol (1.00 mL) was added Pd/C (10% wt Pd on carbon, 2.00 mg, 20% wt) in a pressure reactor. The reactor was purged three times with nitrogen and three times with hydrogen before being pressurized to a final pressure of 5 Mpa (hydrogen). After stirring for 12 h at room temperature, the reaction mixture was filtered through a pad of Celite and the filtrate was evaporated in vacuo. Without purification, the residue was used directly in the following step. To a solution of crude **S2** in ethanol (1.00 mL) was added Pd/C (10% wt Pd on carbon, 5.00 mg, 50% wt) in a pressure reactor. The reactor was purged three times with nitrogen and three times with hydrogen before being pressurized to a final pressure of 12 Mpa (hydrogen). After stirring for 12 h at room temperature, the reaction mixture was filtered through a pad of Celite. The filtrate was concentrated in vacuo and purified by silica gel column chromatography (10% ethyl acetate – petroleum ether) to give lactone **28** as a white solid (3.00 mg, 30%), R_f = 0.54 (30% ethyl acetate – petroleum ether). Compounds **28** were recrystallized from dichloromethane/hexane (V/V = 1/4) at 20 °C to obtain colorless crystals, CCDC (1945496). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.21 (d, *J* = 8.4 Hz, 1H), 7.11 (d, *J* = 8.4 Hz, 1H), 4.91 (dd, *J* = 3.9, 1.8 Hz, 1H), 3.85 (s, 3H), 3.84 – 3.82 (m, 1H), 3.69 (d, *J* = 8.2 Hz, 1H), 3.38 (dd, *J* = 8.2, 1.8 Hz, 1H), 2.53 (s, 3H), 2.06 – 2.01 (m, 1H), 1.99 – 1.96 (m, 1H), 1.76 (dd, *J* = 13.3, 3.4 Hz, 1H), 1.72 – 1.65 (m, 1H), 1.47 – 1.39 (m, 1H), 1.14 (t, *J* = 7.0 Hz, 3H), 1.10 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 205.7, 173.7, 157.8, 144.4, 136.2, 127.7, 125.0, 116.9, 78.0, 74.0, 56.2, 49.6, 46.0, 41.6, 40.6, 28.8, 16.7, 15.7, 14.3, 10.3. IR (cm^{-1}) ν_{max} 1759, 1668, 1633, 1489, 1334, 1186, 1105, 746. HRMS (m/z): ESI [M] calcd for $C_{20}H_{24}O_5$+H $[M+H]^+$: 345.1702 Found $[M+H]^+$: 345.1692.

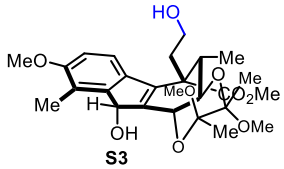




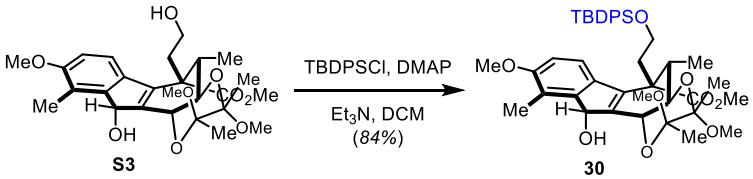
To a solution of **26** (60.0 mg, 0.123 mmol, 1.0 equiv.) in tetrahydrofuran (1.50 mL) and water (1.50 mL) at 0 °C were added sodium acetate (241 mg, 2.94 mmol, 24 equiv.), sodium periodate (131 mg, 0.614 mmol, 5.0 equiv.) and a solution of osmium(VIII) oxide in toluene (50.0 mg/1.00 ml, 200 μL, 0.037 mmol ,0.3 equiv.) in sequence. The resulting reaction mixture was warmed to room temperature. After 3 h, a further sodium periodate (131 mg, 0.614 mmol, 5.0 equiv.) was added to the white suspension. The mixture was quenched by an aqueous solution of saturated sodium thiosulfate, diluted by water (10 ml), and then extracted with ethyl acetate (3×10 mL). The combined organic layer was washed with brine (3×5 mL), dried over sodium sulfate, filtered, concentrated, and purified by silica gel column chromatography (10%

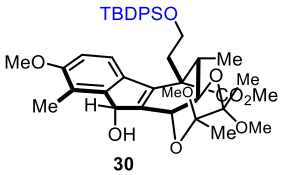
ethyl acetate – petroleum ether) to give aldehyde **29** as a yellow solid (52 mg, 86%), R_f = 0.34 (20% ethyl acetate – petroleum ether). M.p. 74 – 75 °C. $[\alpha]_D^{20}$ = +2.3×10² (c = 0.16 in CH_2Cl_2). ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.43 (dd, *J* = 3.4, 1.5 Hz, 1H), 6.85 (d, *J* = 8.2 Hz, 1H), 6.63 (d, *J* = 8.2 Hz, 1H), 5.37 (s, 1H), 4.74 (d, *J* = 8.5 Hz, 1H), 4.12 (dd, *J* = 11.7, 8.5 Hz, 1H), 3.80 (s, 3H), 3.67 (s, 3H), 3.61 (brs, 1H), 3.39 (s, 3H), 3.29 (dd, *J* = 16.5, 1.5 Hz, 1H), 3.22 (s, 3H), 2.93 (dd, *J* = 16.5, 3.5 Hz, 1H), 2.32 (s, 3H), 2.18 – 2.12 (m, 1H), 1.37 (d, 3H), 1.33 (d, 3H),1.04 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 200.2, 172.6, 157.4, 144.8, 139.4, 136.0, 131.5, 125.2, 117.2, 108.9, 100.2, 99.8, 75.1, 70.5, 69.7, 55.7, 52.4, 50.1, 48.2, 47.5, 45.9, 38.3, 18.0, 17.6, 11.7, 10.2. IR (cm^{-1}) ν_{max} 3357, 2924, 2833, 1730, 1726, 1483, 1466, 1439, 1231, 1211, 1140, 1117, 1036, 902, 810, 745, 706. HRMS (m/z): ESI [M] calculated for $C_{26}H_{34}O_9$+Na $[M+Na]^+$: 513.2101, Found $[M+Na]^+$: 513.2085.



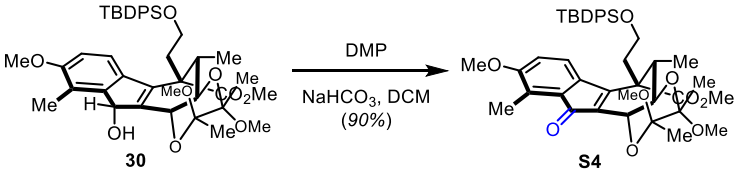


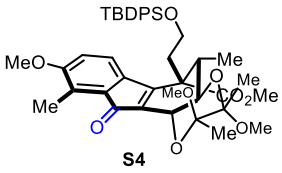
To a solution of aldehyde **29** (92.0 mg, 0.188 mmol, 1.0 equiv.) in methanol (2.00 mL) at 0 °C was added sodium borohydride (18 mg, 0.468 mmol, 2.5 equiv.). The resulting suspension was stirred at 0 °C for 10 min and stirred at room temperature for 1 h. TLC analysis indicated that **29** had been completely consumed. The reaction mixture was quenched by an aqueous solution of saturated ammonium chloride and diluted with water. The layers were separated and the aqueous layer was extracted with ethyl acetate (3×10 mL). The combined organic layer was washed with brine (3×5 mL), dried over sodium sulfate, filtered, concentrated, and purified by silica gel column chromatography (20% ethyl acetate – petroleum ether) to give diol **S3** as a yellow solid (92.0 mg, 99%), R_f = 0.37 (40% ethyl acetate – petroleum ether). M.p. 181 – 182 °C. $[\alpha]_D^{20}$ = +2.2×10² (c = 0.25 in CH_2Cl_2). ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.86 (d, *J* = 8.2 Hz, 1H), 6.62 (d, *J* = 8.2 Hz, 1H), 5.37 (s, 1H), 4.69 (d, *J* = 8.6 Hz, 1H), 4.06 (dd, *J* = 11.7, 8.6 Hz, 1H), 3.79 (s, 3H), 3.66 (brs, 1H), 3.63 (s, 3H), 3.54 – 3.48 (m, 1H), 3.39 – 3.35 (m, 1H), 3.38 (s, 3H), 3.21 (s, 3H), 2.51 – 2.45 (m, 1H), 2.32 (s, 3H), 2.25 – 2.21 (m, 1H), 2.19 – 2.17 (m, 1H), 1.36 (s, 3H), 1.33 (s, 3H), 1.04 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 173.9, 157.2, 144.7, 138.4, 137.5, 132.3, 124.9, 117.2, 109.0, 100.1, 99.8, 75.1, 70.5, 70.1, 59.2, 55.7, 52.1, 51.2, 48.2, 47.4, 37.0, 35.5, 18.0, 17.6, 11.7, 10.6. IR (cm^{-1}) ν_{max} 3540, 2953, 2920, 2870, 2850, 1734, 1653, 1483, 1460, 1377, 1229, 1211, 1121, 1036, 905, 746. HRMS (m/z): ESI [M] calculated for $C_{26}H_{36}O_9$+Na $[M+Na]^+$: 515.2257, Found $[M+Na]^+$: 515.2248.





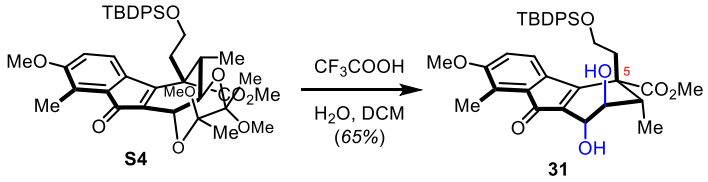
To a mixture of **S3** (71.0 mg, 0.144 mmol, 1.0 equiv.), 4-dimethylaminopyridine (2.00 mg, 0.014 mmol, 0.1 equiv.) and triethylamine (60 μL, 0.432 mmol, 3.0 equiv.) in 3.00 mL of dichloromethane was added ^{t}Butyldiphenyl chlorosilane (75.0 μL, 0.288 mmol, 2.0 equiv.) dropwise. The resulting suspension was stirred at room temperature for 5 h. TLC analysis indicated that **S3** had been completely consumed. The reaction mixture was quenched by an aqueous solution of saturated ammonium chloride and diluted by water. The layers were separated and the aqueous layer was extracted with dichloromethane (3×15 mL). The combined organic layer was washed with brine (3×5 mL), dried over sodium sulfate, filtered, concentrated, and purified by silica gel column chromatography (20% ethyl acetate – petroleum ether) to give silyl ether **30** as a white solid (88.0 mg, 84%), R_f = 0.23 (8% ethyl acetate – petroleum ether). M.p. 80 – 81 °C. $[\alpha]_D^{20}$ = +1.7×10² (c = 0.32 in CH_2Cl_2). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.51 (dd, *J* = 8.0, 1.3 Hz, 2H), 7.44 (dd, *J* = 8.0, 1.3 Hz, 2H), 7.42 – 7.28 (m, 4H), 7.24 – 7.21 (m, 2H), 6.81 (d, *J* = 8.2 Hz, 1H), 6.59 (d, *J* = 8.2 Hz, 1H), 5.22 (s, 1H), 4.60 (d, *J* = 8.5, 1H), 4.02 (dd, *J* = 11.7, 8.6 Hz, 1H), 3.81 (s, 3H), 3.63 (brs, 1H), 3.62 (s, 3H), 3.54 – 3.49 (m, 1H), 3.36 – 3.31 (m, 1H), 3.30 (s, 3H), 3.19 (s, 3H), 2.58 – 2.52 (m, 1H), 2.32 (s, 3H), 2.29 – 2.24 (m, 1H), 2.23 – 2.18 (m, 1H), 1.33 (s, 3H), 1.30 (s, 3H), 0.97 (d, *J* = 6.8 Hz, 3H), 0.93 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 173.8, 157.0, 144.7, 138.4, 137.5, 135.4 (4C), 133.6, 133.3, 132.5, 129.5, 129.4, 127.6 (2C), 127.5 (2C), 124.6, 117.3, 109.0, 100.0, 99.7, 75.1, 70.5, 70.0, 60.4, 55.7, 51.9, 51.2, 48.0, 47.4, 36.7, 34.5, 26.7 (3), 18.9, 18.0, 17.6, 11.7, 10.3. IR (cm^{-1}) ν_{max} 3539, 2955, 2922, 2918, 2870, 2850, 1732, 1481, 1464, 1377, 1209, 1111, 1084, 1036, 853, 743, 704, 687. HRMS (m/z): ESI [M] calculated for $C_{42}H_{54}O_9Si$+Na $[M+Na]^+$: 753.3435, Found $[M+Na]^+$: 753.3423.

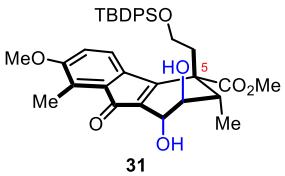




To a solution of silyl ether **30** (112 mg, 0.153 mmol, 1.0 equiv.) in dichloromethane (2.00 mL) at room temperature were added sodium hydrogen carbonate (38.0 mg, 0.459 mmol, 2.0 equiv.) and Dess-Martin periodinane reagent (130 mg, 0.306 mmol, 1.5 equiv.) in sequence. The resulting suspension was stirred at room temperature for 20 min. TLC analysis indicated that **30** had been completely consumed. An aqueous solution of 1:1 10% sodium thiosulfate/saturated sodium hydrogen carbonate was added and the reaction mixture was diluted with water. The layers were separated and the aqueous layer was

extracted with dichloromethane (3×15 mL). The combined organic layer was washed with brine (3×8 mL), dried over sodium sulfate, filtered, concentrated, and purified by silica gel column chromatography (10% ethyl acetate – petroleum ether) to give enone **S4** as a yellow solid (100 mg, 90%), R_f = 0.43 (20% ethyl acetate – petroleum ether). M.p. 54 – 55 °C. $[\alpha]_D^{20}$ = +1.8×10² (c = 0.34 in CH_2Cl_2). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.52 (dd, *J* = 8.0, 1.3 Hz, 1H), 7.48 (dd, *J* = 8.0, 1.3 Hz, 1H), 7.39 – 7.30 (m, 4H), 7.27 – 7.24 (m, 2H), 6.66 (d, *J* = 8.0 Hz, 1H), 6.47 (d, *J* = 8.0 Hz, 1H), 4.48 (d, *J* = 8.5 Hz, 1H), 3.93 (dd, *J* = 11.8, 8.5 Hz, 1H), 3.79 (s, 3H), 3.64 (s, 3H), 3.62 – 3.57 (m, 1H), 3.50 – 3.45 (m, 1H), 3.34 (s, 3H), 3.20 (s, 3H), 2.52 – 3.47 (m, 1H), 2.37 (s, 3H), 2.35 – 2.29 (m, 1H), 2.25 – 2.19 (m, 1H), 1.38 (s, 3H), 1.30 (s, 3H), 0.96 (d, *J* = 6.8 Hz, 3H), 0.93 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 194.5, 172.8, 159.6, 156.0, 135.4 (4C) , 133.3, 133.1 (2C), 131.5, 129.9, 129.6 (2C), 129.0, 127.7 (2), 127.6 (2), 118.2, 110.7, 100.0, 99.6, 69.6, 66.6, 60.1, 55.7, 52.1, 51.8, 48.1, 47.4, 36.3, 35.1, 29.7, 26.7 (3), 18.9, 17.8, 10.5, 9.5. IR (cm^{-1}) ν_{max} 1703, 1580, 1548, 1479, 1427, 1186, 808, 744. HRMS (m/z): ESI [M] calculated for $C_{42}H_{52}O_9Si$+Na $[M+Na]^+$: 751.3278, Found $[M+Na]^+$: 751.3258.

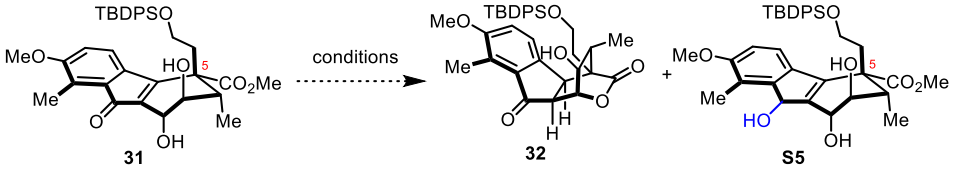




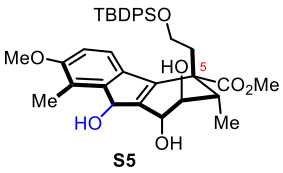
To a solution of enone **S4** (100 mg, 0.137 mmol, 1.0 equiv.) in dichloromethane (5.00 mL) at room temperature were treated with water (500 µL, 27.4 mmol, 200 equiv.) and trifluoroacetic acid (400 µL, 5.49 mmol, 40 equiv.). The resulting reaction mixture was stirred at room temperature for 12 h. TLC analysis indicated that **S4** had been completely consumed. An aqueous solution of saturated sodium hydrogen carbonate was added until the pH of the aqueous layer reached 7 – 8. The mixture was transferred to a separatory funnel and extracted with dichloromethane (3×25 mL). The combined organic layer was washed with brine (3×8 mL), dried over sodium sulfate, filtered, concentrated, and purified by silica gel column chromatography (20% ethyl acetate – petroleum ether) to give diol **31** as a red solid (55 mg, 65%), R_f = 0.28 (30% ethyl acetate – petroleum ether). M.p. 167 – 168 °C. $[\alpha]_D^{20}$ = +1.4×10² (c = 0.15 in CH_2Cl_2). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 – 7.50 (m, 4H), 7.42 – 7.36 (m, 2H), 7.34 – 7.28 (m, 4H), 6.68 (d, *J* = 8.0 Hz, 1H), 6.47 (d, *J* = 8.0 Hz, 1H), 4.33 (d, *J* = 7.7 Hz, 1H), 3.83 – 3.79 (m, 1H), 3.79 (s, 3H), 3.64 (s, 3H), 3.56 (dd, *J* = 9.2, 4.4 Hz, 2H), 2.55 – 2.48 (m, 1H), 2.52 (brs, 1H), 2.38 (s, 3H), 2.36 – 2.28 (m, 1H), 2.24 – 2.16 (m, 1H), 1.02 (d, *J* = 6.8 Hz, 3H), 0.95 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 198.3, 172.6, 159.7, 155.3, 135.5 (2C), 135.4 (2C), 133.2 (2C), 133.1, 132.1, 129.8, 129.7, 129.6, 127.7 (2C), 127.6 (2C), 119.0, 111.1, 74.1, 71.0, 60.1, 55.8, 52.4, 51.9, 38.1, 34.8, 26.7 (2), 18.9, 11.5, 9.9. IR (cm^{-1}) ν_{max}

3419, 2951, 2928, 2855, 1734, 1692, 1474, 1429, 1211, 1040, 1007, 821, 739, 702, 615. HRMS (m/z): ESI [M] calculated for $C_{36}H_{42}O_7Si$+Na $[M+Na]^+$: 637.2597, Found $[M+Na]^+$: 637.2573.

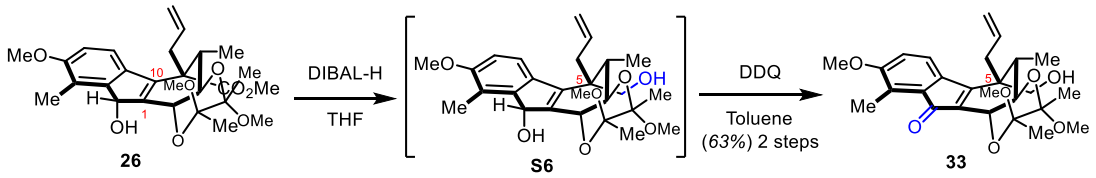
2. Screening Conditions of Hydrogenation of diol 31



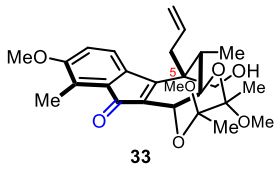
Entry	***Conditions***	***Results***
1	50% wt Pd/C, EtOH, rt, H_2, 9 Mpa, 20 h	NR
2	50% wt. Pd/C, EtOH, 65 °C, 20 h, H_2, 9 Mpa, 24 h	Trace **S5**
3	0.5 eq PtO_2, EtOH, rt, 20 h, H_2, 9 MPa, 18 h	**S5**
4	20% wt. Raney-Ni, EtOH, rt, 20 h, H_2, 9 Mpa, 5 h	messy
5	50% wt $Pd(OH)_2$/C, EtOH, rt, H_2, 9 Mpa, 20 h	NR
6	0.2 eq Crabtree's catalyst, 1.0 eq $B(^iOPr)_3$, rt, 22 h, 10 MPa	ND
7	0.2 eq Crabtree's catalyst, 1.0 eq $B(^iOPr)_3$, DCE, 80 °C, 22 h, 10 MPa	NR
8	0.5 eq $Ph(PPh_3)_3Cl$, PhH, 65 °C, 8.5 Mpa, 24 h	NR



To a solution of diol **31** (5.00 mg, 0.013 mmol, 1.0 equiv.) in ethanol (1.00 mL) was added Platinum(IV) oxide (1.50 mg, 0.007 mmol, 0.5 equiv.) in a pressure reactor. The reactor was purged three times with nitrogen and three times with hydrogen before being pressurized to a final pressure of 9 Mpa (hydrogen). After stirring at room temperature for 12 h, the reaction mixture was filtered through a pad of Celite. The filtrate was concentrated *in vacuo* and purified by silica gel column chromatography (50% ethyl acetate – petroleum ether) to give **S5** as yellow solid (3.50 mg, 70%), R_f = 0.14 (50% ethyl acetate – petroleum ether). M.p. 44 – 45 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.54 – 7.52 (m, 2H), 7.48 – 7.46 (m, 2H), 7.40 – 7.30 (m, 4H), 72.7 – 7.24 (m, 2H), 6.78 (d, *J* = 8.2 Hz, 1H), 6.56 (d, *J* = 8.2 Hz, 1H), 5.27 (s, 1H), 4.28 (d, *J* = 7.8 Hz, 1H), 3.80 (s, 3H), 3.78 – 3.75 (m, 1H), 3.58 (s, 3H), 3.55 – 3.50 (m, 1H), 3.45 – 3.41 (m, 1H), 2.59 (m, 1H), 2.35 – 2.30 (m, 1H), 2.29 (s, 3H), 2.23 – 2.16 (m, 1H), 1.03 (d, *J* = 6.8 Hz, 3H), 0.97 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 173.7, 157.0, 144.3, 143.6, 136.2, 135.6 (2C), 135.5 (2C), 133.3, 132.6, 129.6, 129.5, 127.7 (2C), 127.6 (2C), 125.1, 117.7, 109.2, 75.0, 74.2, 71.5, 60.4, 55.7, 52.0, 51.3, 38.9, 34.1, 29.7, 26.7 (3C), 19.0, 11.6 (2C). HRMS (m/z): ESI [M] calculated for $C_{36}H_{44}O_7Si$+Na $[M+Na]^+$: 639.2754., Found $[M+Na]^+$: 639.2748.

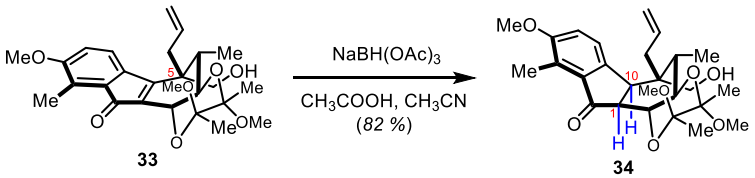


26 S6 33



33

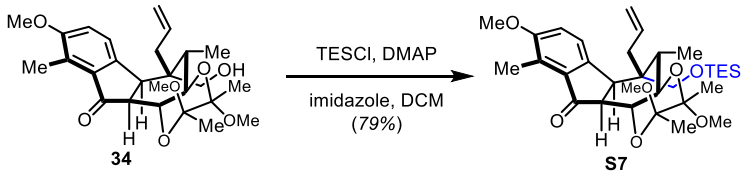
To a solution of cyclized product **26** (1.04 g, 2.13 mmol, 1.0 equiv.) in tetrahydrofuran at –78 ºC was added diisobutylaluminium hydride (63.9 mL, 95.9 mmol, 45 equiv.) via cannula over 10 min. The resulting suspension was stirred at –78 ºC for 1 h and stirred at 0 ºC for 2h. TLC analysis indicated that **26** had been completely consumed. The reaction mixture was quenched by dropping slowly to methanol at 0 ºC. The ice-water bath was removed and an aqueous solution of saturated potassium sodium tartrate was added. The mixture was stirred vigorously for 8 h. The mixture was transferred to a separatory funnel and extracted with ethyl acetate (3×200 mL). The combined organic layer was washed with brine (3×30 mL), dried over sodium sulfate, filtered, and concentrated *in vacuo*. Without further purification, the residue was used directly in the following step. To a solution of the crude **S6** in toluene at room temperature was added 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (1.45 g, 6.39 mmol, 3.0 equiv.). The resulting suspension was then immersed in an oil bath preheated to 85 °C. After 2 h, TLC analysis indicated that **S6** had been completely consumed. The reaction mixture was diluted slowly with sufficient saturated sodium hydrogen carbonate aqueous solution until the pH of the aqueous layer reached 7 – 8. The mixture was extracted with ethyl acetate (3×100 mL). The combined organic layer was washed with brine (3×10 mL), dried over sodium sulfate, filtered, concentrated, and purified by silica gel column chromatography (15% ethyl acetate – petroleum ether) to give enone **33** as a red solid (615 mg, 63%), R_f = 0.46 (30% ethyl acetate – petroleum ether). $[\alpha]_D^{20}$ = +2.93×10² (c = 0.11 in CH_2Cl_2). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.06 (d, *J* = 8.1 Hz, 1H), 6.56 (d, *J* = 8.1 Hz, 1H), 5.48 – 5.38 (m, 1H), 4.99 (s, 1H), 4.96 (d, *J* = 5.4 Hz, 1H), 4.46 (d, *J* = 8.6 Hz, 1H), 4.11 (dd, *J* = 12.1, 8.6, 1H), 4.05 (d, *J* = 11.8 Hz, 1H), 3.84 (brs, 1H), 3.80 (s, 3H), 3.43 (s, 3H), 3.25 (s, 3H), 2.58 (dd, *J* = 14.1, 5.2 Hz, 1H), 2.39 (s, 3H), 2.21 (dd, *J* = 14.1, 9.4 Hz, 1H), 2.15 – 2.09 (m, 1H), 1.37 (s, 3H), 1.33 (s, 3H), 1.17 (d, *J* = 6.9 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 195.1, 159.5, 159.1, 134.0, 132.9, 132.6, 130.5, 129.0, 120.0, 119.6, 110.5, 100.1, 99.7, 69.7, 66.8, 65.4, 55.7, 48.6, 48.2, 47.6, 36.4, 36.1, 17.9, 17.8, 9.6, 8.8. IR (cm^{-1}) ν_{max} 3508, 2953, 2949, 2926, 2855, 1697, 1476, 1466, 1184, 1117, 1030, 741. HRMS (m/z): ESI [M] calculated for $C_{26}H_{34}O_7$+Na $[M+Na]^+$: 481.2202, Found $[M+Na]^+$: 481.2190.

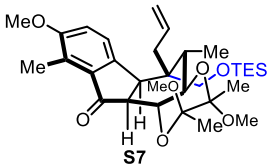


33 34

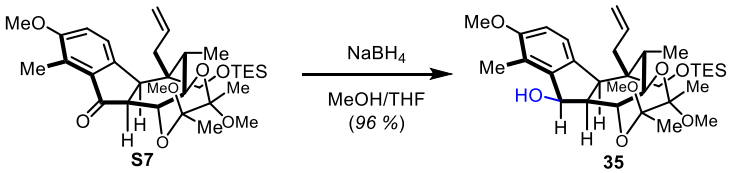
To a solution of enone **33** (615 mg, 1.34 mmol, 1.0 equiv.) in acetonitrile (0.005 M, 260 mL) at room temperature were added sodium triacetoxyborohydride (4.26 g, 20.1 mmol, 15 equiv.) and acetic acid

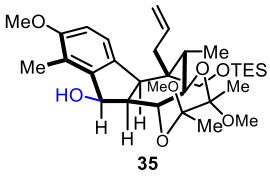
(77.0 μL, 1.34 mmol, 1.0 equiv.). The resulting orange suspension was stirred at 85 °C for 18 h. The color of the suspension turned light-yellow, indicating that reduction of C1=C10 olefin had occurred. The solvent was removed *in vacuo*. An aqueous solution of saturated sodium hydrogen carbonate was added until the pH of the aqueous layer reached 7 – 8. The mixture was transferred to a separatory funnel and extracted with ethyl acetate (3×50 mL). The combined organic layer was washed with brine (3×10 mL), dried over sodium sulfate, filtered, concentrated, and purified by silica gel column chromatography (15% ethyl acetate – petroleum ether) to give known **34** as a white solid (540 mg, 87%).



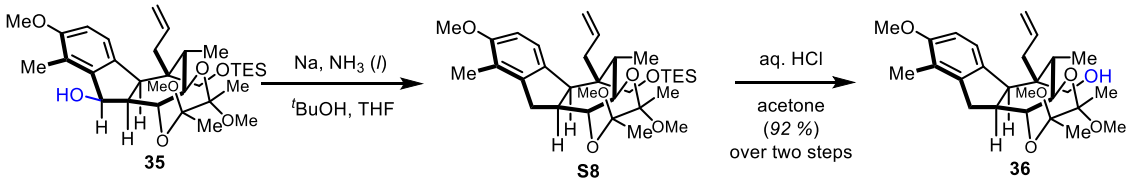


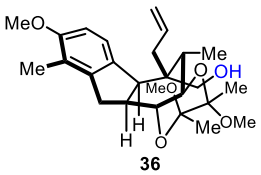
To a mixture of **34** (1.66 g, 3.60 mmol, 1.0 equiv.), 4-dimethylaminopyridine (44.0 mg, 0.360 mmol, 0.10 equiv.) and imidazole (1.72 g, 143 mmol, 4.0 equiv.) in 18.0 mL of dichloromethane at 0 °C was added triethylchlorosilane (3.00 mL, 18.0 mmol, 2.0 equiv.) via syringe. The reaction mixture was stirred at 0 °C for 10 min and stirred at room temperature for 15 min. TLC analysis indicated that **34** had been completely consumed. The mixture was quenched with an aqueous solution of saturated ammonium chloride. The layers were separated and the aqueous layer was extracted with dichloromethane (3×15 mL). The combined organic layers were washed with brine (3×5 mL), dried over sodium sulfate, filtered, concentrated, and purified by silica gel column chromatography (2% ~ 3% ethyl acetate – petroleum ether) to give TES ether **S7** as a white foamy solid (1.63 g, 79%), R_f = 0.54 (5% ethyl acetate – petroleum ether). $[\alpha]_D^{20}$ = +78 (c = 1.3 in CH_2Cl_2). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.26 (d, *J* = 8.3 Hz, 1H), 7.01 (d, *J* = 8.3 Hz, 1H), 5.57 – 5.47 (m, 1H), 4.88 (dd, *J* = 10.2, 2.1 Hz, 1H), 4.78 (dd, *J* = 16.9, 2.1 Hz, 1H), 4.02 (dd, *J* = 10.7, 8.2 Hz, 1H), 3.98 (d, *J* = 8.2 Hz, 1H), 3.86 (s, 3H), 3.73 (d, *J* = 10.5 Hz, 1H), 3.62 (t, *J* = 10.5 Hz, 1H), 3.48 – 3.45 (m, 1H), 3.46 (s, 3H), 3.27 (s, 3H), 2.99 (t, *J* = 8.2 Hz, 1H), 2.50 (s, 3H), 1.81 (m, 1H), 1.66 (dd, *J* = 14.3, 6.9 Hz, 1H), 1.33 (s, 3H), 1.32 (s, 3H), 1.30 – 1.25 (m, 1H), 1.21 (d, *J* = 7.0 Hz, 3H), 1.01 (t, *J* = 7.9 Hz, 9H), 0.68 (q, *J* = 7.9 Hz, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 207.2, 157.2, 144.7, 135.8, 133.1, 126.8, 124.4, 118.3, 115.3, 99.4, 99.0, 72.4, 67.8, 65.8, 56.1, 54.3, 48.1, 47.8, 44.6, 41.4, 38.7, 38.6, 17.9, 17.8, 12.9, 10.2, 7.0 (3C), 4.5 (3C). IR (cm^{-1}) ν_{max} 2954, 2910, 2878, 1714, 1267, 1123, 814, 748. HRMS (m/z): ESI [M] calculated for $C_{32}H_{50}O_7Si$+Na $[M+Na]^+$: 597.3324 Found $[M+Na]^+$: 597.3309.





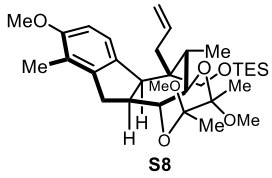
To a solution of TES ether **S7** (1.52 g, 2.64 mmol, 1.0 equiv.) in tetrahydrofuran (10.0 mL) and methanol (10.0 ml) at –78 °C was added sodium borohydride (1.00 g, 26.4 mmol, 10 equiv.) carefully. The resulting white suspension was stirred –78 °C for 5 min and stirred at 0 °C for 15 min. The mixture was quenched at 0 °C by an aqueous solution of saturated ammonium chloride and diluted with water. The layers were separated and the aqueous layer was extracted with ethyl acetate (3×10 mL). The combined organic layers were washed with brine (3×10 mL), dried over sodium sulfate, filtered, concentrated, and purified by silica gel column chromatography (5% ~ 10% ethyl acetate – petroleum ether) to give compound **35** as a white foamy solid (1.46 g, 96%), R_f = 0.35 (10% ethyl acetate – petroleum ether). M.p. 90 – 91 °C. $[\alpha]_D^{20}$ = +53 (c = 1.1 in CH_2Cl_2). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.16 (d, *J* = 8.4 Hz, 1H), 6.63 (d, *J* = 8.4 Hz, 1H), 5.88 (m, 1H), 5.21 (t, *J* = 5.2 Hz, 1H), 5.10 (dd, *J* = 17.1, 2.1 Hz, 1H), 5.00 (dd, *J* = 10.2, 2.1 Hz, 1H), 4.03 (d, *J* = 5.2 Hz, 1H), 3.95 (t, *J* = 10.2 Hz, 1H), 3.82 (d, *J* = 10.2 Hz, 1H), 3.81 – 3.76 (m, 1H), 3.79 (s, 3H), 3.59 (d, *J* = 10.2 Hz, 1H), 3.25 (s, 3H), 3.16 (s, 3H), 3.04 (d, *J* = 5.6 Hz, 1H), 2.84 (m, 1H), 2.74 (dd, *J* = 14.7, 8.3 Hz, 1H), 2.37 (dd, *J* = 14.7, 5.9 Hz, 1H), 2.32 (s, 3H), 1.84 (m, 1H), 1.30 (s, 3H), 1.24 (s, 3H), 1.11 (d, *J* = 6.9 Hz, 3H), 0.98 (t, *J* = 8.1 Hz, 9H), 0.63 (q, *J* = 8.1 Hz, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.1, 143.9, 134.8, 134.0, 125.0, 122.8, 117.8, 108.9, 99.6, 99.4, 77.8, 71.0 (2C), 66.1, 55.7, 48.5, 47.8, 47.2, 44.6, 43.9, 39.0, 38.8, 17.9, 17.7, 11.1, 10.4, 6.9 (3C), 4.3 (3C). IR (cm^{-1}) ν_{max} 2955, 2911, 2835, 1275, 1260, 1121, 1308, 764, 750. HRMS (m/z): ESI [M] calculated for $C_{32}H_{52}O_7Si$+Na $[M+Na]^+$: 599.3380, Found $[M+Na]^+$: 599.3362.





To a solution of liquid ammonia (12.0 mL) and ^{t}BuOH (100 μL, 0.14 mmol, 10 equiv.) at −78 °C was added sodium (584 mg, 2.54 mmol, 20 equiv.) in portions. The resulting dark blue suspension was stirred at −78 °C for 20 min. Afterwards, a THF solution (12.0 mL) of compound **35** (730 mg, 1.27 mmol, 1.0 equiv.) was added dropwise over 10 minutes via syringe. The reaction mixture was stirred at −78 °C for 15 min. TLC analysis indicated that **35** had been completely consumed. The reaction was quenched by the addition of SOLID ammonium chloride. The cold bath was removed and the liquid ammonia was left to evaporate under a stream of nitrogen for 2 h. The mixture was diluted with water and transferred to a separatory

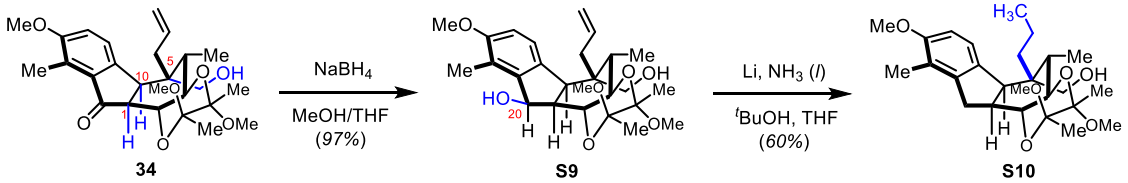
funnel and the aqueous layer was extracted with ethyl acetate (3×20 mL). The combined organic layers were washed with brine (3×10 mL), dried over sodium sulfate, filtered, and concentrated *in vacuo*. The residue was used in the next step without further purification.

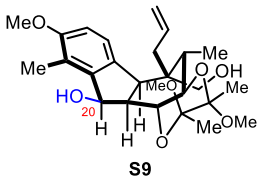


S8

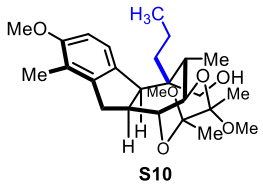
Compound **S8**: **S8** was purified by silica gel column chromatography (3% ~ 5% ethyl acetate – petroleum ether) to obtain as a white foamy solid, R_f = 0.52 (5% ethyl acetate – petroleum ether). $[\alpha]_D^{20}$ = +45 (c = 0.67 in CH_2Cl_2). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.22 (d, *J* = 8.3 Hz, 1H), 6.56 (d, *J* = 8.3 Hz, 1H), 6.01 (m, 1H), 5.19 (dd, *J* = 17.2, 2.3 Hz, 1H), 5.05 (dd, *J* = 10.3, 2.3 Hz, 1H), 3.92 (d, *J* = 10.2 Hz, 1H), 3.78 (s, 3H), 3.72 (d, *J* = 11.2 Hz, 1H), 3.56 (d, *J* = 10.2 Hz, 1H), 3.25 – 3.21 (m, 1H), 3.23 (s, 3H), 3.12 (d, *J* = 5.2 Hz, 1H), 3.04 (s, 3H), 2.98 (d, *J* = 14.8 Hz, 1H), 2.90 (dd, *J* = 14.8, 8.7 Hz, 1H), 2.60 – 2.58 (m, 1H), 2.56 – 2.55 (m, 1H), 2.54 – 2.52 (m, 1H), 2.08 (s, 3H), 1.79 – 1.72 (m, 1H), 1.29 (s, 3H), 1.22 (s, 3H), 1.10 (d, *J* = 7.0 Hz, 3H), 0.98 (t, *J* = 8.0 Hz, 9H), 0.62 (q, *J* = 8.0 Hz, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.4, 143.8, 135.5, 135.2, 123.1, 123.0, 117.7, 107.6, 99.4, 99.3, 71.3, 71.1, 66.0, 55.6, 50.2, 47.6, 47.3, 44.4, 42.2, 39.1, 37.7, 32.6, 17.8 (2C), 12.0, 10.0, 7.0 (3C), 4.4 (3C). IR (cm^{-1}) ν_{max} 2953, 2909, 2876, 1481, 1456, 1260, 1121, 1099, 1038, 748. HRMS (m/z): EI [M] calculated for $C_{32}H_{52}O_6Si$ $[M]^+$: 560.3533 Found $[M]^+$: 560.3527.

Following the procedure for reduction of **35**, to the solution of crude **S8** in acetone (10.0 mL) at room temperature was added 1 N aqueous hydrochloric acid solution (2.00 mL) dropwise over 5 min. The resulting reaction mixture was stirred at room temperature for 30 min. An aqueous solution of saturated sodium hydrogen carbonate was added until the pH of the aqueous layer reached 7 – 8. The layers were separated and the aqueous layer was extracted with ethyl acetate (3×20 mL). The combined organic layers were washed with brine (3×15 mL), dried over sodium sulfate, filtered, concentrated, and purified by silica gel column chromatography (20% ethyl acetate – petroleum ether) to give **36** as a white foamy solid (1.04 g, 92%), R_f = 0.44 (20% ethyl acetate – petroleum ether). M.p. 97 – 98 °C. $[\alpha]_D^{20}$ = +60 (c = 0.34 in CH_2Cl_2). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.14 (d, *J* = 8.3 Hz, 1H), 6.56 (d, *J* = 8.3 Hz, 1H), 6.23 – 6.15 (m,1H), 5.33 – 5.29 (m, 1H), 5.3 – 5.10 (m, 1H), 3.97 (d, *J* = 11.6 Hz, 1H), 3.78 (d, *J* = 11.6 Hz, 1H), 3.78 (s, 3H), 3.61 (dd, *J* = 11.3, 10.3 Hz, 1H), 3.51 (d, *J* = 5.1 Hz, 1H), 3.27 (t, *J* = 10.3 Hz, 1H), 3.22 (s, 3H), 3.05 (s, 3H), 3.00 (d, *J* = 15.1 Hz, 1H), 2.81 (dd, *J* = 15.1, 5.1 Hz, 1H), 2.75 (dd, *J* = 15.1, 9.2 Hz, 1H), 2.66 – 2.61 (m, 1H), 2.60 – 2.57 (m, 1H), 2.09 (s, 3H), 1.83 – 1.76 (m, 1H), 1.29 (s, 3H), 1.22 (s, 3H), 1.07 (d, *J* = 6.9 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.4, 144.1, 136.8, 135.1, 123.4, 122.5, 117.9, 107.6, 99.4 (2C), 71.1, 70.8, 67.6, 55.6, 48.6, 47.7, 47.3, 44.6, 42.0, 40.5, 38.9, 32.5, 17.8 (2C), 12.1, 9.6. IR (cm^{-1}) ν_{max} 3493, 2953, 2930, 2835, 1456, 1260, 1119, 1101, 1030, 764, 750. HRMS (m/z): ESI [M] calculated for $C_{26}H_{38}O_6$+Na $[M+Na]^+$: 469.2566, Found $[M+Na]^+$: 469.2551.

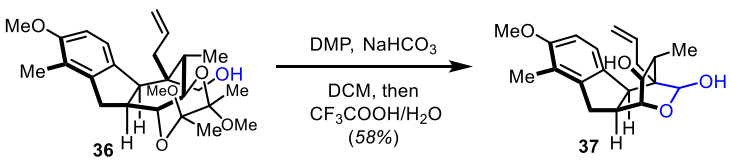


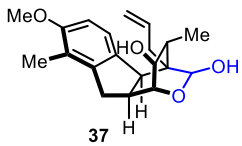


Compound **S9:** using the similar reduction method described above, compound **S9** was obtained as a white foamy solid (220 mg, 97%), R_f = 0.52 (20% ethyl acetate – petroleum ether). ^{1}H NMR (500 MHz, CDCl3) δ 7.12 (d, *J* = 8.3 Hz, 1H), 6.64 (d, *J* = 8.3 Hz, 1H), 6.07 – 5.99 (m, 1H), 5.27 (d, *J* = 5.4 Hz, 1H), 5.22 (dd, *J* = 17.0, 1.8 Hz, 1H), 5.08 – 5.05 (m, 1H), 3.99 (t, *J* = 10.4 Hz, 1H), 3.88 (d, *J* = 11.5 Hz, 1H), 3.82 (s, 1H), 3.80 (s, 3H), 3.78 (d, *J* = 11.5 Hz, 1H), 3.68 (t, *J* = 10.4 Hz, 1H), 3.33 (d, *J* = 5.6 Hz, 1H), 3.25 (s, 3H), 3.17 (s, 3H), 2.89 – 2.85 (m, 1H), 2.65 (dd, *J* = 14.9, 8.8 Hz, 1H), 2.59 (dd, *J* = 14.9, 5.3 Hz, 1H), 2.34 (s, 3H), 1.92 – 1.85 (m, 1H), 1.30 (s, 3H), 1.24 (s, 3H), 1.11 (d, *J* = 7.0 Hz, 3H). 13C NMR (125 MHz, CDCl3) δ 157.2, 144.1, 136.1, 133.6, 125.2, 122.4, 118.1, 109.0, 99.7, 99.5, 77.7, 77.2, 76.8, 71.0, 70.6, 67.4, 48.6, 47.8, 47.0, 44.0, 43.5, 41.1, 38.9, 17.9, 11.1, 10.3. HRMS (m/z): ESI [M] calculated for $C_{26}H_{38}O_7$+Na [M+Na]$^+$: 485.2515, Found [M+Na]+: 485.2526.



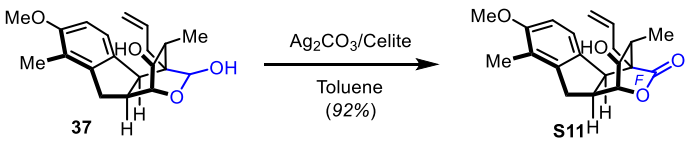
Compound **S10:** using the similar single electron reduction method described above, compound **S10** was obtained as a yellow oil (10.0 mg, 60%), R_f = 0.41 (20% ethyl acetate – petroleum ether). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.05 (d, *J* = 8.4 Hz, 1H), 6.57 (d, *J* = 8.4 Hz, 1H), 3.99 (d, *J* = 11.3 Hz, 1H), 3.78 (s, 3H), 3.77 (d, *J* = 11.3 Hz, 1H), 3.73 (d, *J* = 4.7 Hz, 1H), 3.70 – 3.67 (m, 1H), 3.23 (s, 3H), 3.23 – 3.20 (m, 1H), 3.04 (s, 3H), 2.99 (d, *J* = 15.2 Hz, 1H), 2.60 (dd, *J* = 15.2, 5.3 Hz, 1H), 2.58 – 2.50 (m, 1H), 2.08 (s, 3H), 2.04 – 1.96 (m, 1H), 1.78 – 1.74 (m, 1H), 1.73 – 1.67 (m, 1H),1.59 – 1.51 (m, 2H), 1.29 (s, 3H), 1.22 (s, 3H), 1.08 (d, *J* = 7.0 Hz, 3H), 1.00 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (125 MHz, CDCl3) δ 156.4, 143.8, 135.5, 123.2, 122.4, 107.7, 99.4 (2C), 71.4, 70.9, 67.3, 55.6, 49.7, 47.7, 47.3, 43.9, 42.1, 39.2, 37.0, 32.6, 17.8 (2C), 17.2, 14.8, 12.0, 9.9. HRMS (m/z): ESI [M] calculated for $C_{26}H_{40}O_6$+Na [M+Na]$^+$: 471.2718, Found [M+Na]+: 471.2723.

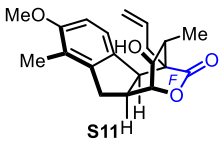




To a solution of primary alcohol **36** (17.0 mg, 0.038 mmol, 1.0 equiv.) in dichloromethane (2 mL) at room temperature were added sodium hydrogen carbonate (7.00 mg, 0.076 mmol, 2.0 equiv.) and Dess–Martin periodinane reagent

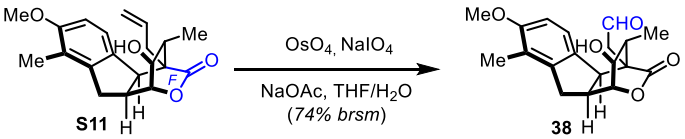
(25.0 mg, 0.057 mmol, 1.5 equiv.). The resulting yellow suspension was stirred at room temperature for 15 min. TLC analysis indicated that **36** had been completely consumed. An aqueous solution of 1:1 10% sodium thiosulfate/saturated sodium hydrogen carbonate was added. The layers were separated and the aqueous layer was extracted with dichloromethane (3×5 mL). The combined organic layers were treated with water (200 μl) and trifluoroacetic acid (1.00 ml). The resulting solution was stirred at room temperature for 30 min and cooled to 0 ºC. An aqueous solution of saturated sodium hydrogen carbonate was added until the pH of the aqueous layer reached 7 – 8. The aqueous layer was extracted with dichloromethane (3×20 mL). The combined organic layers were washed with brine (3×5 mL), dried over sodium sulfate, filtered, concentrated, and purified by silica gel column chromatography (20% ~ 25% ethyl acetate – petroleum ether) to give cyclic hemiacetal **37** as a white solid (7.30 mg, 58%), R_f = 0.2 (30% ethyl acetate – petroleum ether). **37** exists as a mixture of two diastereomers. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.09 (d, *J* = 8.4 Hz, 0.5H), 7.07 (d, *J* = 8.4 Hz, 0.5H), 6.73 (d, *J* = 8.4 Hz, 0.5H), 6.71 (d, *J* = 8.4 Hz, 0.5H), 6.34 – 6.26 (m, 0.5H), 6.18 – 6.10 (m, 0.5H), 5.29 (dd, *J* = 17.1, 1.7 Hz, 0.5H), 5.26 – 5.24 (m, 0.5H), 5.22 (d, *J* = 1.9 Hz, 0.5H), 5.17 (s, 0.5H), 5.15 (dd, *J* = 10.2, 1.9 Hz, 0.5H), 5.09 (s, 0.5H), 4.08 – 4.05 (m, 0.5H), 3.99 (dd, *J* = 4.7, 2.6 Hz, 0.5H), 3.91 (d, *J* = 5.9 Hz, 0.5H), 3.90 – 3.89 (m, 0.5H), 3.82 (s, 1.5H), 3.81 (s, 1.5H), 3.49 (dd, *J* = 17.2, 6.5 Hz, 0.5H), 3.46 – 3.44 (m, 0.5H), 3.38 (d, *J* = 10.7 Hz, 0.5H), 3.27 – 3.21 (m,0.5H), 3.08 – 3.06 (m, 0.5H), 3.05 – 3.02 (m, 0.5H), 2.88 (d, *J* = 11.3 Hz, 0.5H), 2.85 – 2.83 (m, 0.5H), 2.61 (dd, *J* = 14.6, 9.0 Hz, 0.5H), 2.49 (d, *J* = 7.4, 0.5H), 2.36 – 2.31 (m, 0.5H), 2.09 (s, 3H), 1.44 – 1.39 (m, 0.5H), 1.33 – 1.29 (m, 1H), 1.09 (d, *J* = 7.1 Hz, 1.5H), 1.00 (d, *J* = 7.1 Hz, 1.5H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.0 (2C), 146.2, 144.6, 136.2, 134.6, 134.0, 133.2, 123.6, 123.5, 122.8, 122.5, 118.7, 117.4, 109.3, 108.7, 97.5, 95.7, 77.1, 76.9, 72.6, 72.3, 55.7, 55.7, 47.2, 42.9, 42.7, 42.1, 41.0 (2C), 38.9, 38.4, 37.1, 34.0, 33.3, 31.5, 15.8, 15.7, 12.4 (2C). IR (cm^{-1}) ν_{max} 3375, 2963, 2926, 2855, 1261, 1101, 1020, 802. HRMS (m/z): ESI [M] calculated for $C_{20}H_{24}O_5$+Na $[M+Na]^+$: 367.1521, Found $[M+Na]^+$: 367.1511.

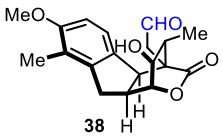




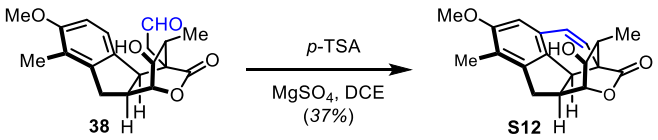
To a solution of cyclic hemiacetal **37** (300 mg, 0.908 mmol, 1.0 equiv.) in toluene (0.020 M, 50 ml) at room temperature was added Fetizon reagent (silver carbonate/Celite) (4.14 g, 7.26 mmol, 8.0 equiv.) in one portion. [Fetizon reagent was prepared according to the literature method, which contains about 1.00 mmol of Ag_2CO_3/0.570 g Fetizon reagent.] The resulting brown suspension was then immersed in an oil bath preheated to 100 °C. After 15 min, the color of the suspension turned dark, indicating that oxidation of hemiacetal **37** had occurred.

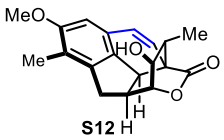
After a further 35 min, TLC analysis indicated that **32** had been completely consumed. The reaction mixture was cooled to room temperature, filtered through a pad of silica gel, and the filtrate was evaporated *in vacuo*. The crude product was purified by silica gel column chromatography (10% ~ 15% ethyl acetate – petroleum ether) to give compound **S11** as a white solid (275 mg, 92%), R_f = 0.49 (30% ethyl acetate – petroleum ether). M.p. 192 – 193 °C. $[\alpha]_D^{20}$ = –75 (c = 0.84 in CH_2Cl_2). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.15 (d, *J* = 8.4 Hz, 1H), 6.75 (d, *J* = 8.4 Hz, 1H), 6.18 – 6.09 (m, 1H), 5.37 – 5.32 (m, 1H), 5.26 – 5.24 (m, 1H), 4.52 (t, *J* = 3.8 Hz, 1H), 3.82 (d, *J* = 12.0 Hz, 1H), 3.82 (s, 3H), 3.64 (brs, 1H), 3.34 (dd, *J* = 17.0, 3.5 Hz, 1H), 3.21 – 3.15 (m, 1H), 3.01 (dd, *J* = 17.0, 11.3 Hz, 1H), 2.92 – 2.88 (m, 1H), 2.25 (dd, *J* = 14.9, 9.6 Hz, 1H), 2.10 (s, 3H), 1.61 – 1.55 (m, 1H), 0.94 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 175.7, 157.4, 145.0, 134.9, 132.0, 123.6, 122.8, 118.4, 109.4, 77.7, 76.4, 55.7, 48.5, 45.1, 39.2, 39.1, 34.0, 32.2, 16.7, 12.3. IR (cm^{-1}) ν_{max} 1749, 1717, 1508, 1260, 1101, 1018, 764, 750. HRMS (m/z): EI [M] calculated for $C_{20}H_{24}O_4$ $[M]^+$: 328.1675, Found $[M]^+$: 328.1677.



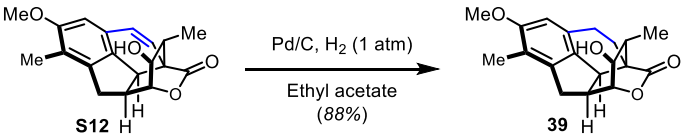


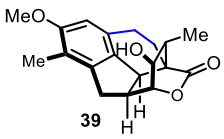
To a solution of compound **S11** (200 mg, 0.610 mmol, 1.0 equiv.) in tetrahydrofuran (12.0 mL) and water (12.0 mL) at 0 °C were added sodium acetate (1. 20 g, 14.6 mmol, 24 equiv.) and a solution of Osmium (VIII) oxide in toluene (50.0 mg/1.00 ml, 620 μL, 0.121 mmol, 0.20 equiv.) in sequence. The resulting reaction mixture was warmed to room temperature. After 2 h, sodium periodate (1.04 g, 4.88 mmol, 5.0 equiv.) was added. After a further 2.5 h, the resulting white suspension was quenched with an aqueous solution of saturated sodium thiosulfate and diluted with water. The layers were separated and the aqueous layer was extracted with ethyl acetate (3×20 mL). The combined organic layers were washed with brine (3×10 mL), dried over sodium sulfate, filtered, concentrated, and purified by silica gel column chromatography (10% ~ 15% ethyl acetate – petroleum ether) to give aldehyde **38** as a white foamy solid (135 mg, 67%), R_f = 0.44 (30% ethyl acetate – petroleum ether) and recover **S11** (10.0 mg, 10%). M.p. 188 – 189 °C. $[\alpha]_D^{20}$ = –19 (c = 0.33 in CH_2Cl_2). ^{1}H NMR (500 MHz, $CDCl_3$) δ 10.07 (dd, *J* = 4.5, 0.8 Hz, 1H), 7.12 (d, *J* = 8.4 Hz, 1H), 6.74 (d, *J* = 8.4 Hz, 1H), 4.61 (t, *J* = 3.9 Hz, 1H), 3.87 (d, *J* = 10.6 Hz, 1H), 3.82 (s, 3H), 3.72 – 3.70 (m, 1H), 3.48 (dd, *J* = 17.1, 4.5 Hz, 1H), 3.32 – 3.26 (m, 1H), 3.07 (dd, *J* = 15.6, 0.8 Hz, 1H), 2.98 (dd, *J* = 17.1, 11.4 Hz, 1H), 2.54 (dd, *J* = 15.6, 4.6 Hz, 1H), 2.09 (s, 3H), 1.63 – 1.57 (m, 1H), 0.94 (d, *J* = 7.1 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 202.5, 175.5, 157.7, 145.2, 130.5, 123.6, 122.8, 109.4, 78.0, 76.5, 55.7, 47.7, 47.3, 43.2, 38.9, 37.7, 31.6, 16.8, 12.3. IR (cm^{-1}) ν_{max} 2960, 2918, 2859, 1744, 1717, 1487, 1260, 1099, 1057, 1016, 800, 748. HRMS (m/z): EI [M] calculated for $C_{19}H_{22}O_5$+H $[M+H]^+$: 331.1545, Found $[M+H]^+$: 331.1529.





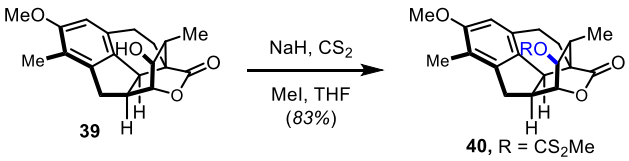
To a solution of aldehyde **38** (135 mg, 0.409 mmol, 1.0 equiv.) and flame-dried anhydrous magnesium sulfate (135 mg) in 1,2-dichloroethane (4.00 ml) at room temperature was added *p*-Toluenesulfonic acid (194 mg, 1.02 mmol, 2.5 equiv.). The flask was then immersed in an oil bath preheated to 75 °C. The reaction mixture was stirred at 75 °C for 2 h. TLC analysis indicated that **38** had been completely consumed. An aqueous solution of saturated sodium hydrogen carbonate was added until the pH of the aqueous layer reached 7 – 8. The layers were separated and aqueous layer was extracted with dichloromethane (3×15 mL). The combined organic layers were washed with brine (3×5 mL), dried over sodium sulfate, filtered, concentrated, and purified by silica gel column chromatography (10 ~ 20% ethyl acetate – petroleum ether) to give compound **S12** as a white solid (46.0 mg, 37%), R_f = 0.47 (30% ethyl acetate – petroleum ether). M.p. 203 – 204 °C. $[\alpha]_D^{20}$ = –50 (c = 0.20 in CH_2Cl_2). ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.60 (d, *J* = 9.5 Hz, 1H), 6.56 (s, 1H), 6.34 (d, *J* = 9.5 Hz, 1H), 4.66 (t, *J* = 4.2 Hz, 1H), 3.82 (s, 3H), 3.68 – 3.67 (m, 1H), 3.66 – 3.65 (m, 1H), 3.56 – 3.50 (m, 1H), 3.27 – 3.24 (m, 1H), 3.22 – 3.20 (m, 1H), 2.12 (s, 3H), 1.37 – 1.33 (m, 1H), 0.92 (d, *J* = 7.1 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 174.7, 158.8, 142.1, 130.4, 128.8, 128.6, 128.4, 122.5, 105.8, 79.6, 75.4, 56.1, 46.7, 46.1, 37.1, 36.4, 33.0, 17.6, 12.7. IR (cm^{-1}) ν_{max} 2963, 2922, 2948, 1757, 1744, 1732, 1277, 1261, 1111, 1038, 764, 750. HRMS (m/z): EI [M] calculated for $C_{19}H_{20}O_4$ $[M]^+$: 312.1362, Found $[M]^+$: 312.1360.

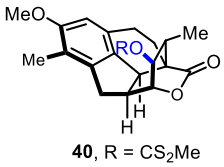




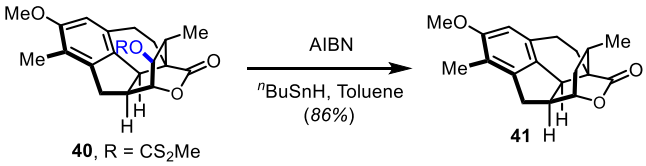
To a solution of compound **S12** (40.0 mg, 0.128 mmol, 1.0 equiv.) in ethyl acetate (6.00 mL) was added Pd/C (10% wt Pd on carbon, 32.0 mg, 80% wt). The reaction vessel was purged with nitrogen for 5 min, and then purged with hydrogen for 5 min. The reaction mixture was stirred at room temperature for 15 min under hydrogen (1 atm). TLC analysis indicated that **S12** had completely converted to **39**. The reaction mixture was purged with nitrogen for 5 min and filtered through a pad of silica gel. The filtrate was evaporated in vacuo and the crude product was purified by silica gel column chromatography (15% ethyl acetate – petroleum ether) to give cyclized product **39** as a white solid (35.0 mg, 88%), R_f = 0.47 (30% ethyl acetate – petroleum ether). M.p. 178 –

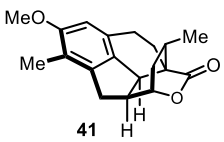
179 °C. $[\alpha]_D^{20}$ = –46 (c = 0.23 in CH_2Cl_2). ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.52 (s, 1H), 4.60 (t, *J* = 4.3 Hz, 1H), 3.80 (s, 3H), 3.59 (t, *J* = 4.3 Hz, 1H), 3.33 – 3.31 (m, 1H), 3.27 – 3.24 (m, 1H), 3.23 – 3.22 (m, 1H), 3.21 – 3.19(m, 1H), 3.06 (dd, *J* = 17.9, 9.6 Hz, 1H), 2.62 – 2.55 (m, 1H), 2.15 – 2.10 (m, 1H), 2.09 (s, 3H), 2.07 – 2.00 (m, 1H), 0.99 – 0.96 (m, 1H), 0.94 (d, *J* = 5.8 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 176.2, 158.5, 142.7, 131.6, 131.2, 120.4, 108.2, 79.1, 75.3, 55.9, 47.4, 44.9, 38.6, 35.9, 32.3, 24.4, 23.1, 17.1, 12.4. IR (cm^{-1}) ν_{max} 3000, 2987, 2914, 1749, 1744, 1535, 1275, 1261, 764, 750. HRMS (m/z): EI [M] calculated for $C_{19}H_{22}O_4$ $[M]^+$: 314.1518, Found $[M]^+$: 314.1521.



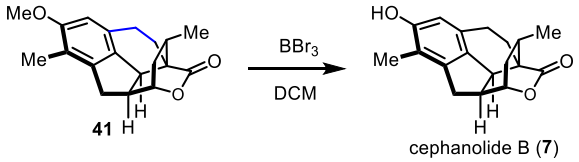


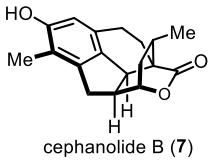
To a solution of cyclized product **39** (26.5 mg, 0.084 mmol, 1.0 equiv.) in tetrahydrofuran (2.00 mL) at 0 °C was added sodium hydride (27.0 mg, 60% dispersion in oil, 0.672 mmol, 8.0 equiv.) in one portion. The resulting suspension was stirred at 0 °C for 45 min, and then carbon disulfide (151 μL, 2.52 mmol, 30 equiv.) was added dropwise via syringe. The resulting yellow suspension was warmed to room temperature and stirred at room temperature for 1 h. Iodomethane (100 μL, 1.68 mmol, 20 equiv.) was added dropwise to the reaction flask. After a further 1 h, the resulting reaction mixture was quenched with an aqueous solution of saturated ammonium chloride and diluted with water. The layers were separated and the aqueous layer was extracted with ethyl acetate (3×10 mL). The combined organic layers were washed with brine (3×5 mL), dried over sodium sulfate, filtered, concentrated, and purified by silica gel column chromatography (5% ethyl acetate – petroleum ether) to give xanthate **40** as a white solid (29.0 mg, 83%), R_f = 0.73 (20% ethyl acetate – petroleum ether). M.p. 155 – 156 °C. $[\alpha]_D^{20}$ = –71 (c = 0.25 in CH_2Cl_2). ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.53 (s, 1H), 5.45 (t, *J* = 4.1 Hz, 1H), 4.97 (t, *J* = 4.1 Hz, 1H), 3.82 (s, 3H), 3.40 – 3.35 (m, 1H), 3.25 – 3.21 (m, 1H), 3.20 – 3.17 (m, 1H), 3.08 (dd, *J* = 17.9, 9.5 Hz, 1H), 2.92 – 2.85 (m, 1H), 2.63 – 2.56 (m, 1H), 2.49 (s, 3H), 2.19 – 2.16 (m, 1H), 2.15 (s, 3H), 2.10 – 2.04 (m, 1H), 1.40 – 1.35 (m, 1H), 1.00 (d, *J* = 7.3 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 215.5, 175.6, 158.6, 142.8, 131.1, 130.5, 120.5, 108.3, 82.4, 75.2, 56.0, 47.2, 44.9, 38.4, 32.5, 32.4, 24.2, 23.2, 19.4, 17.0, 12.7. IR (cm^{-1}) ν_{max} 1759, 1749, 1543, 1508, 1275, 1261, 764, 750. HRMS (m/z): EI [M] calculated for $C_{21}H_{24}O_4S_2$ $[M]^+$: 404.1116, Found $[M]^+$: 404.1118.





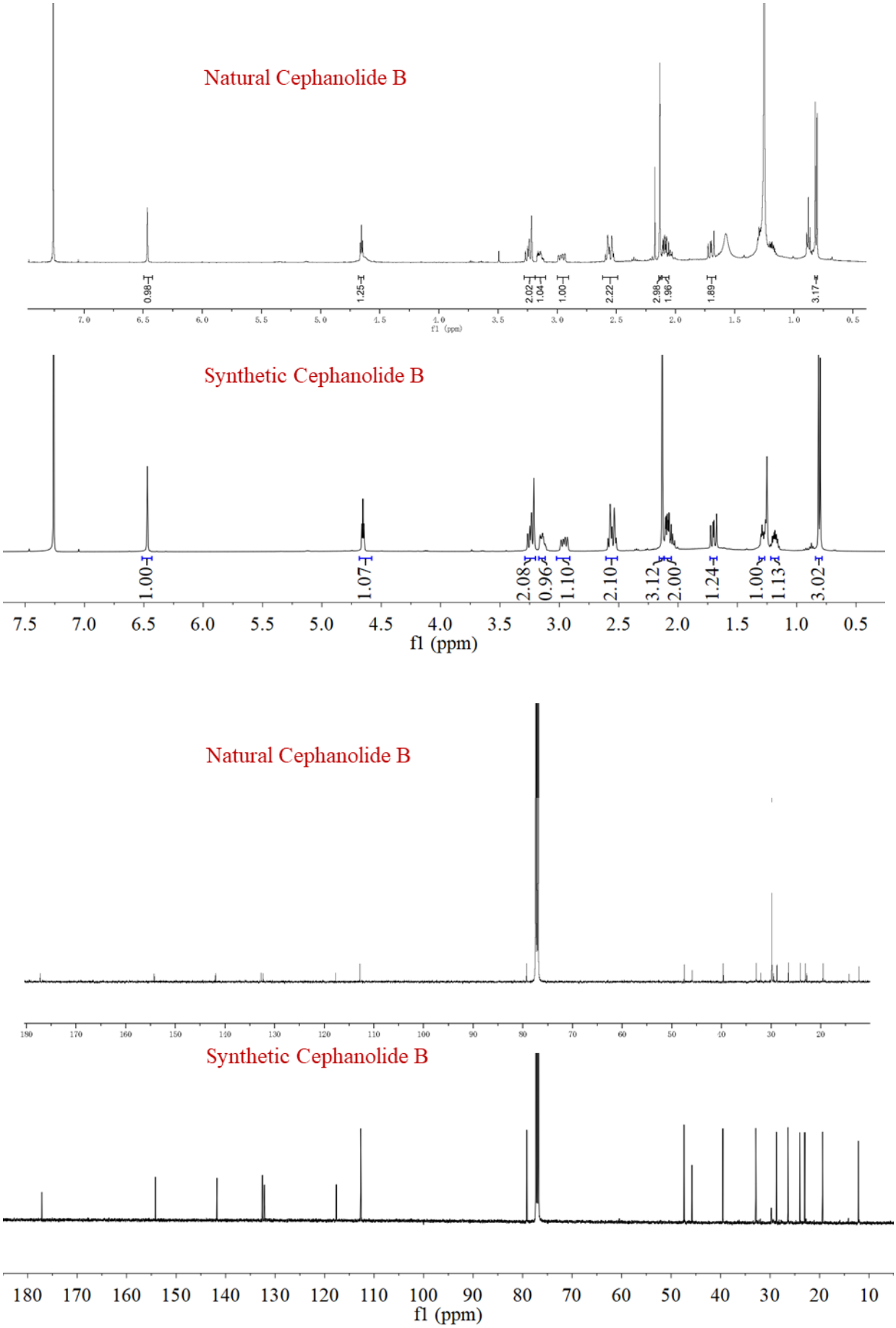
To a solution of xanthate **40** (22.0 mg, 0.053 mmol, 1.0 equiv.) in toluene (2.00 mL) at room temperature were added azodiisobutyronitrile (4.30 mg, 0.026 mmol, 0.5 equiv.) and tributyltin hydride in sequence. The flask was then immersed in an oil bath preheated to 95 °C. The reaction mixture was stirred at 95 ºC for 1.5 h. TLC analysis indicated that **40** had been completely consumed. Solvent was evaporated *in vacuo* and the crude product was purified by silica gel column chromatography (3% ~ 4% ethyl acetate – petroleum ether) to give compound **41** as a white solid (13.5 mg, 86%), R_f = 0.40 (5% ethyl acetate – petroleum ether). M.p. 181 – 182 °C. $[\alpha]_D^{20}$ = –26 (c = 0.13 in CH_2Cl_2). ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.52 (s, 1H), 4.65 (t, *J* = 4.7 Hz, 1H), 3.80 (s, 3H), 3.26 (d, *J* = 10.2 Hz, 1H), 3.23 – 3.21 (m, 1H), 3.17 – 3.11 (m, 1H), 3.01 (dd, *J* = 18.2, 9.1 Hz, 1H), 2.63 – 2.58 (m, 1H), 2.55 (d, *J* = 17.7 Hz, 1H), 2.15 – 2.10 (m, 1H), 2.10 (s, 3H), 2.09 – 2.04 (m, 1H), 1.69 (dd, *J* = 14.4, 10.3 Hz, 1H), 1.30 – 1.26 (m, 1H), 1.20 – 1.12 (m,1H), 0.81 (d, *J* = 7.1 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 177.1, 158.3, 141.5, 132.0, 131.8, 120.2, 108.2, 79.1, 56.0, 47.3, 45.7, 39.4, 32.8, 28.7, 26.3, 24.4, 23.1, 19.4, 12.4. IR (cm^{-1}) ν_{max} 1749, 1543, 1516, 1275, 1260, 1096, 1022, 764, 750. HRMS (m/z): EI [M] calculated for $C_{19}H_{22}O_3$+H $[M+H]^+$: 299.1647, Found $[M+H]^+$: 299.1634.





To a solution of compound **41** (10.0 mg, 0.034 mmol, 1.0 equiv.) in dichloromethane (1.00 mL) at –78 ºC was added a solution of 1.0 M boron tribromide in dichloromethane (340 μL, 0.34 mmol, 10 equiv.) dropwise via syringe. The resulting suspension was stirred at –78 ºC for 10 min and stirred at 0 ºC for 5 h. The reaction mixture was quenched with saturated ammonium chloride aqueous solution and diluted with water. The layers were separated and aqueous layer extracted with dichloromethane (3×15 mL). The combined organic layers were washed with brine (3×5 mL), dried over sodium sulfate, filtered, concentrated, and purified by silica gel column chromatography (10% ~ 15% ethyl acetate – petroleum ether) to give cephanolide B (**7**) as a white solid (7.70 mg, 80%), R_f = 0.44 (30% ethyl acetate – petroleum ether). M.p. 190 – 191 °C. $[\alpha]_D^{20}$ = –26 (c = 0.10 in CH_2Cl_2). ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.47 (s, 1H), 4.65 (t, *J* = 4.7 Hz, 1H), 3.24 (dd, *J* = 15.0, 9.5), 3.23 (d, *J* = 7.5, 1H), 2.96 (dd, *J* = 17.0, 8.5 Hz, 1H), 2.59 – 2.56 (m, 1H), 2.54 – 2.52 (m, 1H), 2.13 (s, 3H), 2.12 – 2.08 (m, 1H), 2.07 – 2.03 (m, 1H), 1.70 (dd, *J* = 14.0, 10.0, 1H), 1.30 – 1.26 (m,1H), 1.22 – 1.15 (m, 1H), 0.81 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 177.2, 154.2, 141.8, 132.6, 132.2, 117.7, 112.8, 79.2, 47.5, 45.8, 39.6, 32.9, 28.8, 26.5, 24.1, 23.1, 19.5, 12.2. IR (cm^{-1}) ν_{max} 3362, 2955, 2920, 2851, 1744, 1730, 1456, 1090, 1074, 669. HRMS (m/z): EI [M] calculated for $C_{18}H_{20}O_3$+H $[M+H]^+$: 285.1491, Found $[M+H]^+$: 285.1475.

3. Comparison of NMR Data of Natural and Synthetic Cephanolide B[3]



position	**natural** 400 MHz, $CDCl_3$	**synthetic** 400 MHz, $CDCl_3$	**Deviation** (natural–synthetic) Δδ (ppm)
1	3.15, m	3.15, m	0
2	4.65, m	4.65, t (4.7)	0
3	a 1.70, dd (14.4, 10.4) b 1.28, ddd (14.4, 4.6, 1.8)	a 1.70, dd (14.0, 10.0) b 1.28, m	0, 0
4	1.18, m	1.19, m	-0.1
6	2.05−2.12, m (2H)	2.03−2.12, m (2H)	-
7	α 2.96, dd (17.5, 9.0) β 2.56, overlap	α 2.96, dd (17.0, 8.5) β 2.56, overlap	0, 0
10	3.23, d (9.3)	3.23, d (7.5)	0.01
15	6.46, s	6.47 s	0
16	2.13, s	2.13, s	0
19	0.81, d (7.1)	0.81, d (7.2)	0
20	α 3.24, dd (15.0, 9.6) β 2.56, overlap	α 3.24, dd (15.0, 9.5) β 2.56, overlap	0, 0

Table 1. Comparison of ^{1}H NMR spectroscopic data of natural and synthetic Cephanolide B[3]

position	natural δ ^{13}C [ppm] 125 MHz, $CDCl_3$	synthetic δ ^{13}C [ppm] 125 MHz, $CDCl_3$	deviation (natural–synthetic) Δδ (ppm)
1	39.6	39.6	0
2	79.2	79.2	0
3	28.8	28.8	0
4	26.5	26.5	0
5	45.9	45.8	0.1
6	23.1	23.1	0
7	24.1	24.1	0
8	132.7	132.6	0.1
9	132.3	132.2	0.1
10	47.5	47.5	0
11	141.9	141.8	0.1
12	117.7	117.7	0
13	154.2	154.2	0
15	112.8	112.8	0
16	12.3	12.2	0.1
18	177.2	177.2	0
19	19.5	19.5	0
20	33.0	32.9	0.1

Table 2. Comparison of ^{13}C NMR spectroscopic data of natural and synthetic Cephanolide B[3]

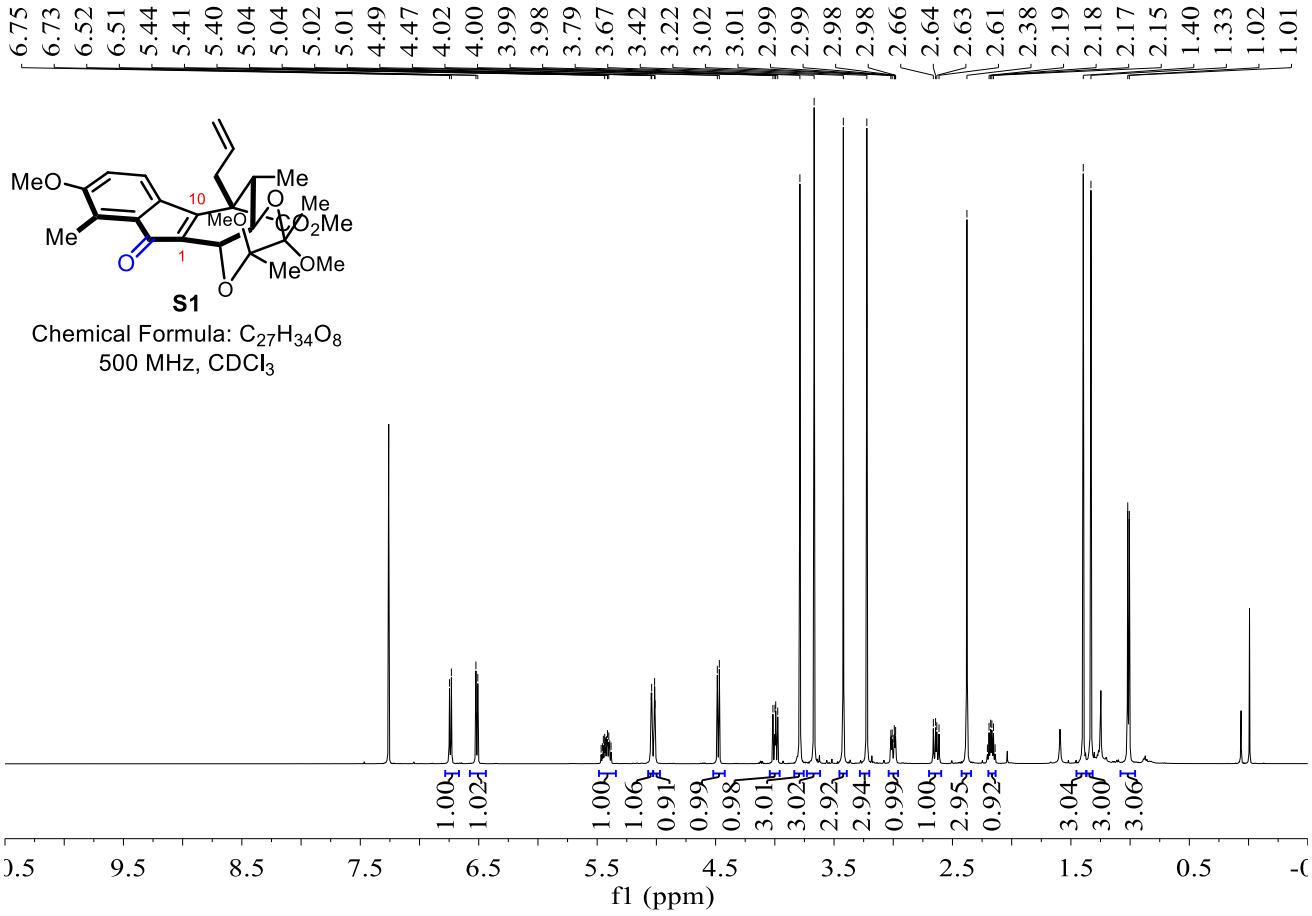
4. Reference

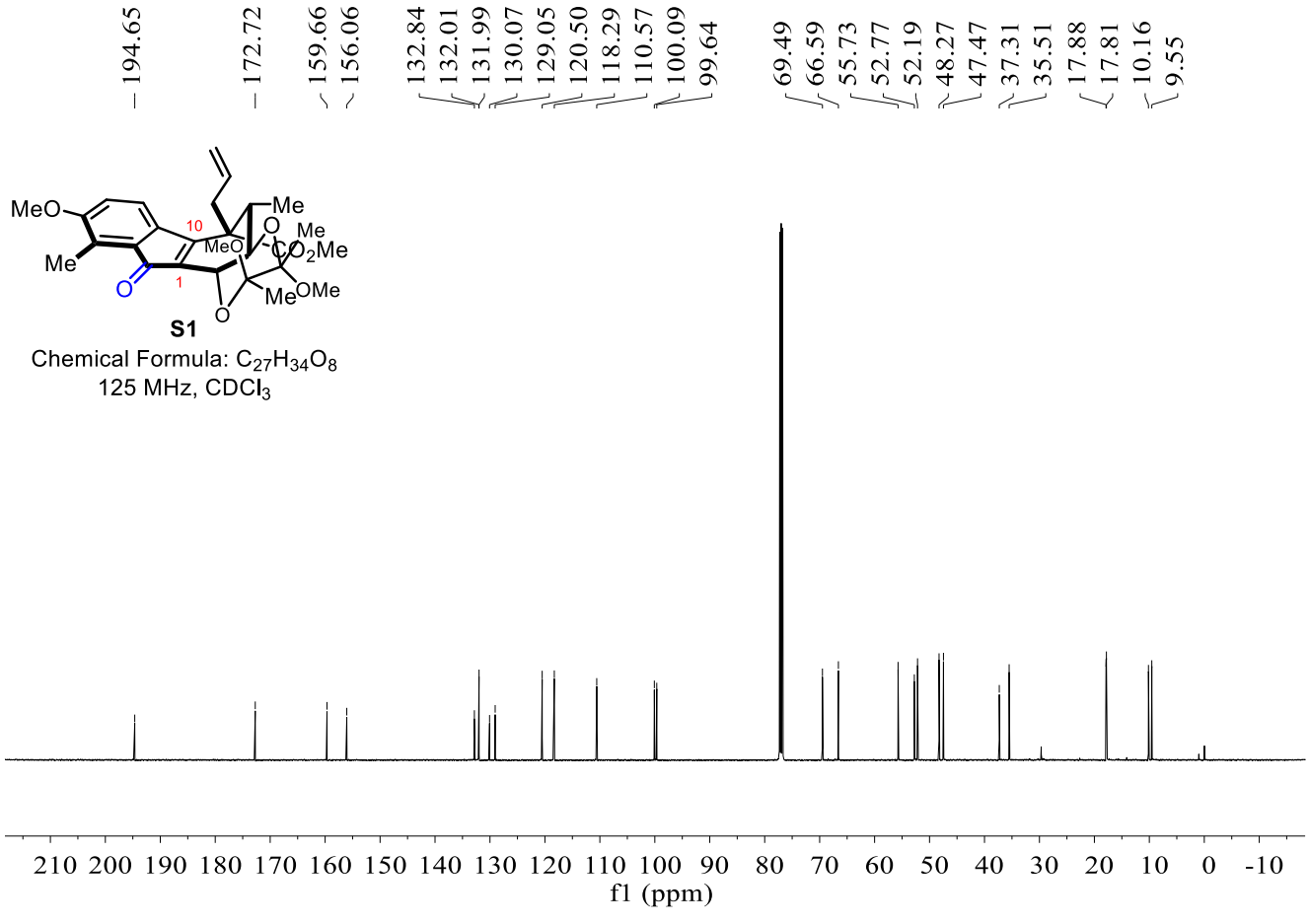
[1] W. C. Still, M. Kahn, A. Mitra, *J. Org. Chem.*, 1978, **43**, 2923–2925.

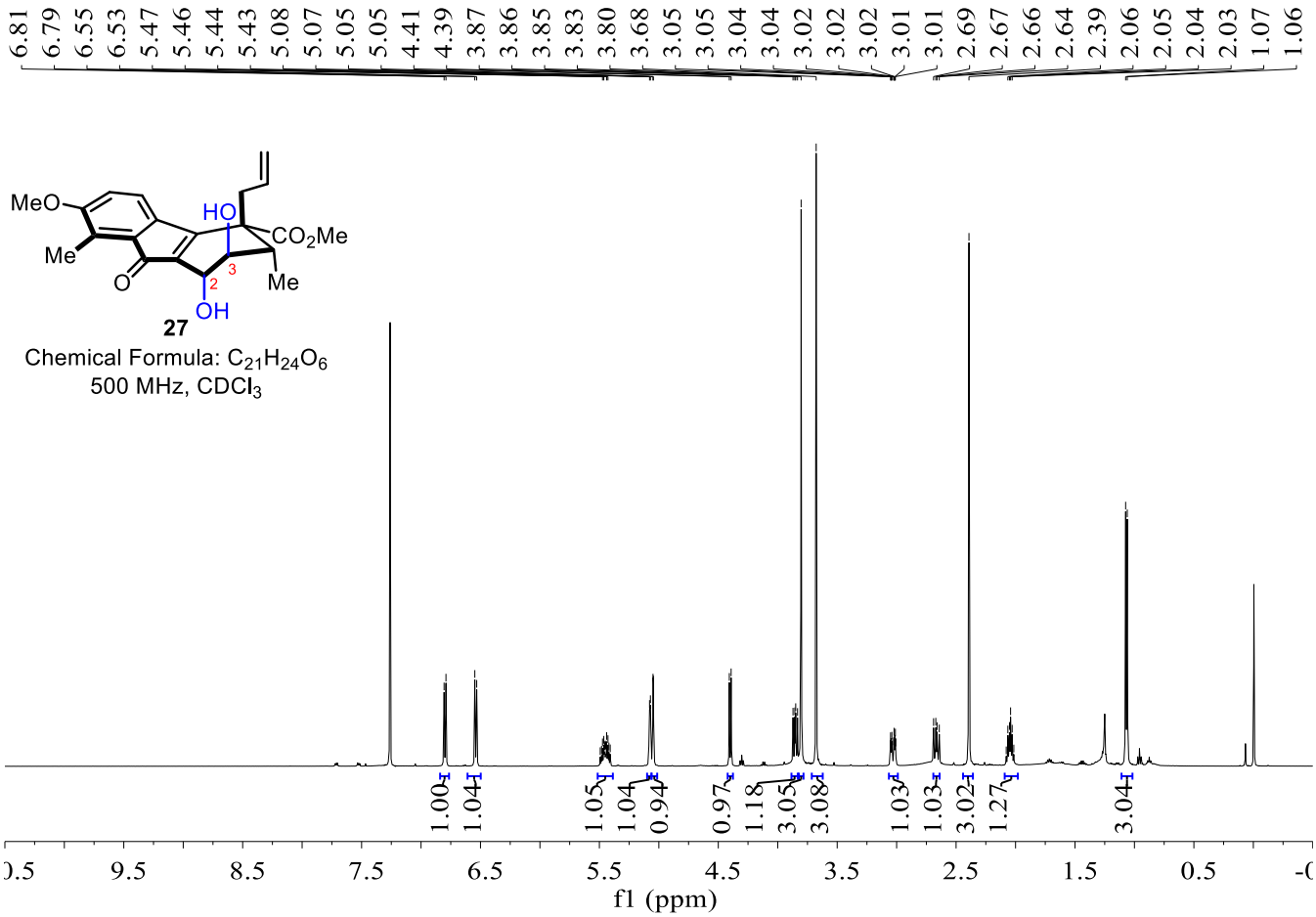
[2] V. Balogh, M. Fetizon, M. Golfier, *J. Org. Chem.*, 1971, **36**, 1339–1341.

[3] Y. Y. Fan, J. B. Xu, H. C. Liu, L. S. Gan, J. Ding, J. M. Yue, *J. Nat. Prod*. 2017, **80**, 3159–3166.

5. ^{1}H and ^{13}C NMR Spectra of the Synthetic Intermediates and Products






6.81 6.79 6.55 6.53 5.47 5.46 5.44 5.43 5.08 5.07 5.05 5.05 4.41 4.39 3.87 3.86 3.85 3.83 3.80 3.68 3.05 3.05 3.04 3.04 3.02 3.02 3.02 3.01 3.01 2.69 2.67 2.66 2.64 2.39 2.06 2.05 2.04 2.03 1.07 1.06
MeO
Me
HO
CO2Me
Me
O
OH
2
3
27
Chemical Formula: C21H24O6
500 MHz, CDCl3
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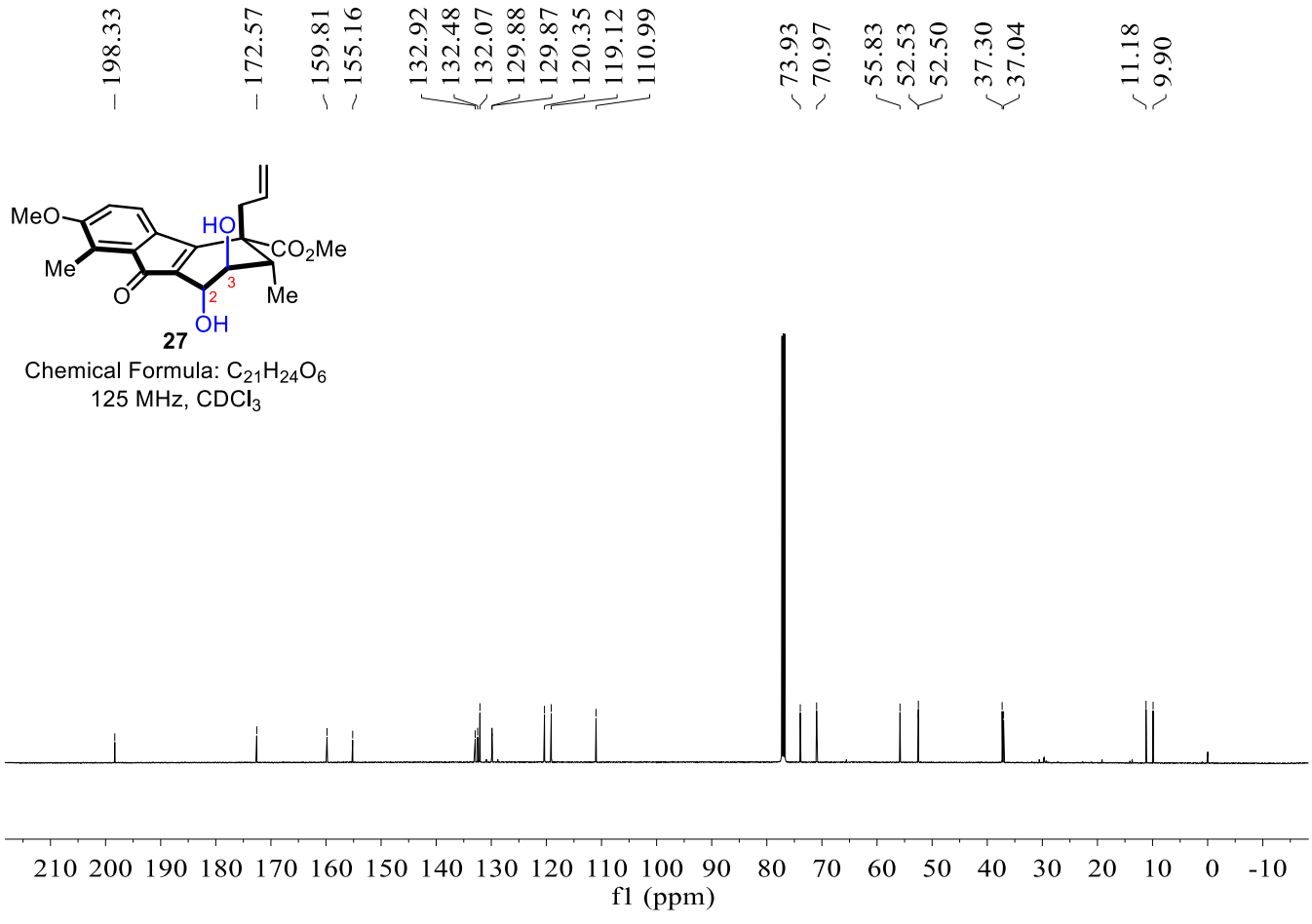
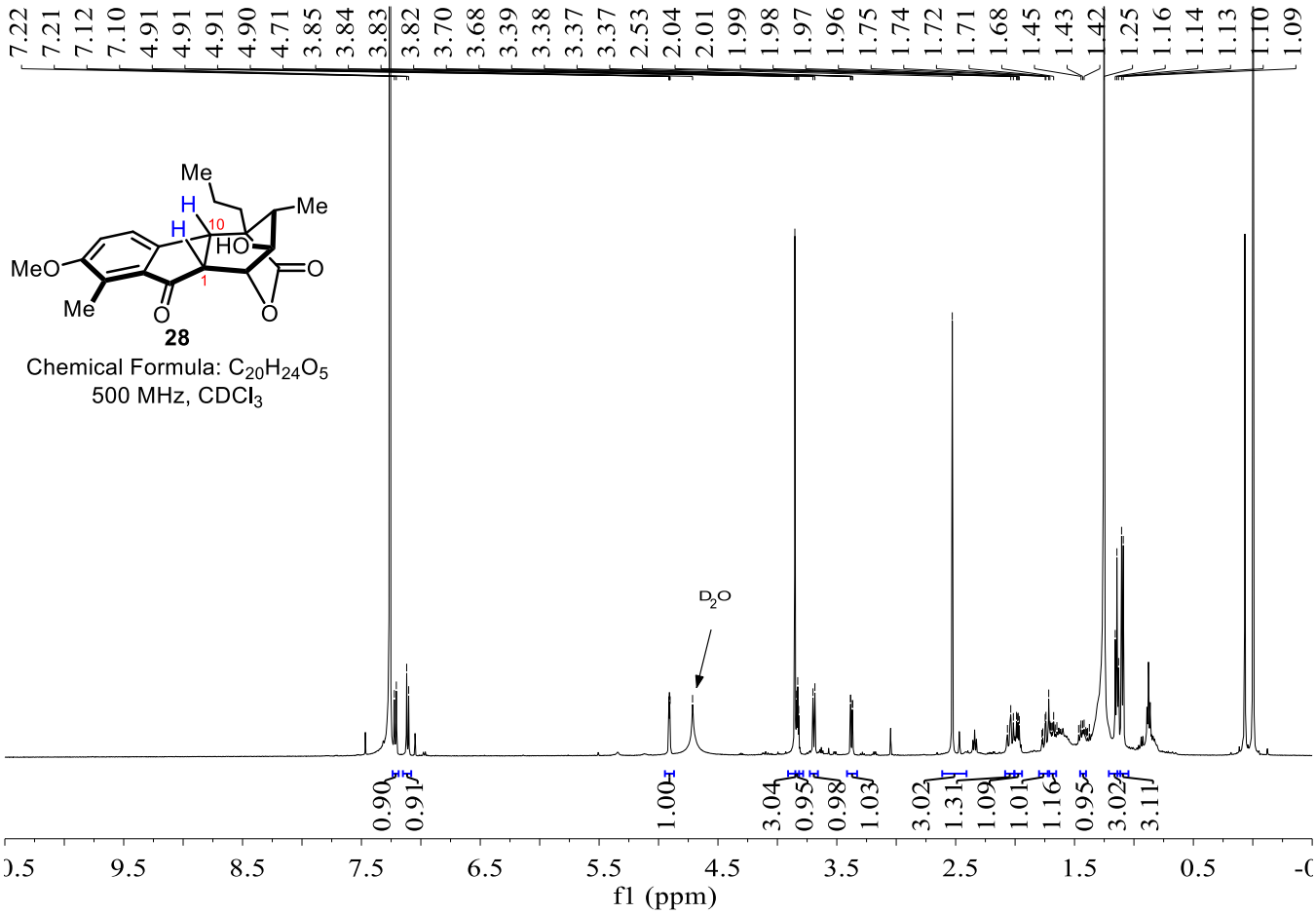
f1 (ppm)


198.33 172.57 159.81 155.16 132.92 132.48 132.07 129.88 129.87 120.35 119.12 110.99 73.93 70.97 55.83 52.53 52.50 37.30 37.04 11.18 9.90
MeO
Me
HO
CO2Me
Me
O
OH
2
3
27
Chemical Formula: C21H24O6
125 MHz, CDCl3
f1 (ppm)


7.22 7.21 7.12 7.10 4.91 4.91 4.91 4.90 4.71 3.85 3.84 3.83 3.82 3.70 3.68 3.39 3.38 3.37 3.37 2.53 2.04 2.01 1.99 1.98 1.97 1.96 1.75 1.74 1.72 1.71 1.68 1.45 1.43 1.42 1.25 1.16 1.14 1.13 1.10 1.09
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H
H
10
Me
HO
MeO
1
O
O
Me
O
28
Chemical Formula: C20H24O5
500 MHz, CDCl3
D2O
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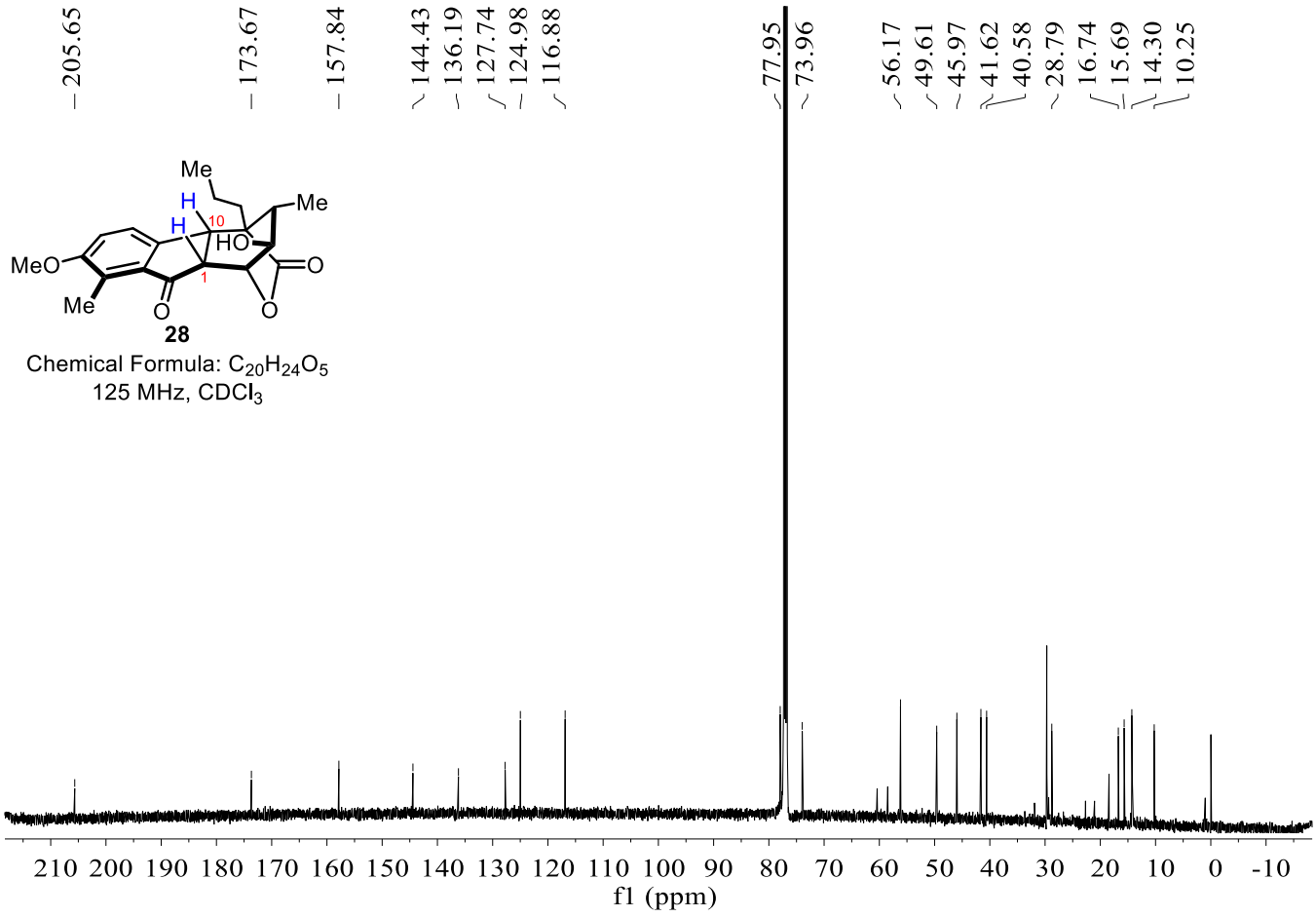
9.5 8.5 7.5 6.5 5.5 4.5 3.5 2.5 1.5 0.5
f1 (ppm)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Me
H
H
10
Me
HO
MeO
1
O
O
Me
O
28
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125 MHz, CDCl3
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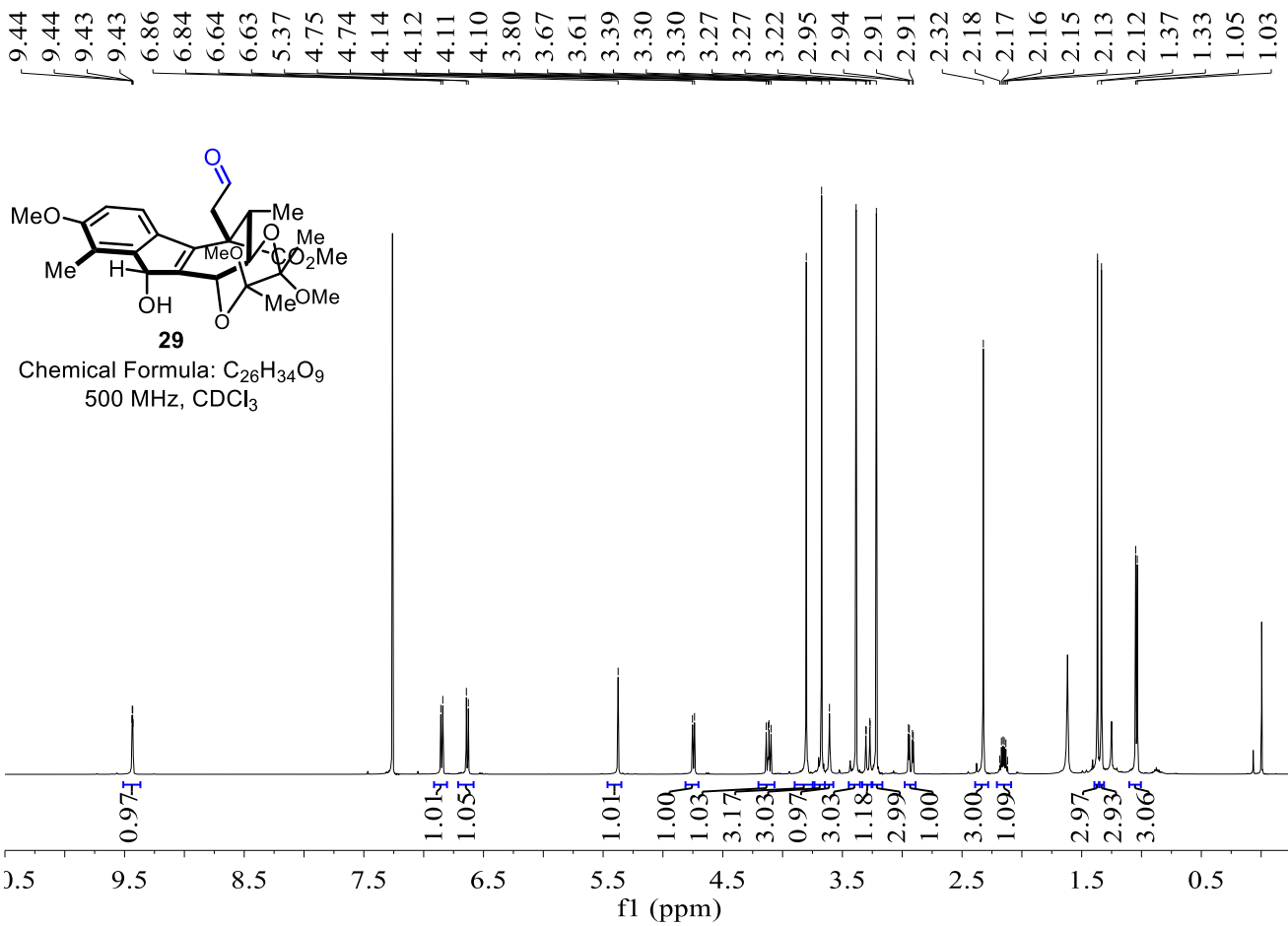
f1 (ppm)


9.44 9.44 9.43 9.43 6.86 6.84 6.64 6.63 5.37 4.75 4.74 4.14 4.12 4.11 4.10 3.80 3.67 3.61 3.39 3.30 3.30 3.27 3.27 3.22 2.95 2.94 2.91 2.91 2.32 2.18 2.17 2.16 2.15 2.13 2.12 1.37 1.33 1.05 1.03
MeO
Me
H
OH
MeO
Me
O
Me
CO2Me
Me
OMe
O
29
Chemical Formula: C26H34O9
500 MHz, CDCl3
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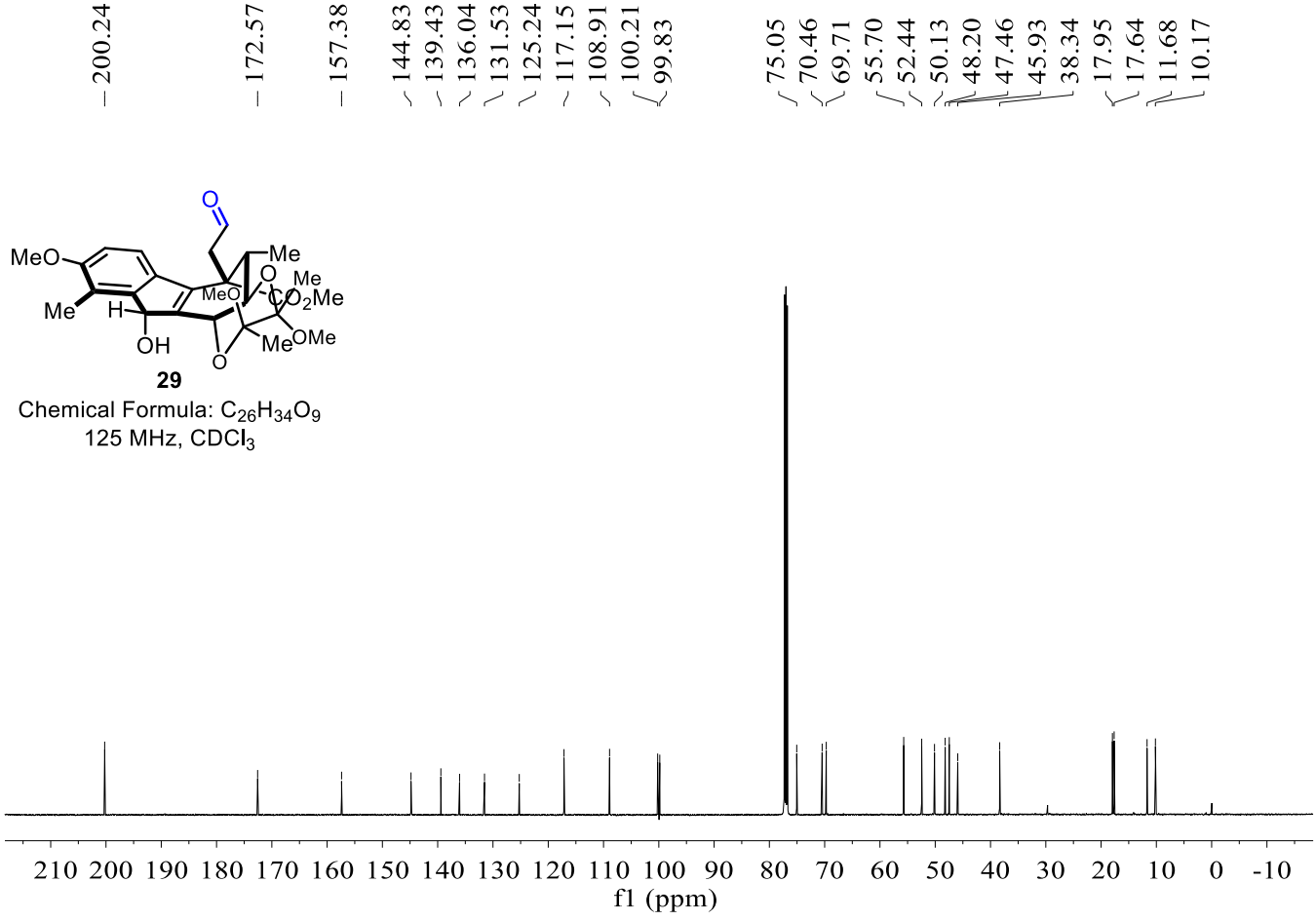
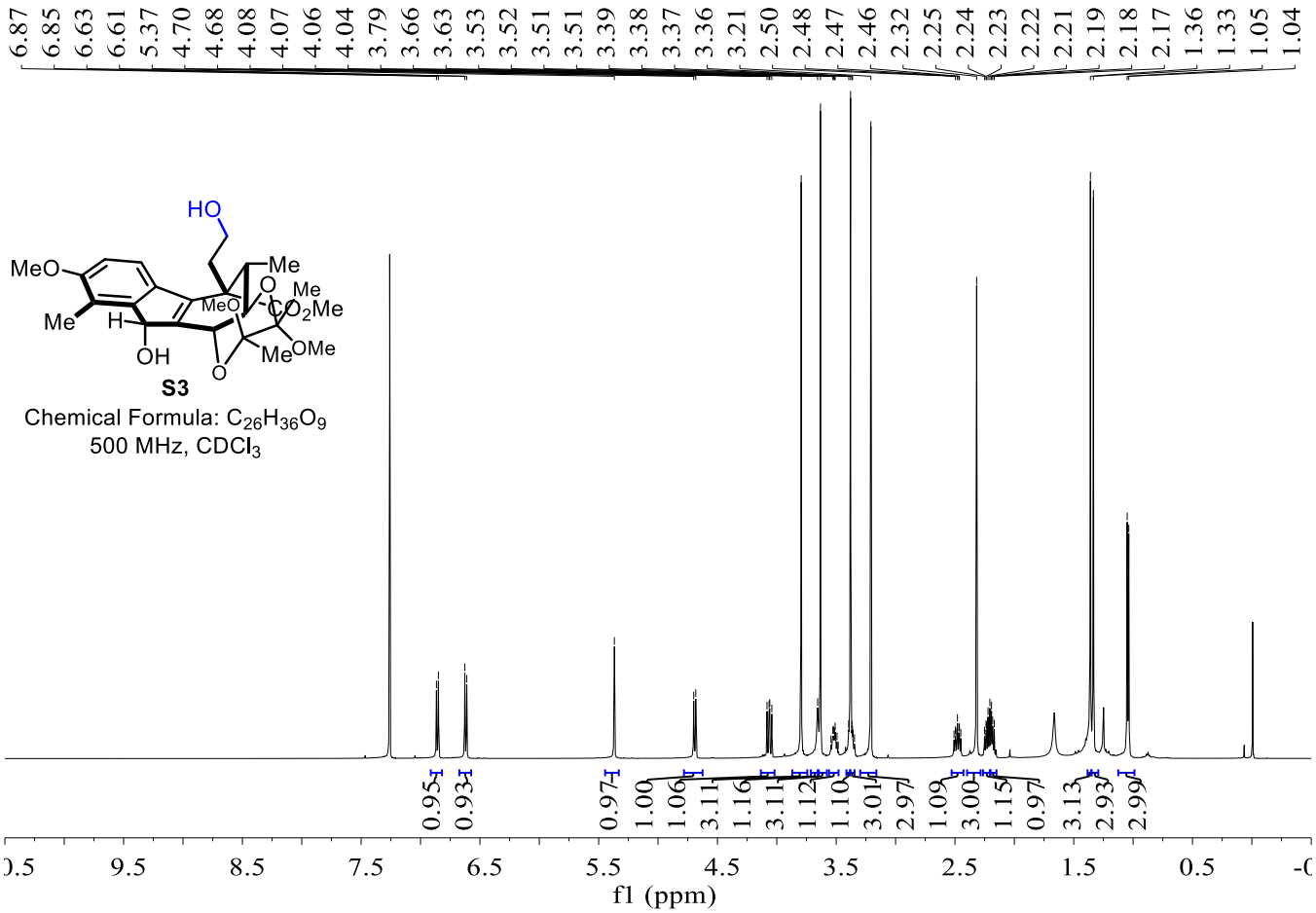
f1 (ppm)


200.24 172.57 157.38 144.83 139.43 136.04 131.53 125.24 117.15 108.91 100.21 99.83 75.05 70.46 69.71 55.70 52.44 50.13 48.20 47.46 45.93 38.34 17.95 17.64 11.68 10.17
MeO
Me
H
OH
MeO
Me
O
Me
CO2Me
Me
OMe
O
29
Chemical Formula: C26H34O9
125 MHz, CDCl3
f1 (ppm)


6.87 6.85 6.63 6.61 5.37 4.70 4.68 4.08 4.07 4.06 4.04 3.79 3.66 3.63 3.53 3.52 3.51 3.51 3.39 3.38 3.37 3.36 3.21 2.50 2.48 2.47 2.46 2.32 2.25 2.24 2.23 2.22 2.21 2.19 2.18 2.17 1.36 1.33 1.05 1.04
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MeO
Me
H
OH
MeO
O
Me
CO2Me
Me
OMe
O
S3
Chemical Formula: C26H36O9
500 MHz, CDCl3
0.95 0.93 0.97 1.00 1.06 3.11 1.16 3.11 1.12 1.10 3.01 2.97 1.09 3.00 1.15 0.97 3.13 2.93 2.99
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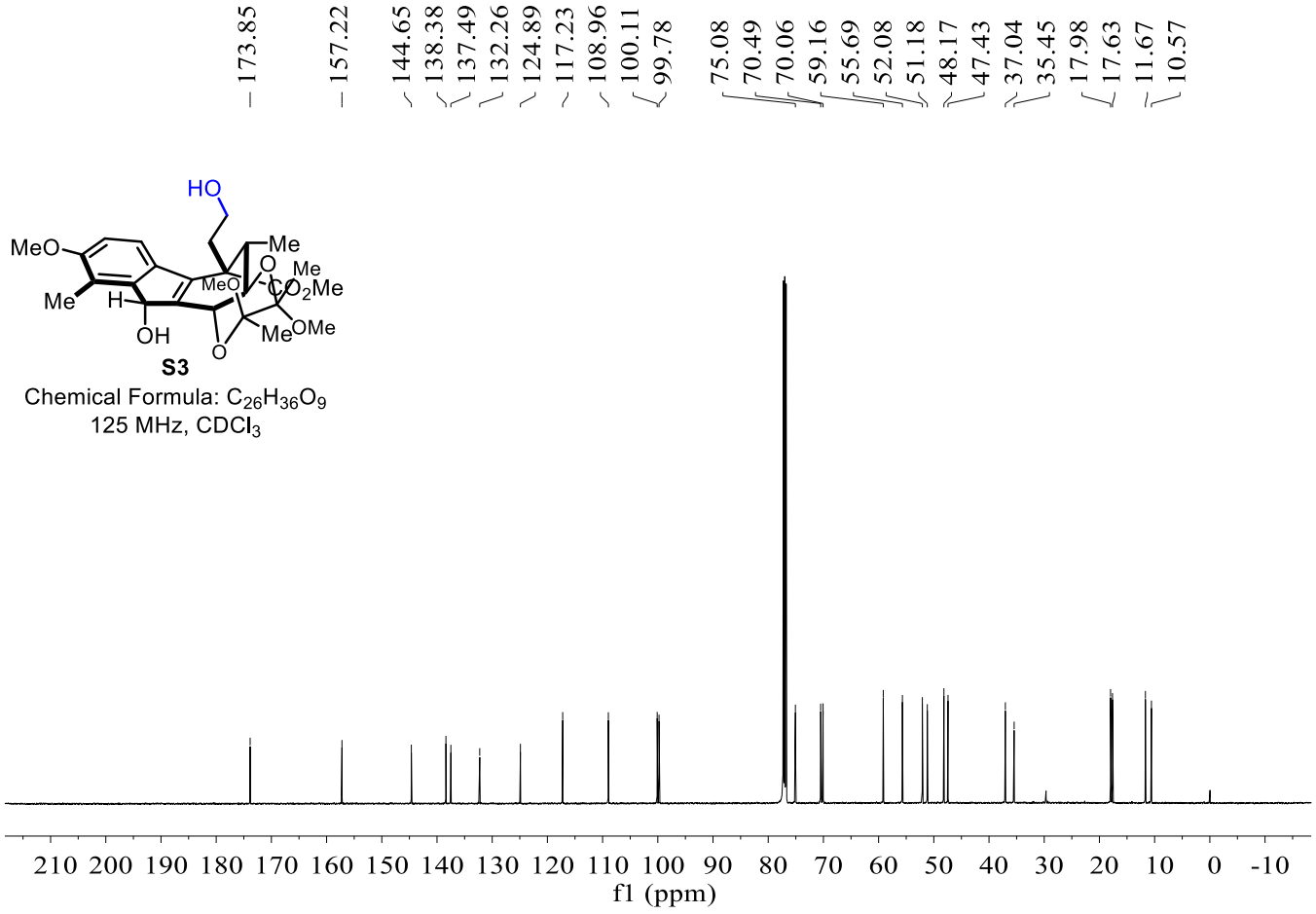
f1 (ppm)


173.85 157.22 144.65 138.38 137.49 132.26 124.89 117.23 108.96 100.11 99.78 75.08 70.49 70.06 59.16 55.69 52.08 51.18 48.17 47.43 37.04 35.45 17.98 17.63 11.67 10.57
HO
MeO
Me
H
OH
MeO
O
Me
CO2Me
Me
OMe
O
S3
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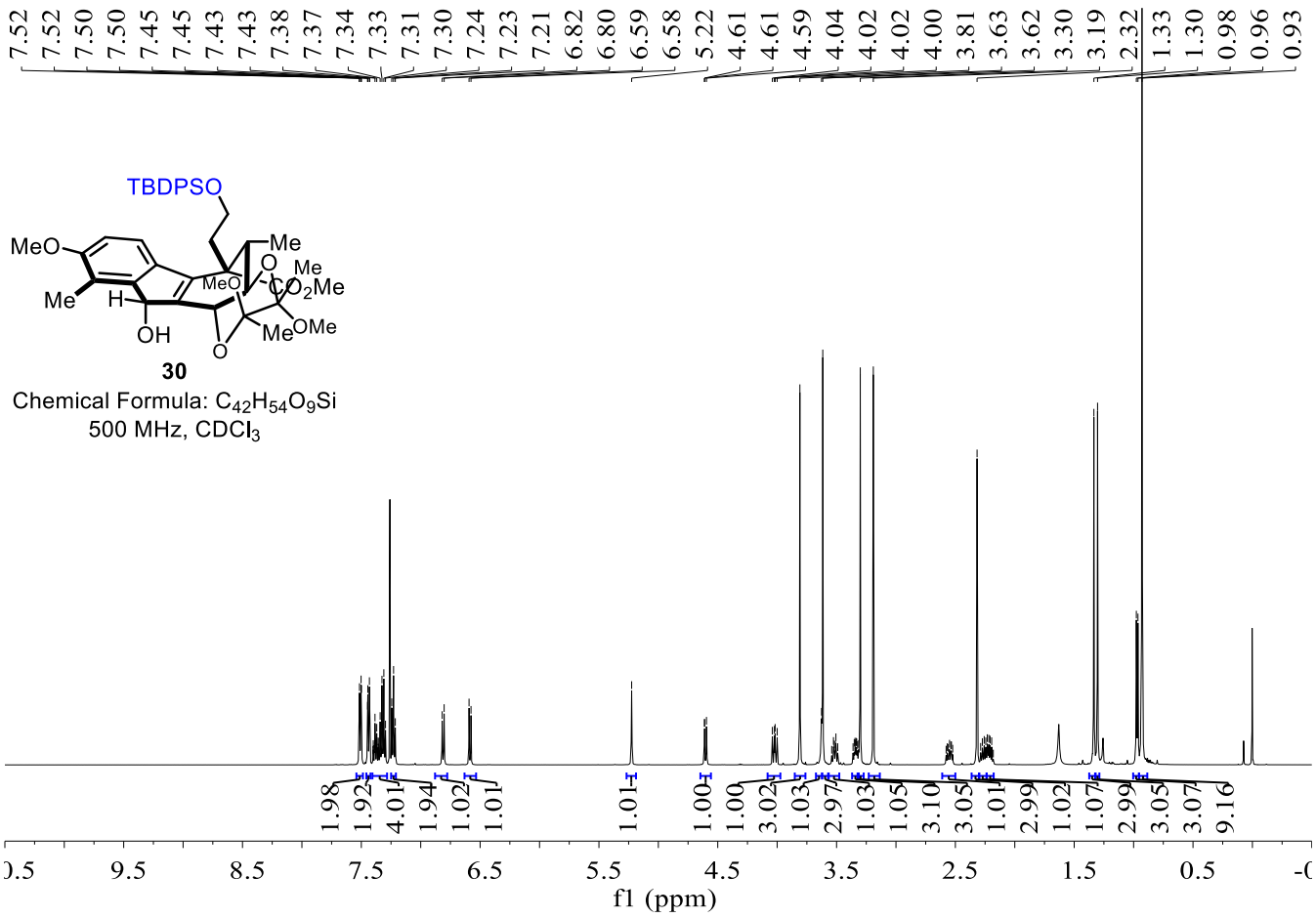
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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TBDPSO
MeO
Me
H
OH
MeO
Me
O
Me
CO2Me
OMe
Me
O
30
Chemical Formula: C42H54O9Si
500 MHz, CDCl3
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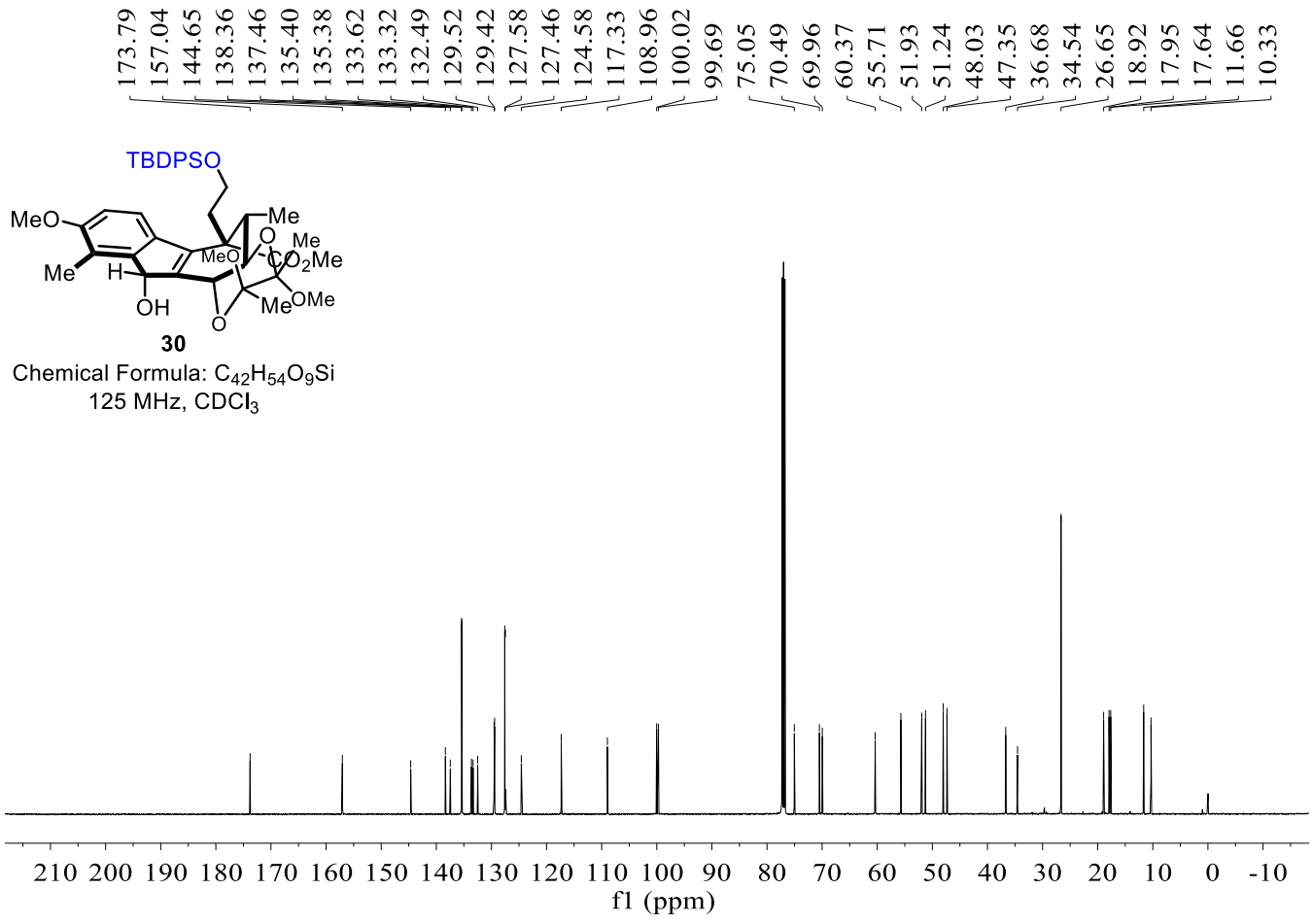
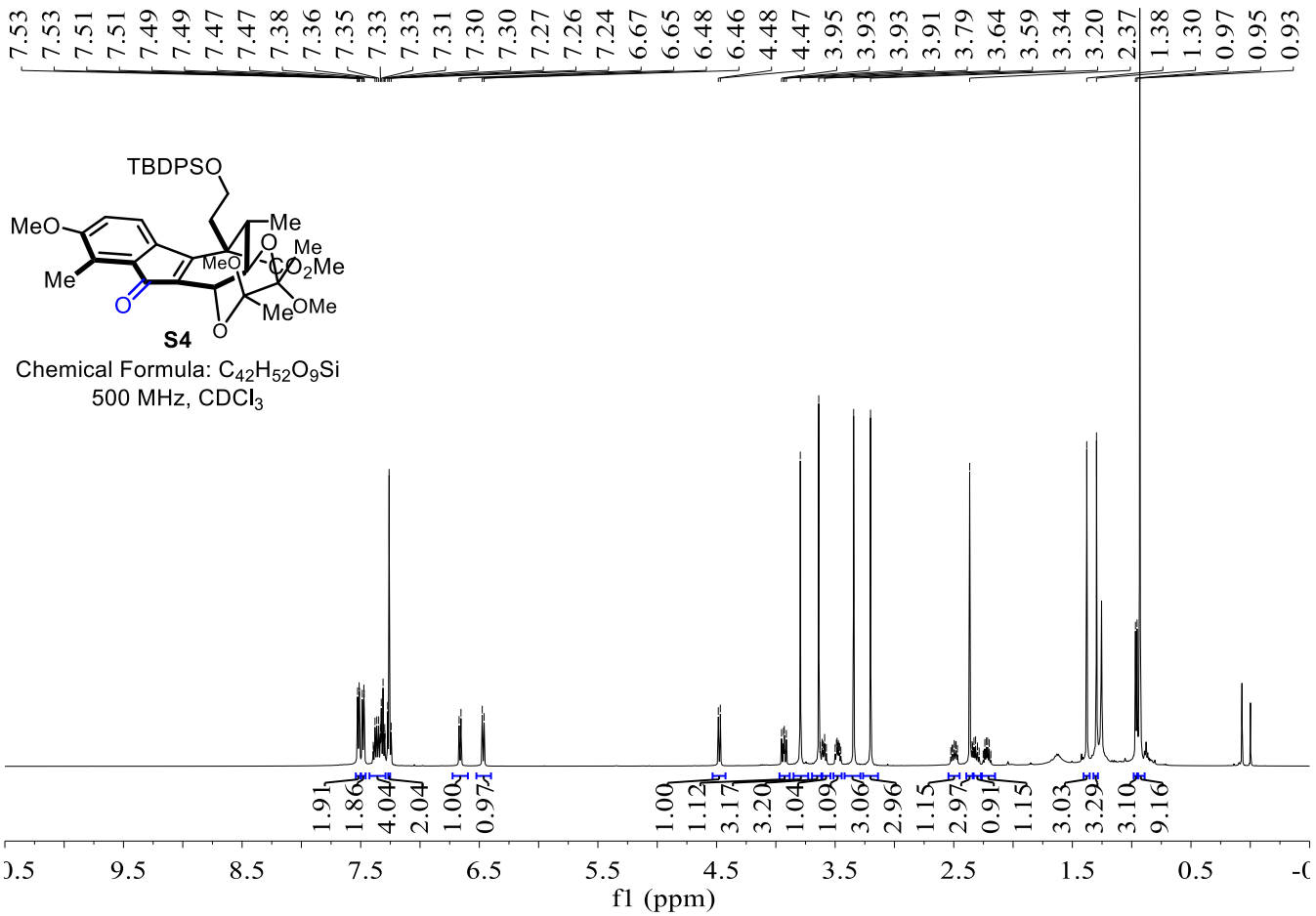
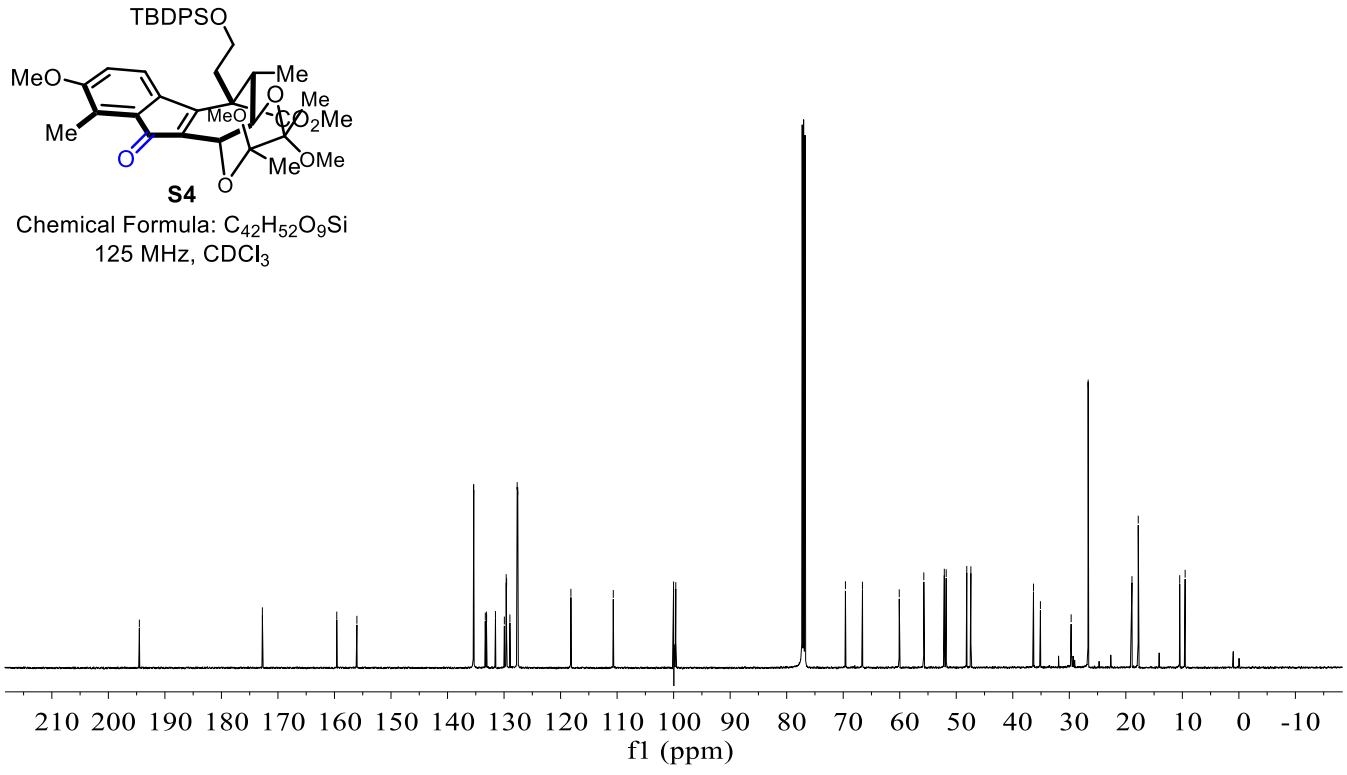
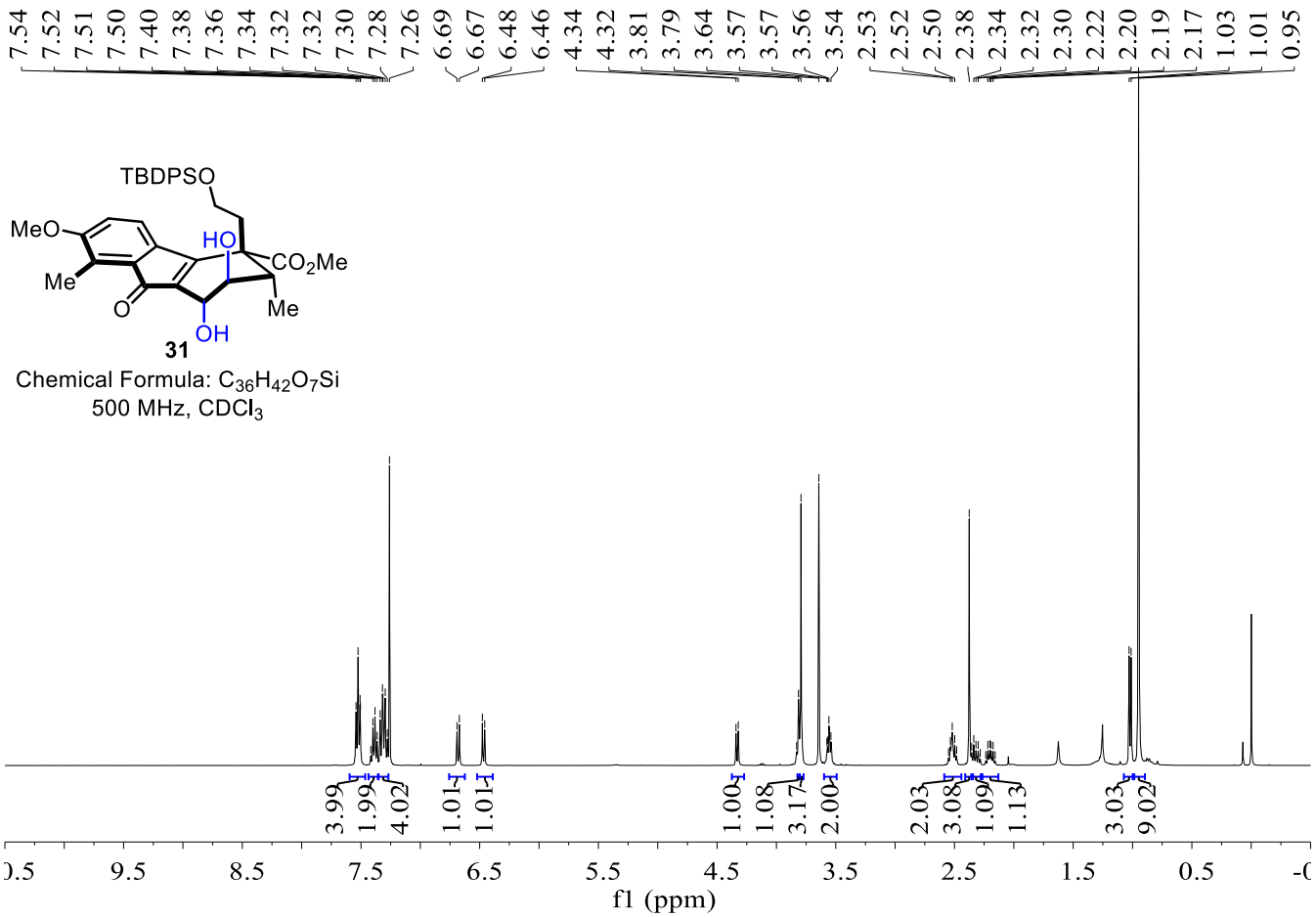
9.5 8.5 7.5 6.5 5.5 4.5 3.5 2.5 1.5 0.5
f1 (ppm)

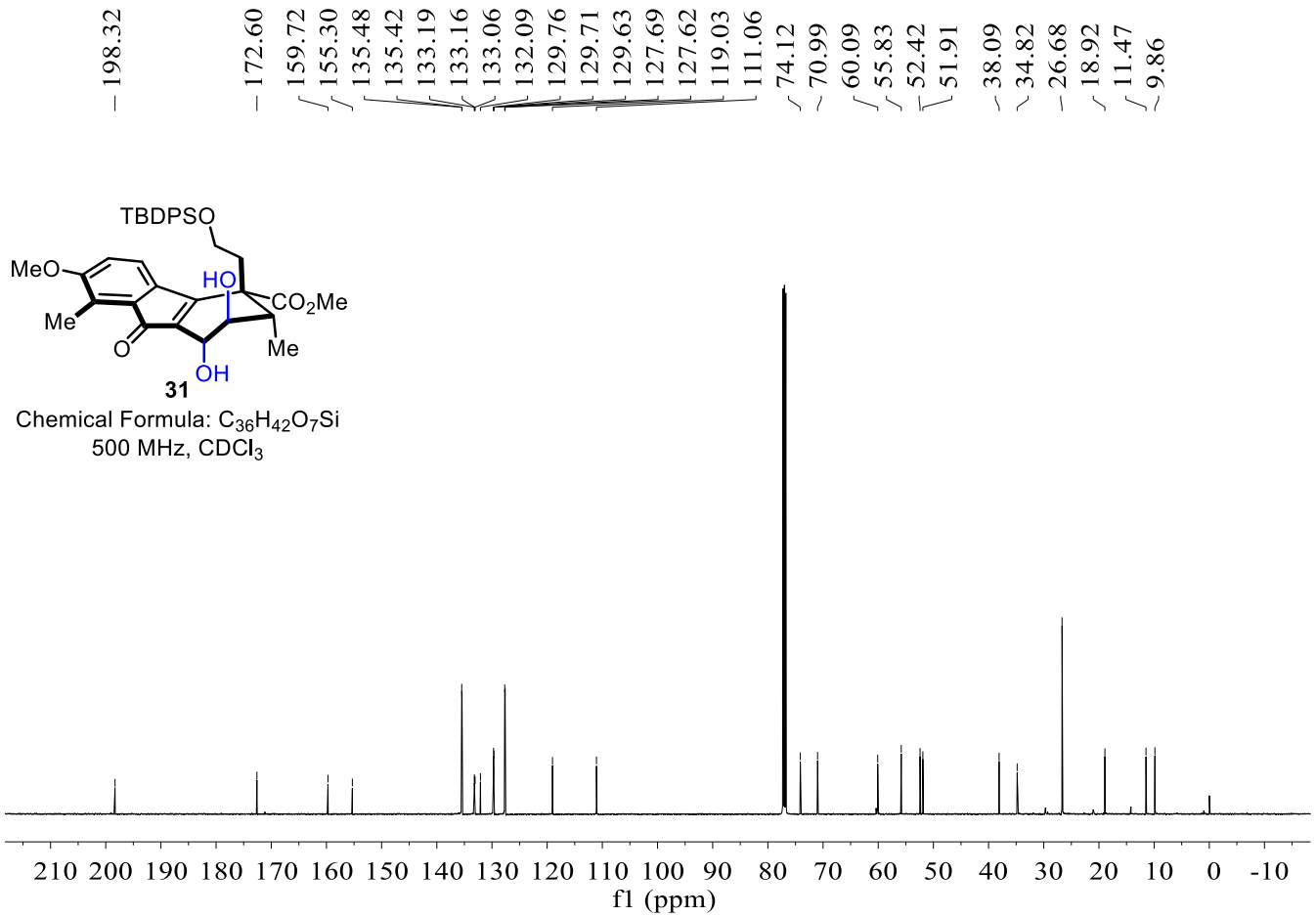

173.79 157.04 144.65 138.36 137.46 135.40 135.38 133.62 133.32 132.49 129.52 129.42 127.58 127.46 124.58 117.33 108.96 100.02 99.69 75.05 70.49 69.96 60.37 55.71 51.93 51.24 48.03 47.35 36.68 34.54 26.65 18.92 17.95 17.64 11.66 10.33
TBDPSO
MeO
Me
H
OH
MeO
Me
O
Me
CO2Me
OMe
Me
O
30
Chemical Formula: C42H54O9Si
125 MHz, CDCl3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


TBDPSO
MeO
Me
Me
MeO
O
Me
CO2Me
Me
OMe
O
O
S4
Chemical Formula: C42H52O9Si
500 MHz, CDCl3
f1 (ppm)

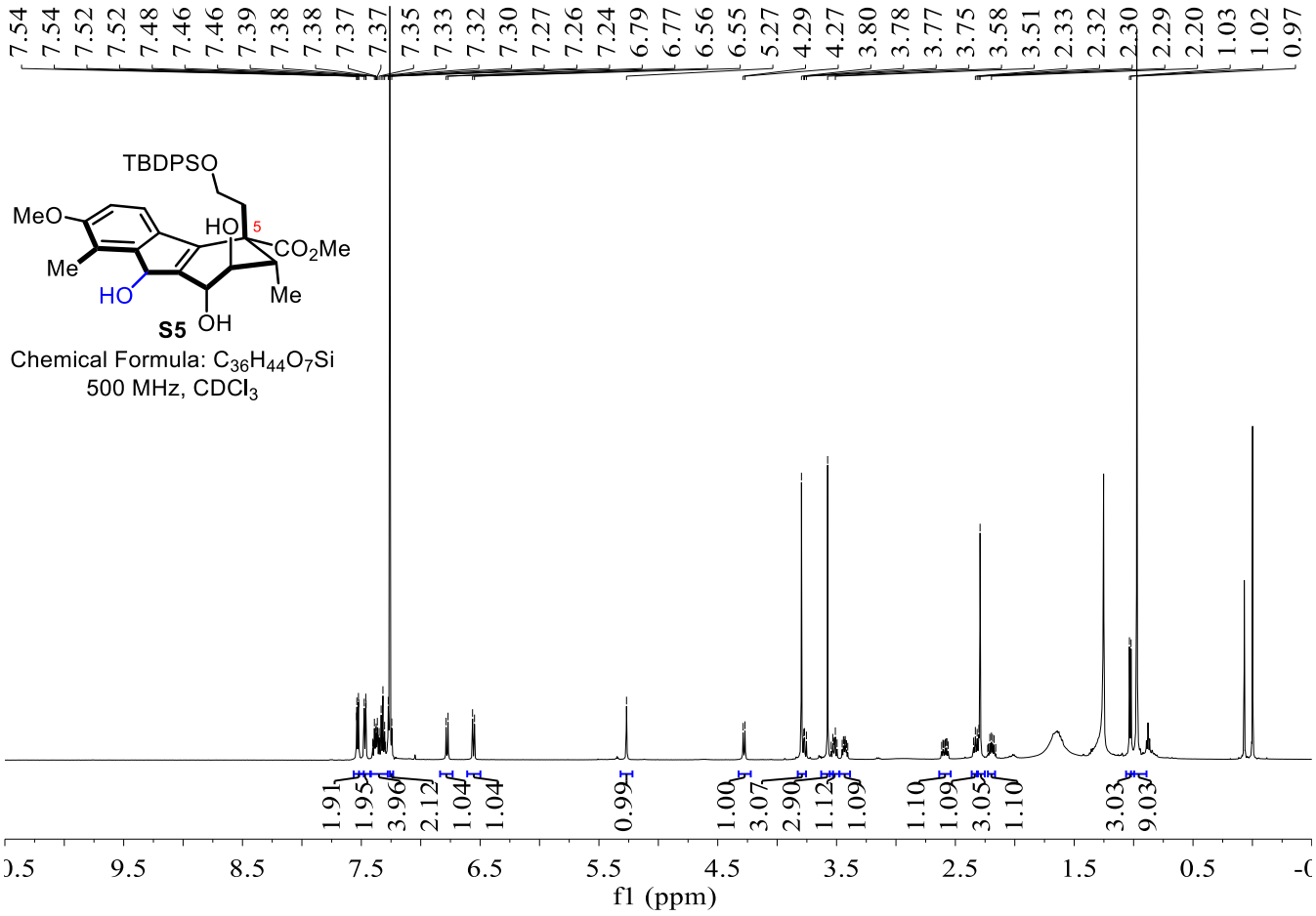

TBDPSO
MeO
Me
Me
MeO
O
Me
CO2Me
Me
OMe
O
O
S4
Chemical Formula: C42H52O9Si
125 MHz, CDCl3
f1 (ppm)

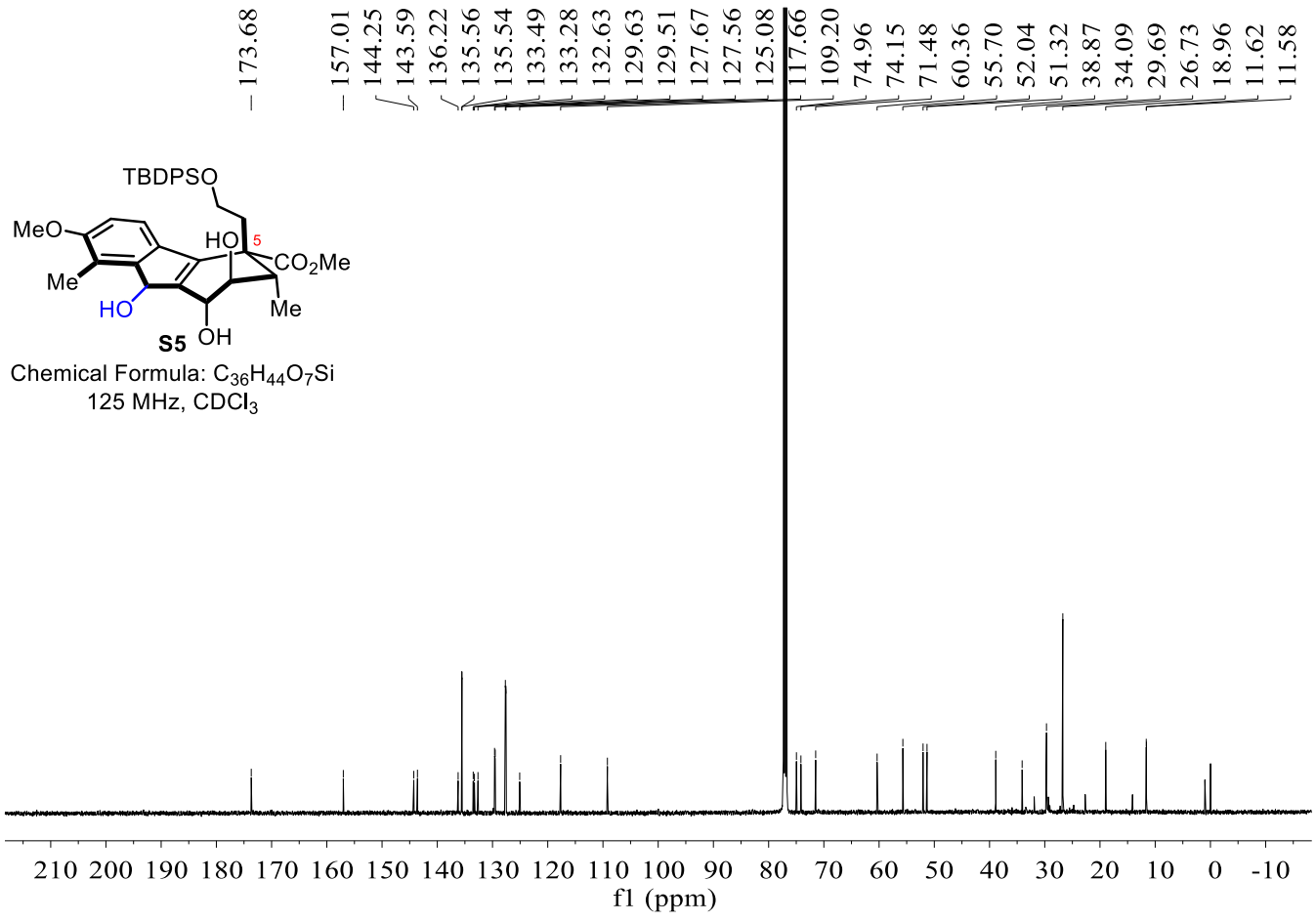


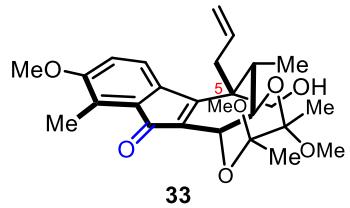
Chemical Formula: $C_{36}H_{42}O_7Si$
500 MHz, $CDCl_3$



Chemical Formula: $C_{36}H_{42}O_7Si$
500 MHz, $CDCl_3$


7.54 7.54 7.52 7.52 7.48 7.46 7.46 7.39 7.38 7.38 7.37 7.37 7.35 7.33 7.32 7.30 7.27 7.26 7.24 6.79 6.77 6.56 6.55 5.27 4.29 4.27 3.80 3.78 3.77 3.75 3.58 3.51 2.33 2.32 2.30 2.29 2.20 1.03 1.02 0.97
TBDPSO
MeO
HO
5
CO2Me
Me
HO
Me
OH
S5
Chemical Formula: C36H44O7Si
500 MHz, CDCl3
1.91 1.95 3.96 2.12 1.04 1.04 0.99 1.00 3.07 2.90 1.12 1.09 1.10 1.09 3.05 1.10 3.03 9.03
9.5 8.5 7.5 6.5 5.5 4.5 3.5 2.5 1.5 0.5
f1 (ppm)


173.68 157.01 144.25 143.59 136.22 135.56 135.54 133.49 133.28 132.63 129.63 129.51 127.67 127.56 125.08 117.66 109.20 74.96 74.15 71.48 60.36 55.70 52.04 51.32 38.87 34.09 29.69 26.73 18.96 11.62 11.58
TBDPSO
MeO
HO
5
CO2Me
Me
HO
Me
OH
S5
Chemical Formula: C36H44O7Si
125 MHz, CDCl3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

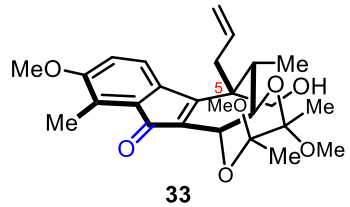


33

Chemical Formula: $C_{26}H_{34}O_7$

400 MHz, $CDCl_3$

f1 (ppm)

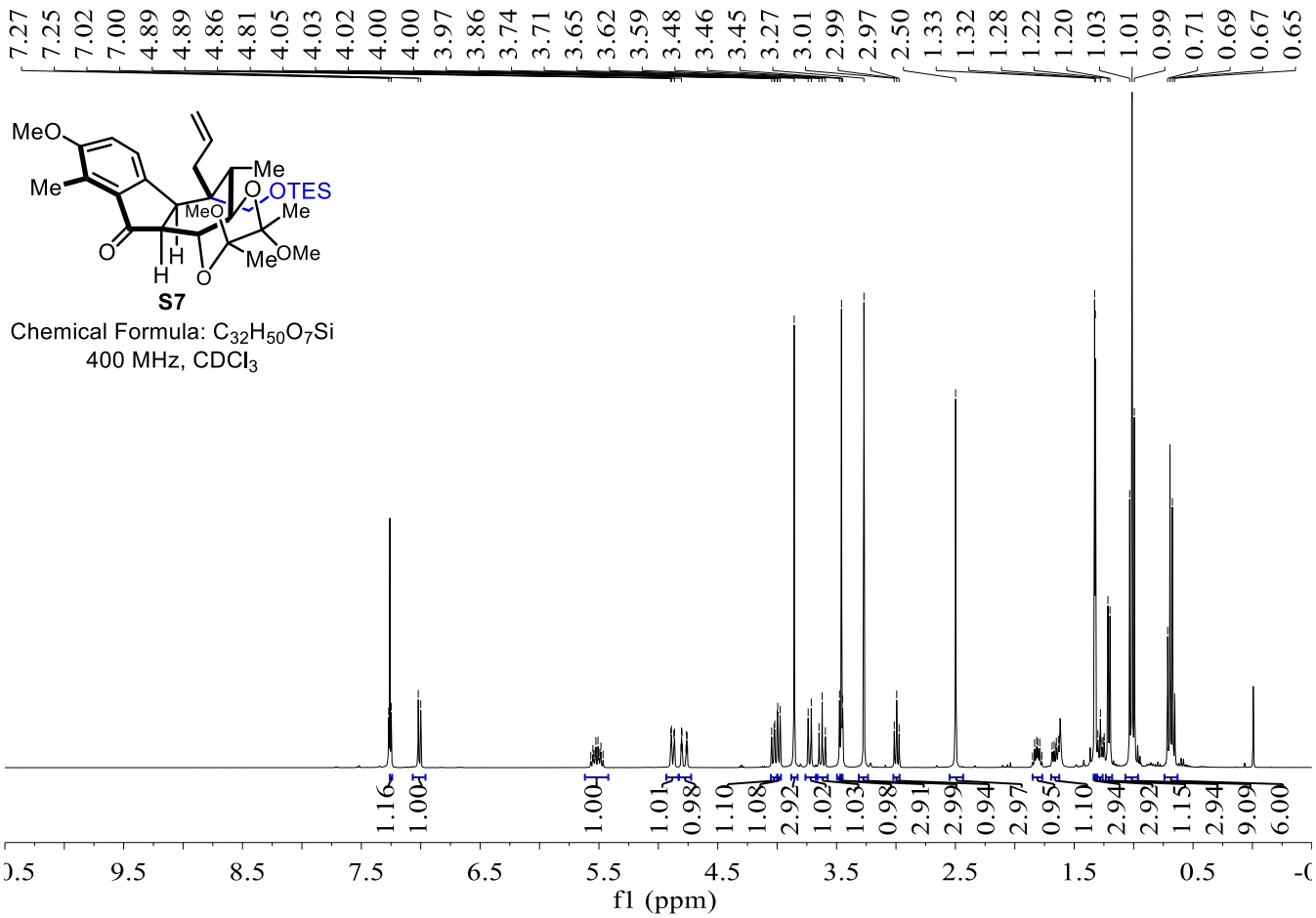


33

Chemical Formula: $C_{26}H_{34}O_7$

101 MHz, $CDCl_3$

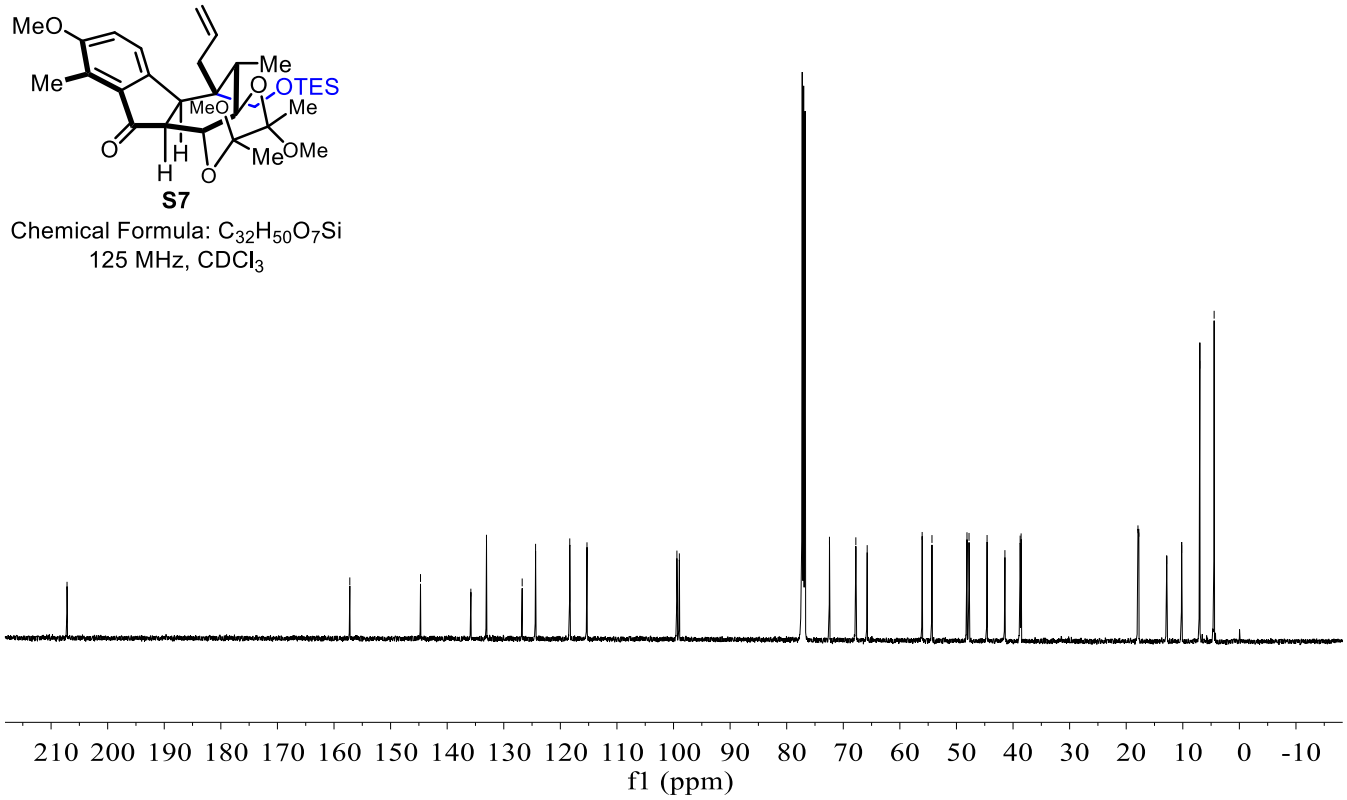
f1 (ppm)



S7

Chemical Formula: $C_{32}H_{50}O_7Si$

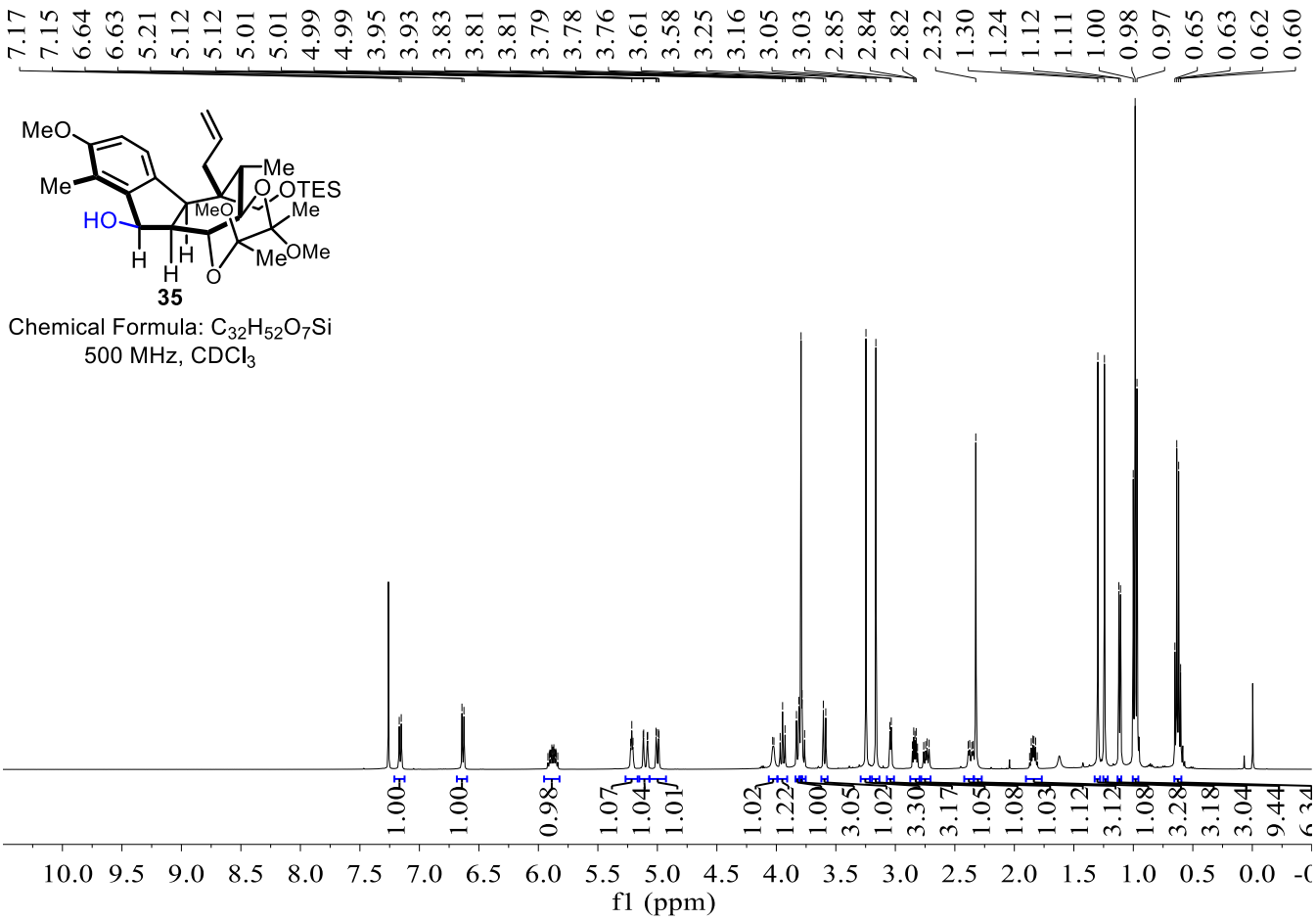
400 MHz, $CDCl_3$



S7

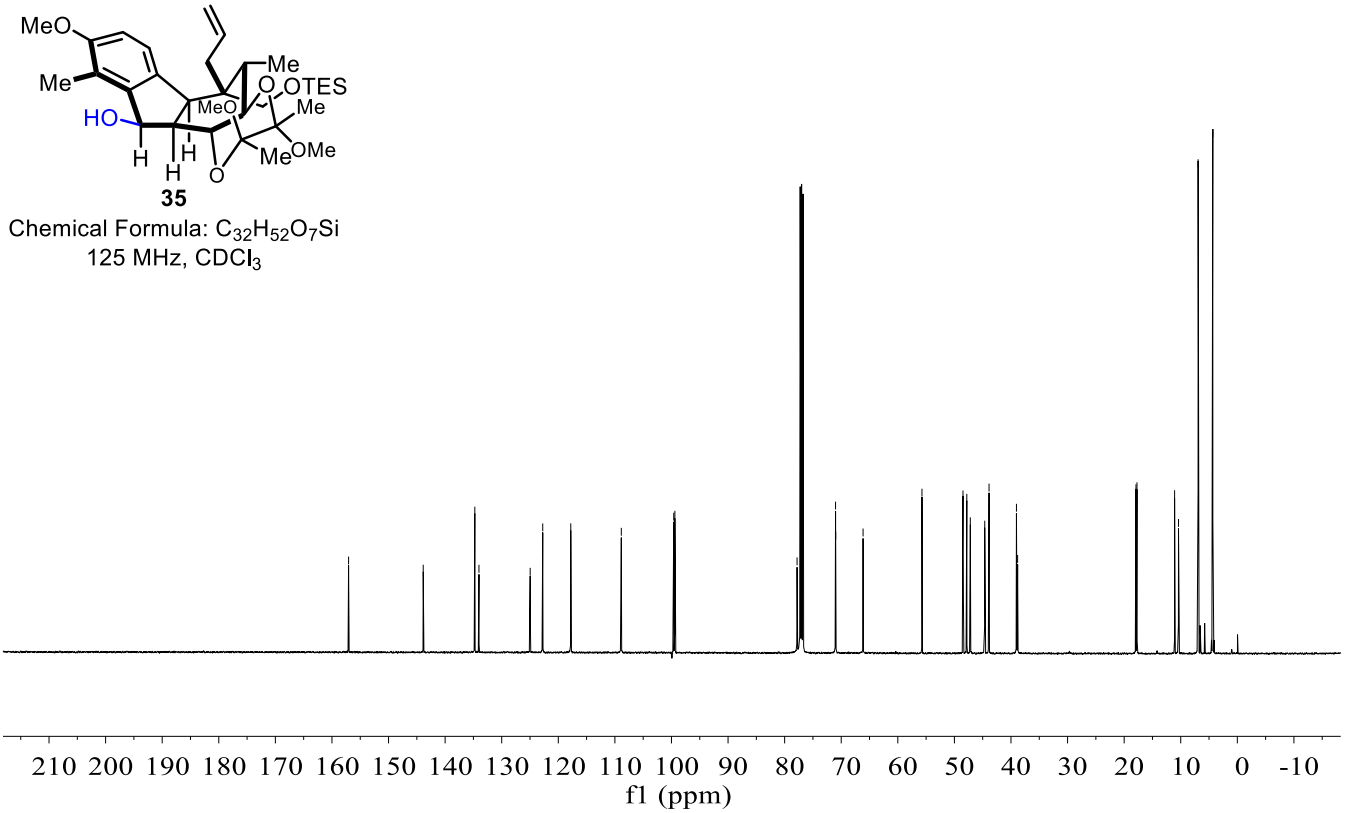
Chemical Formula: $C_{32}H_{50}O_7Si$

125 MHz, $CDCl_3$



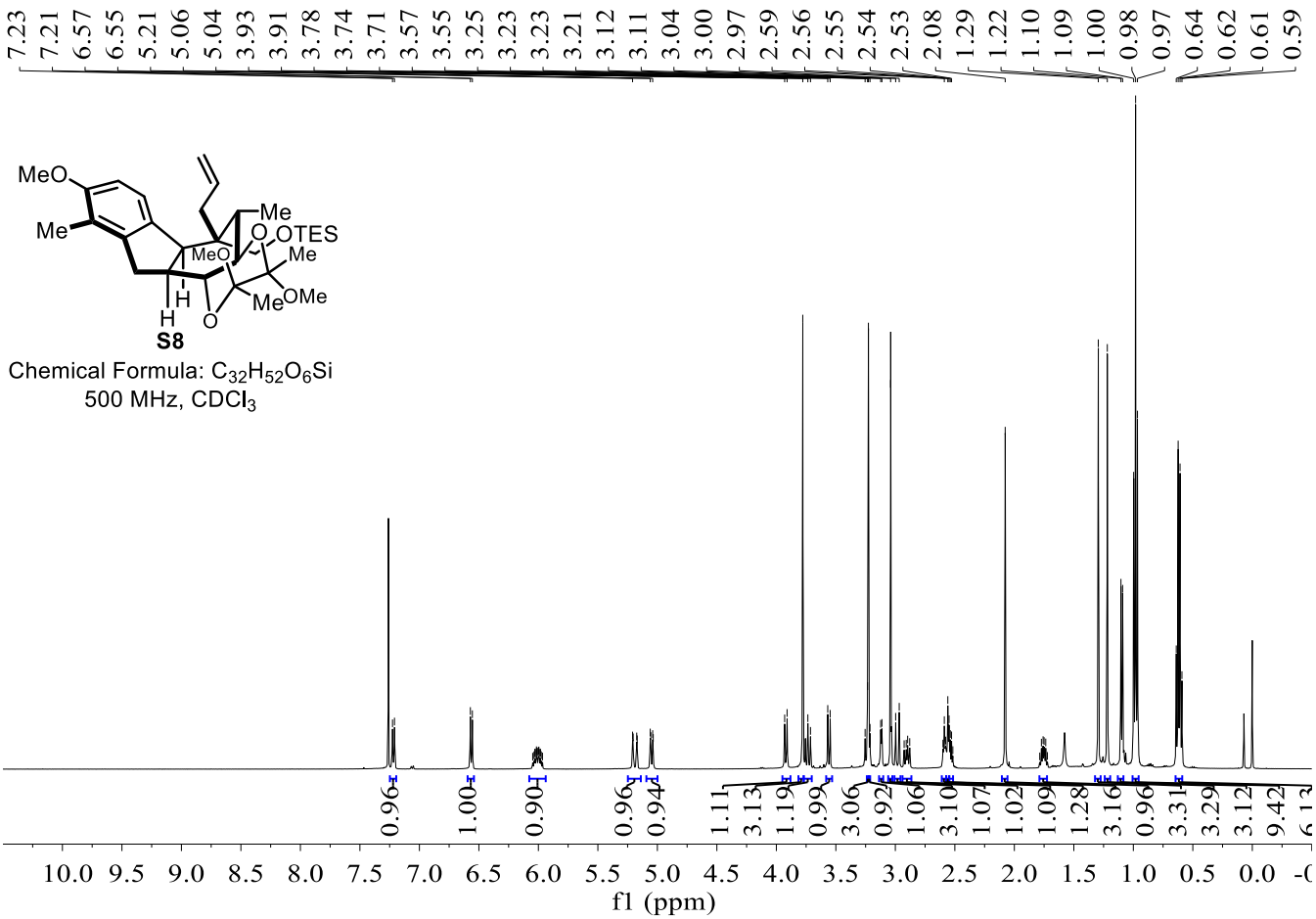
Chemical Formula: $C_{32}H_{52}O_7Si$

500 MHz, $CDCl_3$

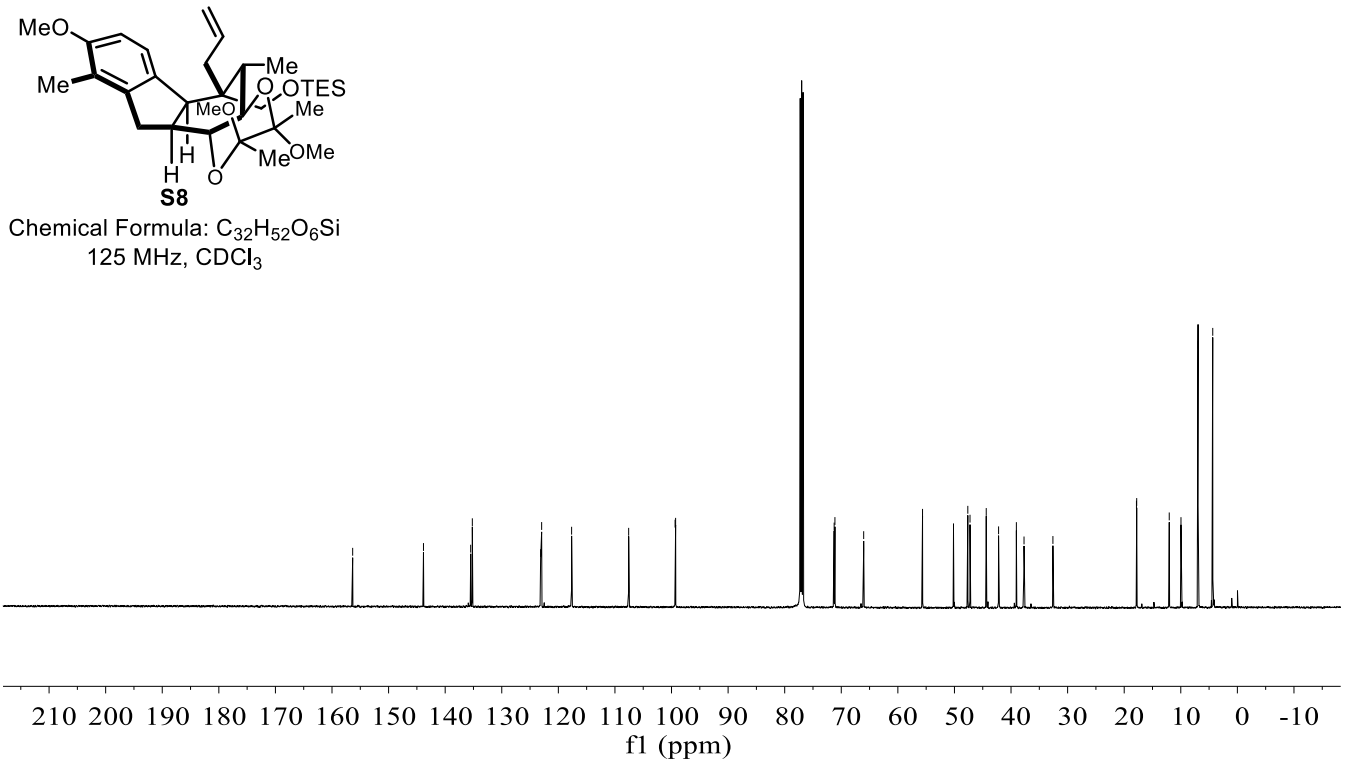


Chemical Formula: $C_{32}H_{52}O_7Si$

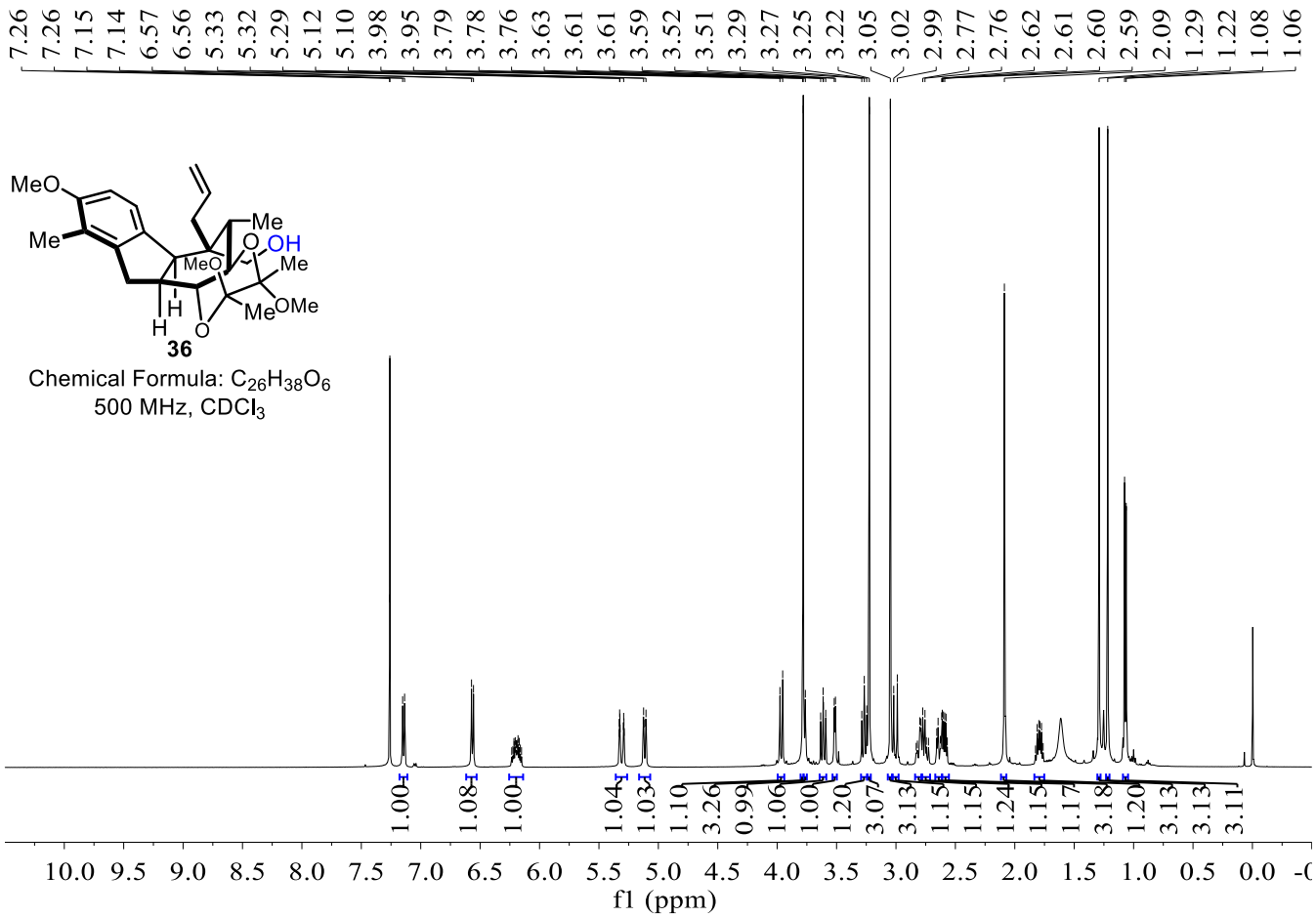
125 MHz, $CDCl_3$

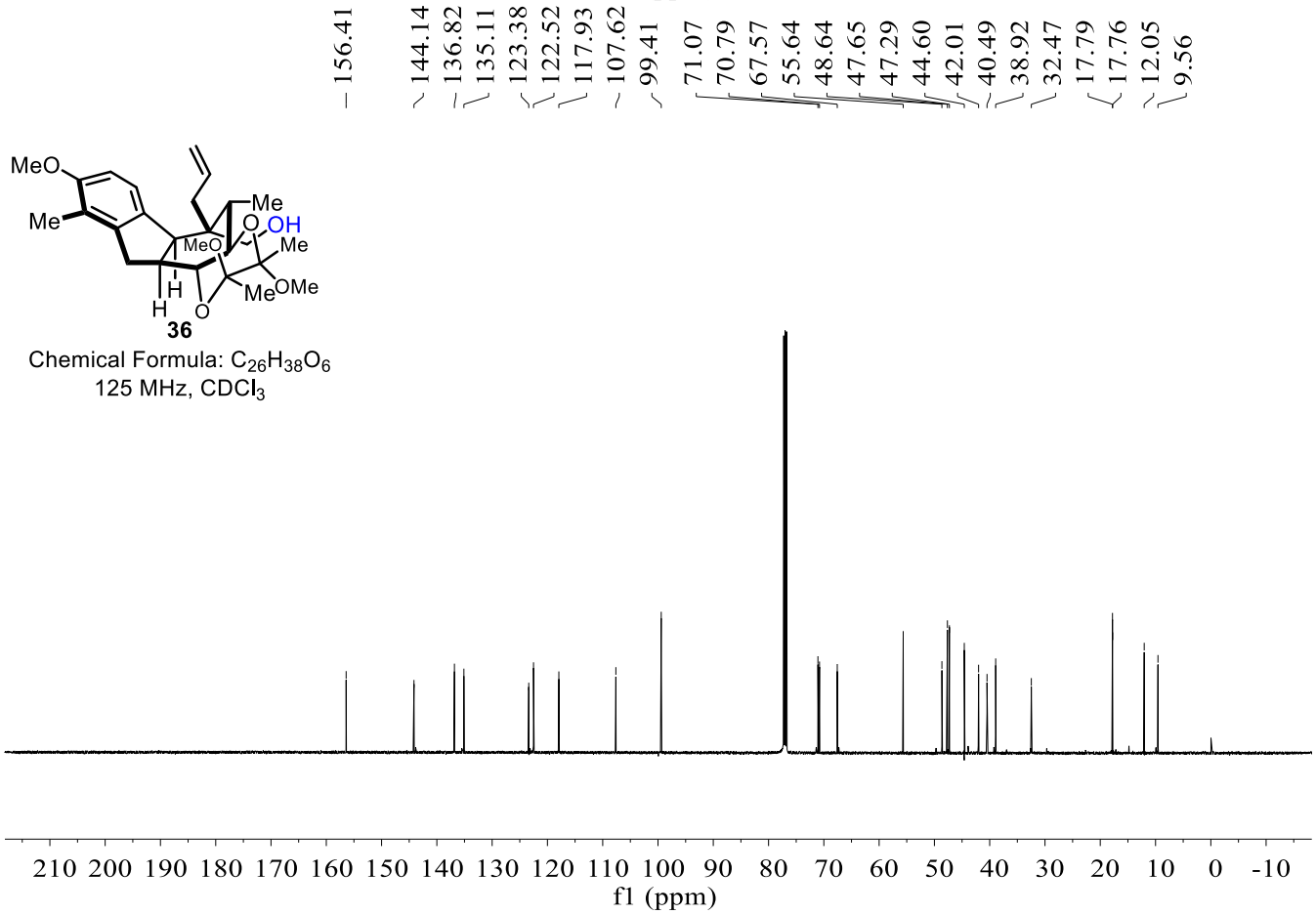


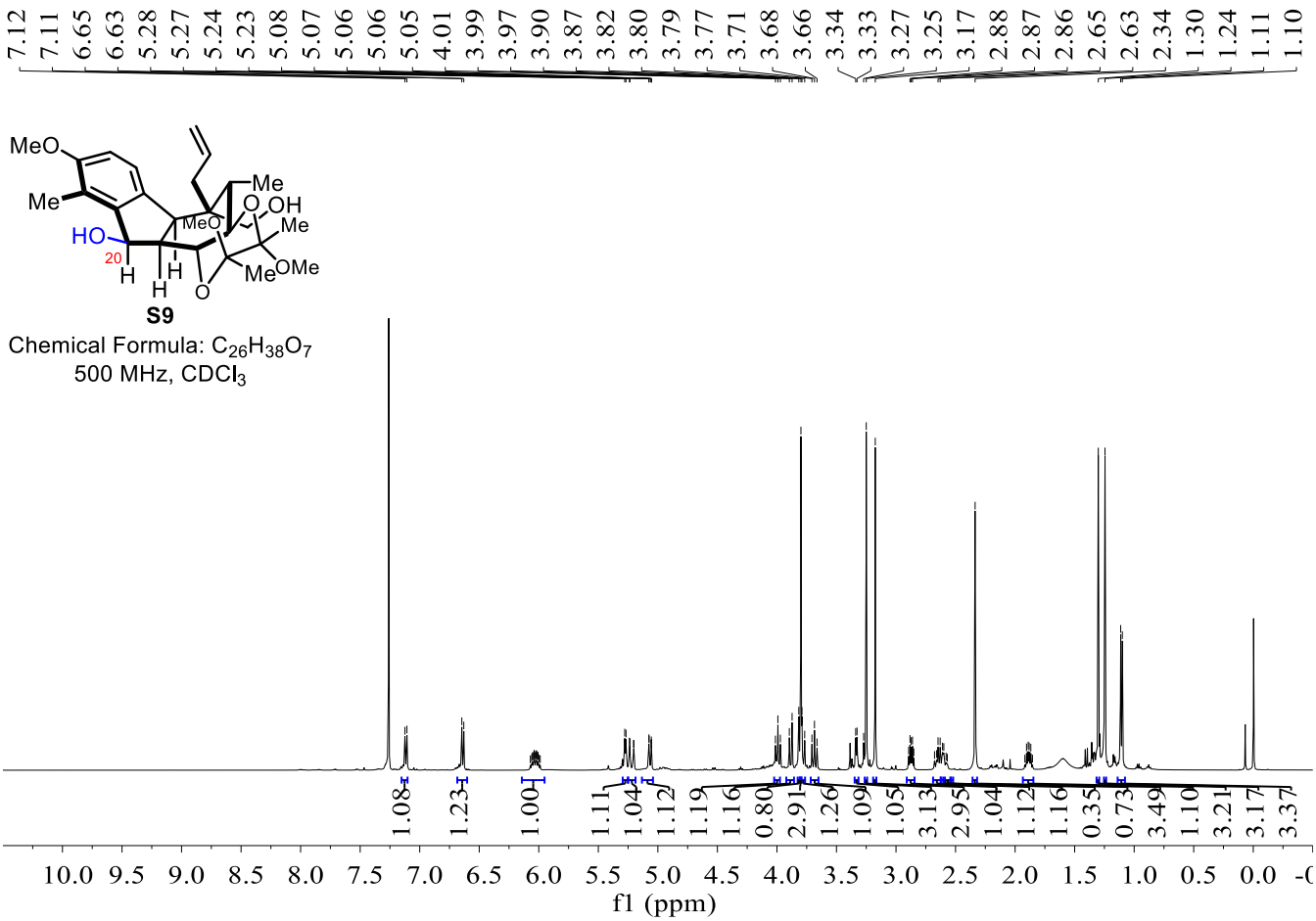
Chemical Formula: $C_{32}H_{52}O_6Si$
500 MHz, $CDCl_3$

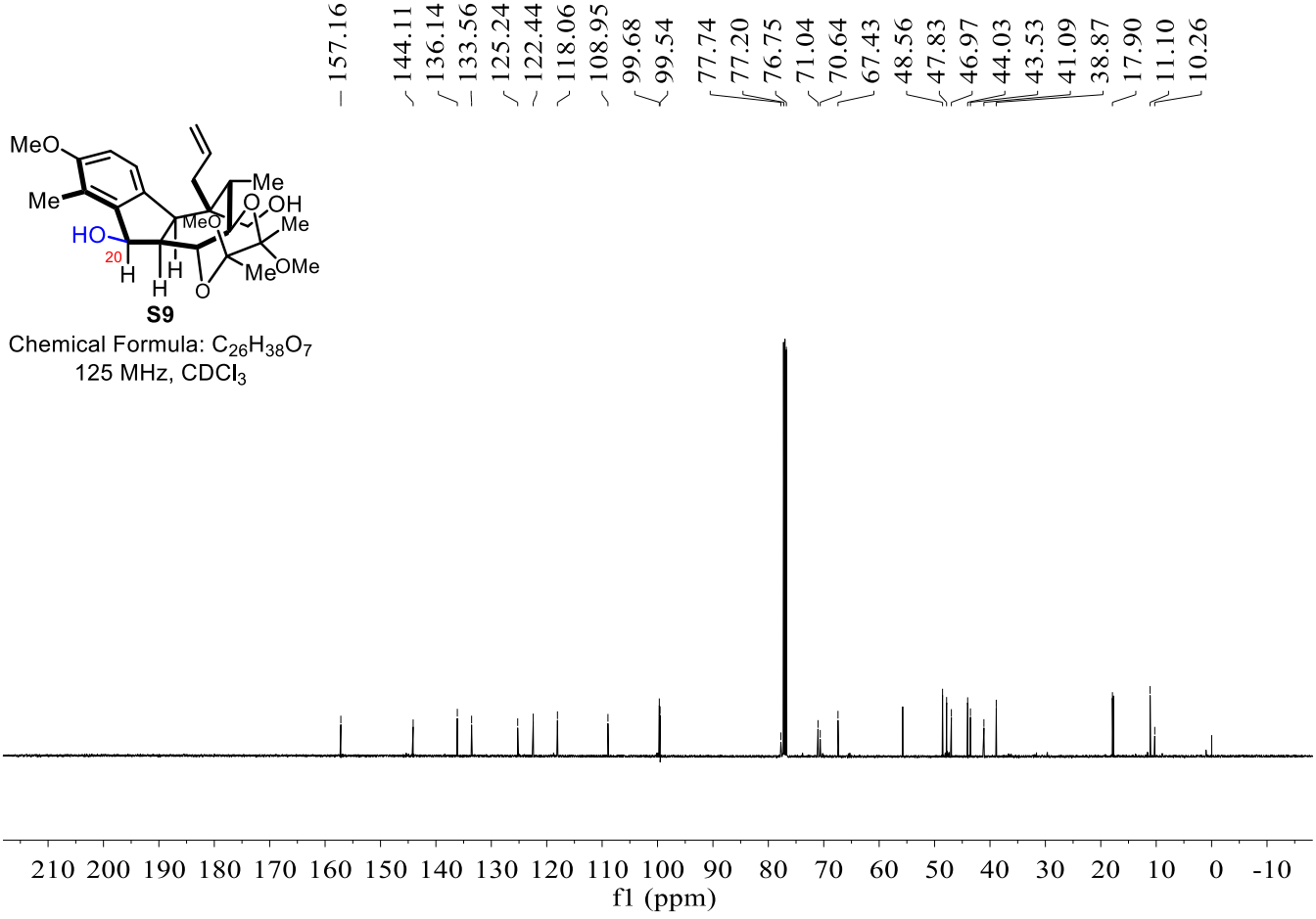


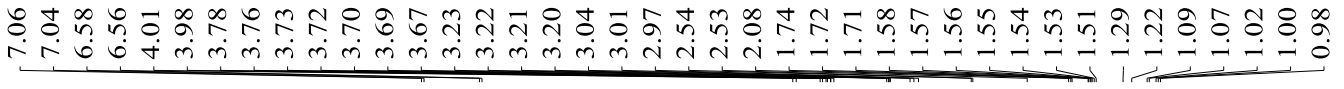
Chemical Formula: $C_{32}H_{52}O_6Si$
125 MHz, $CDCl_3$

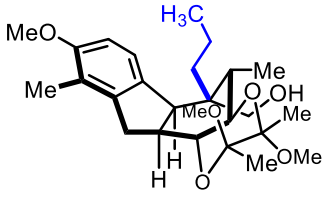

7.26 7.26 7.15 7.14 6.57 6.56 5.33 5.32 5.29 5.12 5.10 3.98 3.95 3.79 3.78 3.76 3.63 3.61 3.61 3.59 3.52 3.51 3.29 3.27 3.25 3.22 3.05 3.02 2.99 2.77 2.76 2.62 2.61 2.60 2.59 2.09 1.29 1.22 1.08 1.06
MeO
Me
Me
O
OH
Me
MeO
H
O
Me
OMe
36
Chemical Formula: C26H38O6
500 MHz, CDCl3
1.00 1.08 1.00 1.04 1.03 1.10 3.26 0.99 1.06 1.00 1.20 3.07 3.13 1.15 1.15 1.24 1.15 1.17 3.18 1.20 3.13 3.13 3.11
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


156.41 144.14 136.82 135.11 123.38 122.52 117.93 107.62 99.41 71.07 70.79 67.57 55.64 48.64 47.65 47.29 44.60 42.01 40.49 38.92 32.47 17.79 17.76 12.05 9.56
MeO
Me
Me
O
OH
Me
MeO
H
O
Me
OMe
36
Chemical Formula: C26H38O6
125 MHz, CDCl3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


7.12 7.11 6.65 6.63 5.28 5.27 5.24 5.23 5.08 5.07 5.06 5.06 5.05 4.01 3.99 3.97 3.90 3.87 3.82 3.80 3.79 3.77 3.71 3.68 3.66 3.34 3.33 3.27 3.25 3.17 2.88 2.87 2.86 2.65 2.63 2.34 1.30 1.24 1.11 1.10
MeO
Me
HO
20
H
H
H
O
MeO
Me
O
OH
Me
Me
OMe
S9
Chemical Formula: C26H38O7
500 MHz, CDCl3
1.08 1.23 1.00 1.11 1.04 1.12 1.19 1.16 0.80 2.91 1.26 1.09 1.05 3.13 2.95 1.04 1.12 1.16 0.35 0.73 3.49 1.10 3.21 3.17 3.37
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


157.16 144.11 136.14 133.56 125.24 122.44 118.06 108.95 99.68 99.54 77.74 77.20 76.75 71.04 70.64 67.43 48.56 47.83 46.97 44.03 43.53 41.09 38.87 17.90 11.10 10.26
MeO
Me
HO
20
H
H
H
O
MeO
Me
O
OH
Me
Me
OMe
S9
Chemical Formula: C26H38O7
125 MHz, CDCl3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

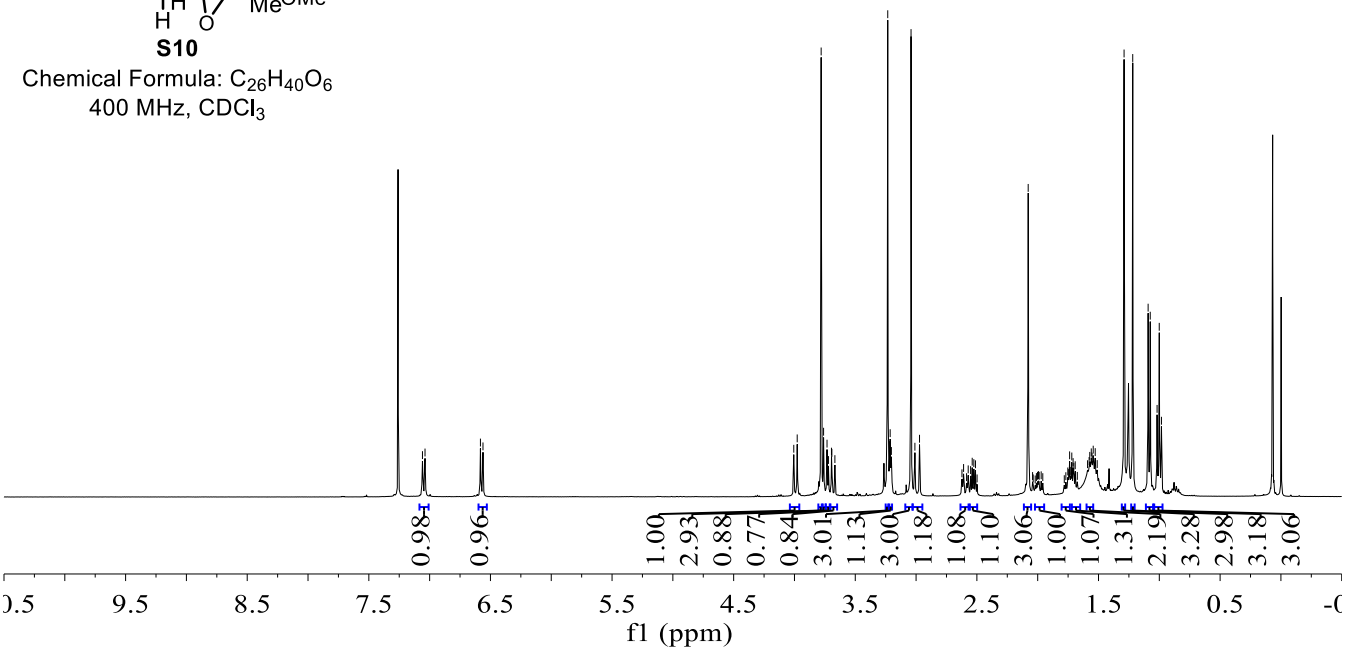


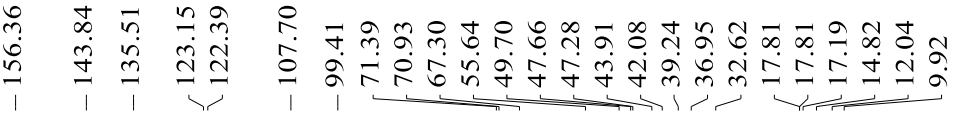


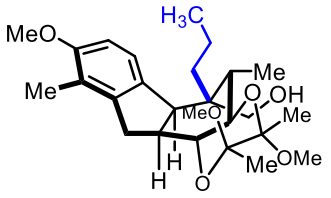
S10

Chemical Formula: $C_{26}H_{40}O_6$

400 MHz, $CDCl_3$



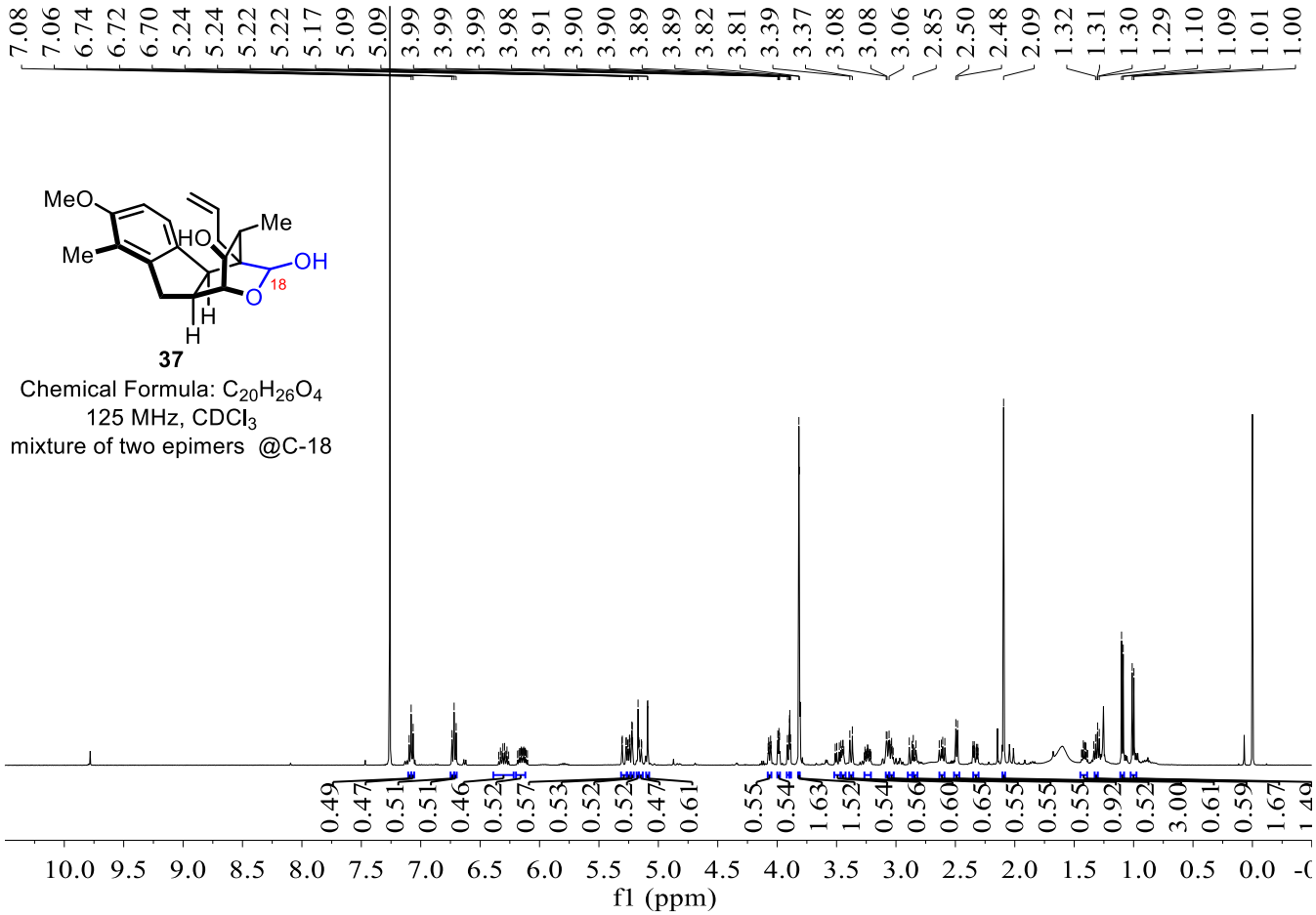




S10

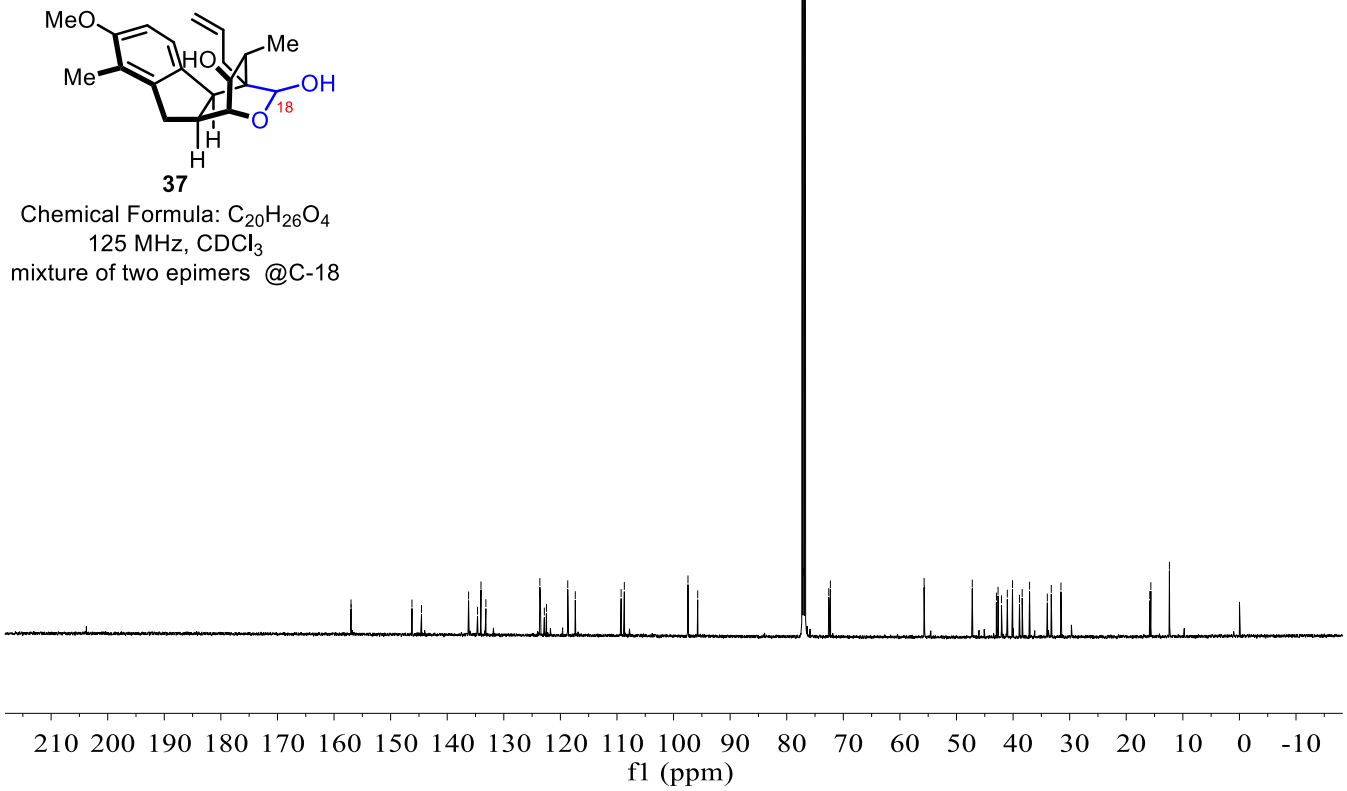
Chemical Formula: $C_{26}H_{40}O_6$

125 MHz, $CDCl_3$



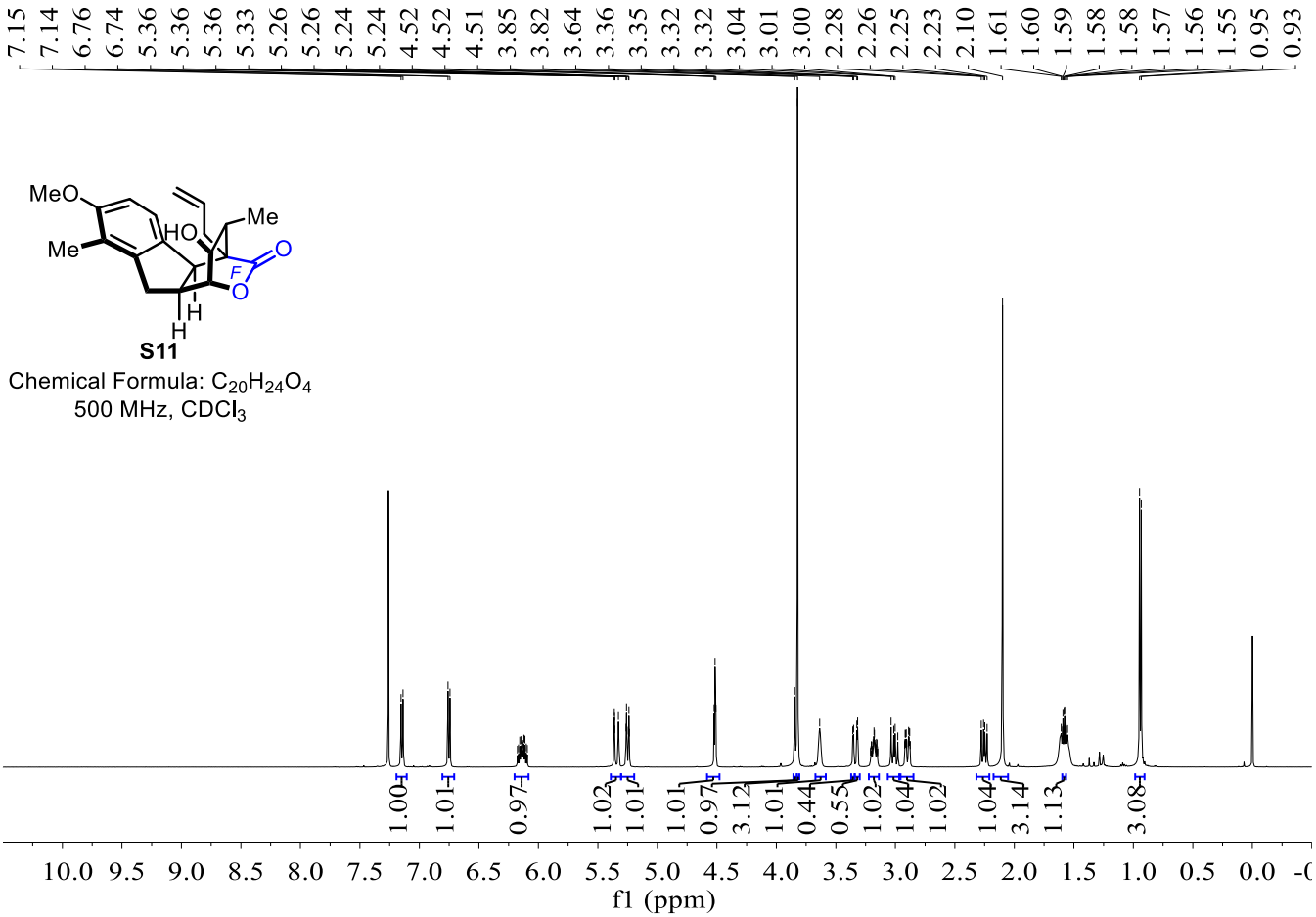
37

Chemical Formula: $C_{20}H_{26}O_4$
125 MHz, $CDCl_3$
mixture of two epimers @C-18



37

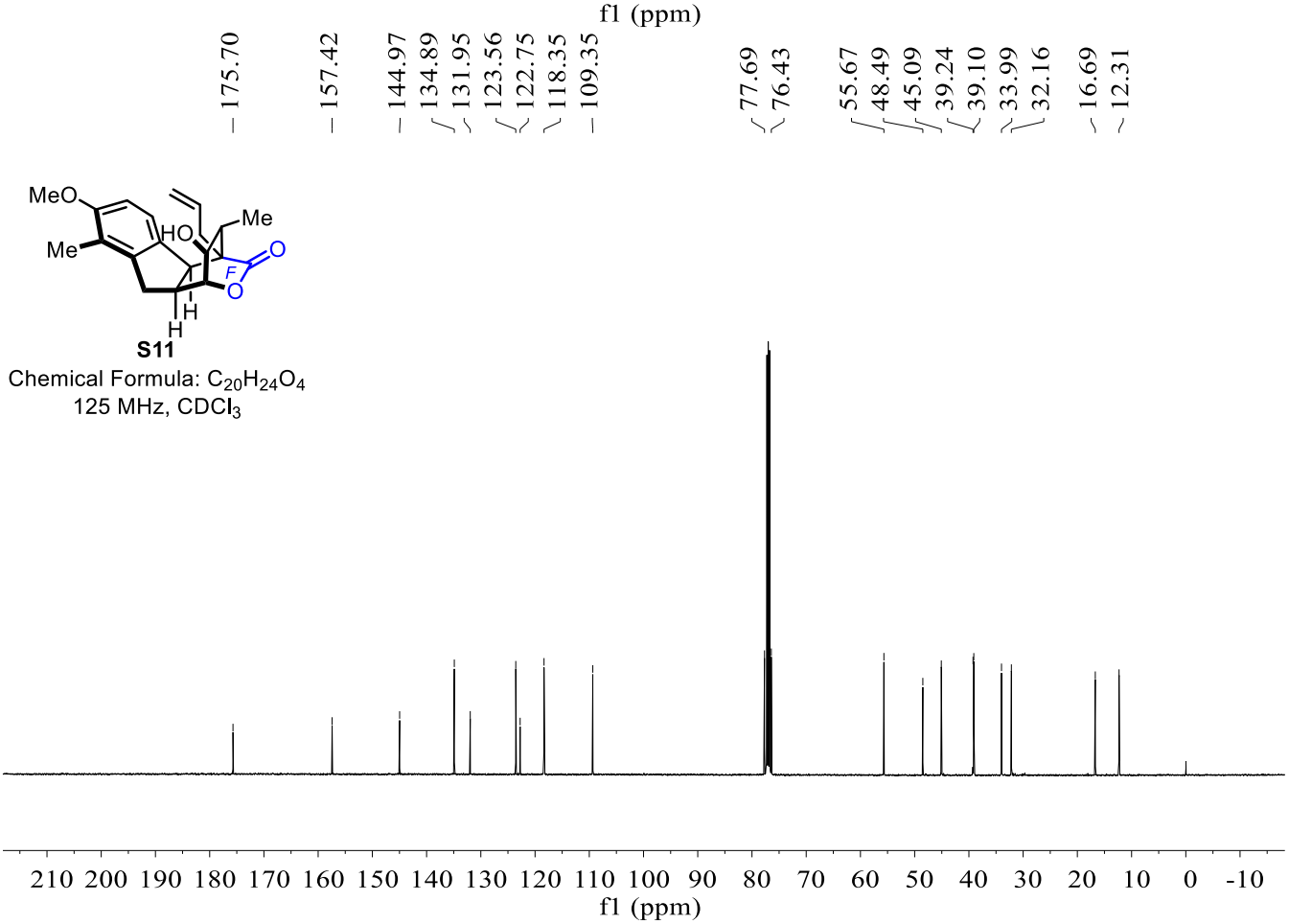
Chemical Formula: $C_{20}H_{26}O_4$
125 MHz, $CDCl_3$
mixture of two epimers @C-18



S11

Chemical Formula: $C_{20}H_{24}O_4$

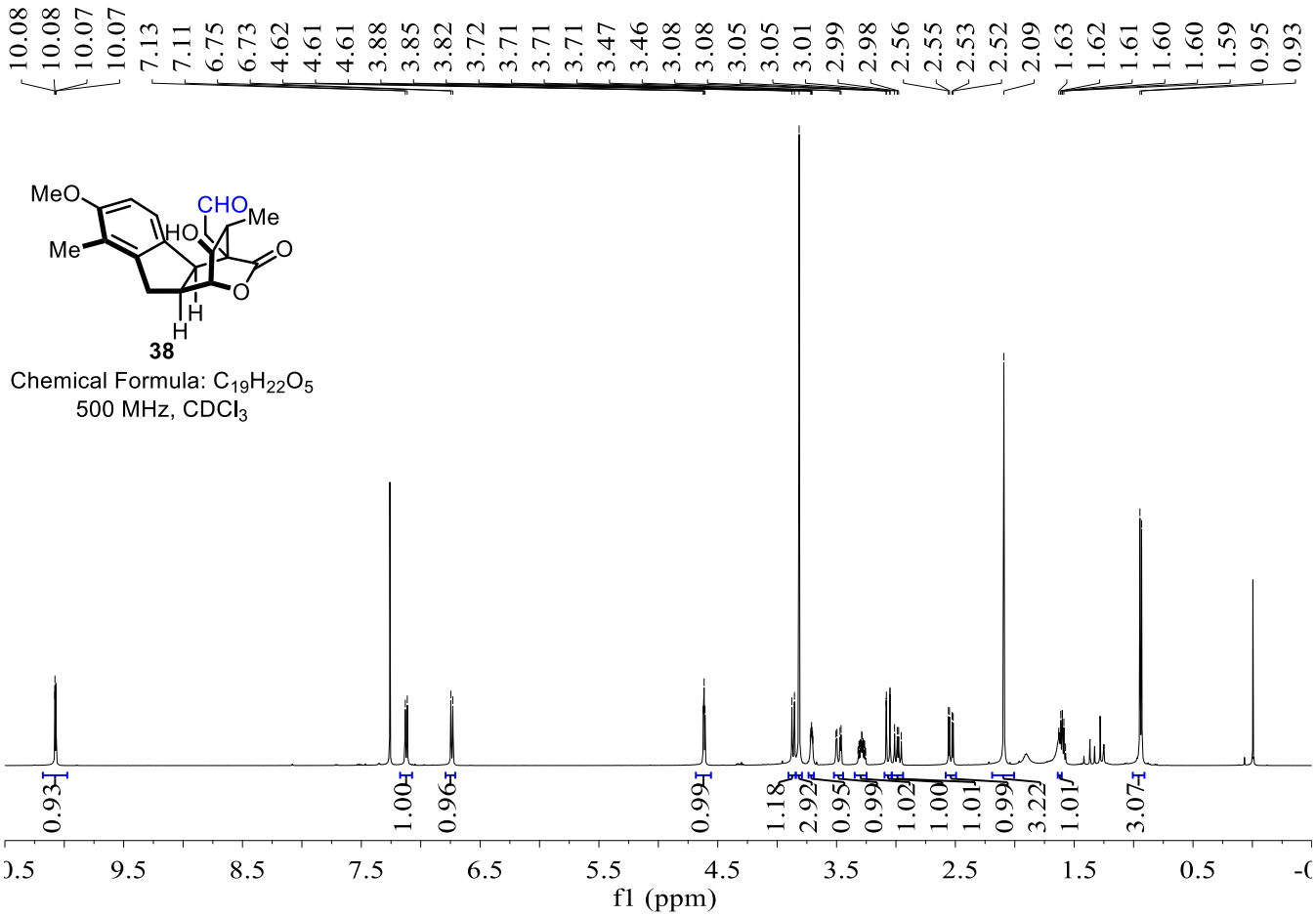
500 MHz, $CDCl_3$

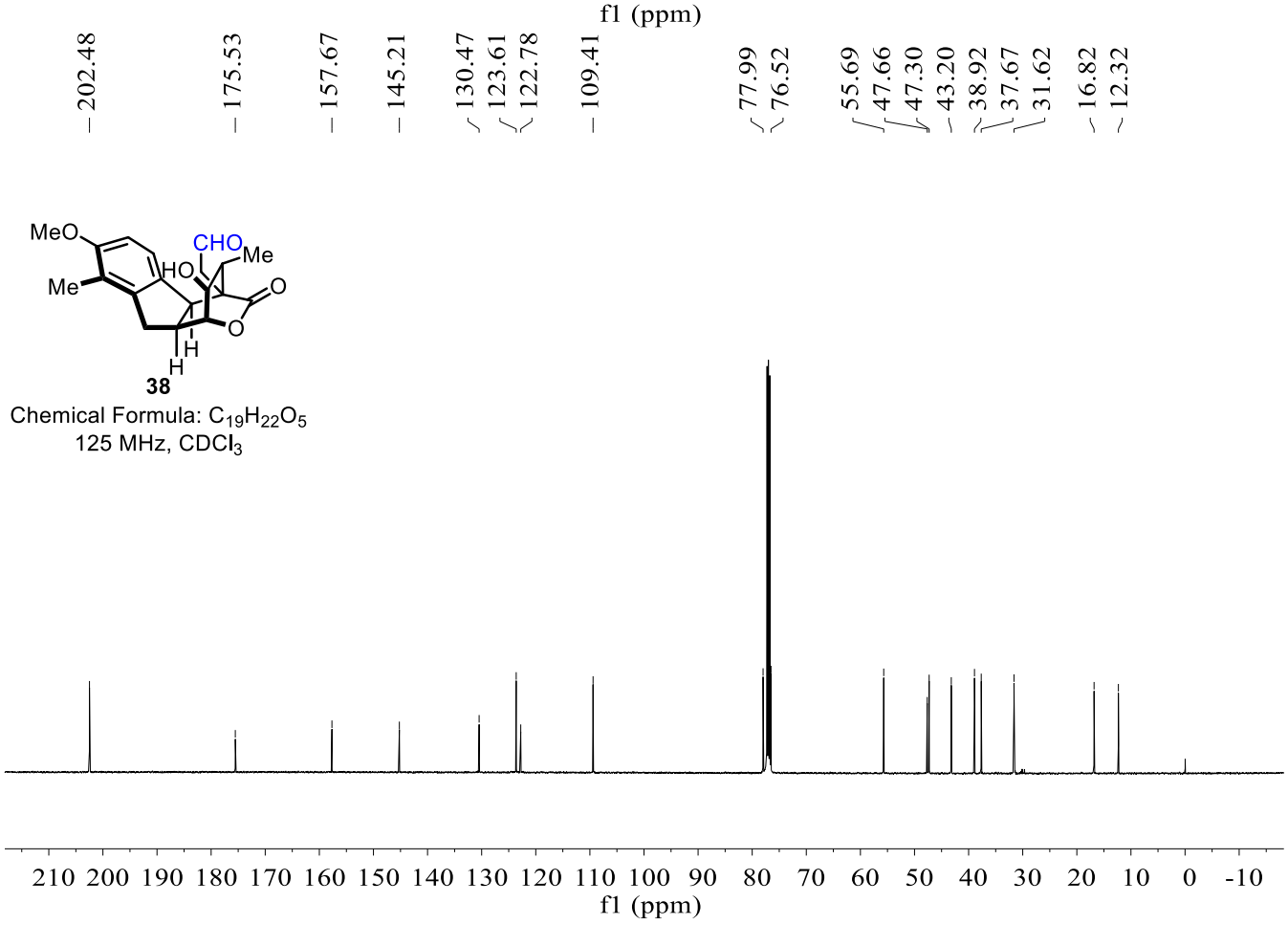


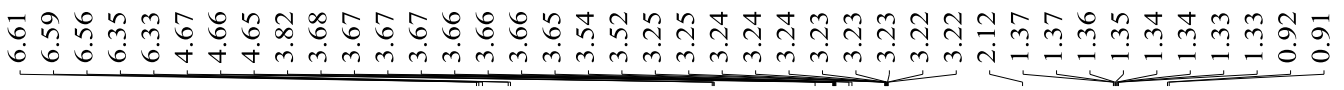
S11

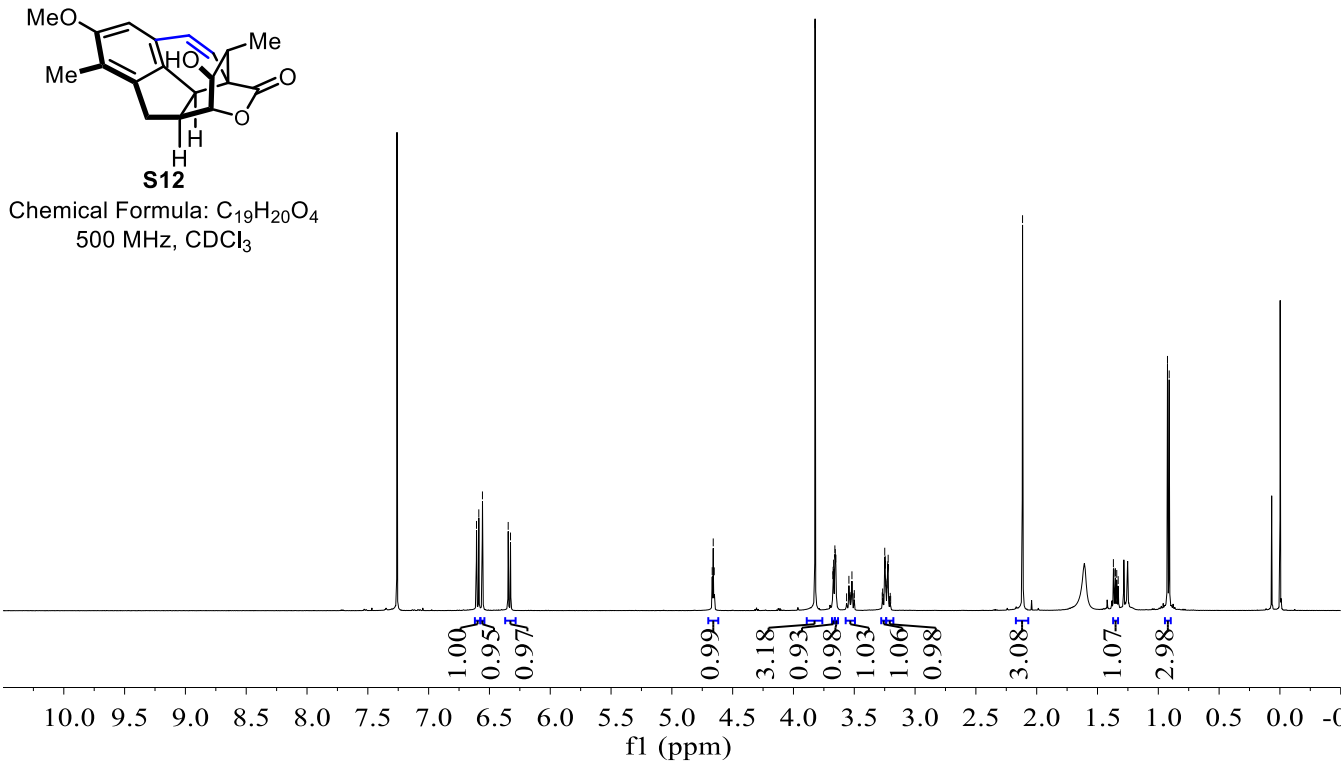
Chemical Formula: $C_{20}H_{24}O_4$

125 MHz, $CDCl_3$


10.08 10.08 10.07 10.07 7.13 7.11 6.75 6.73 4.62 4.61 4.61 3.88 3.85 3.82 3.72 3.71 3.71 3.71 3.47 3.46 3.08 3.08 3.05 3.05 3.01 2.99 2.98 2.56 2.55 2.53 2.52 2.09 1.63 1.62 1.61 1.60 1.60 1.59 0.95 0.93
MeO
CHO
Me
HO
Me
O
O
H
H
38
Chemical Formula: C19H22O5
500 MHz, CDCl3
0.93 1.00 0.96 0.99 1.18 2.92 0.95 0.99 1.02 1.00 1.01 0.99 3.22 1.01 3.07
f1 (ppm)


202.48 175.53 157.67 145.21 130.47 123.61 122.78 109.41 77.99 76.52 55.69 47.66 47.30 43.20 38.92 37.67 31.62 16.82 12.32
MeO
CHO
Me
HO
Me
O
O
H
H
38
Chemical Formula: C19H22O5
125 MHz, CDCl3
f1 (ppm)

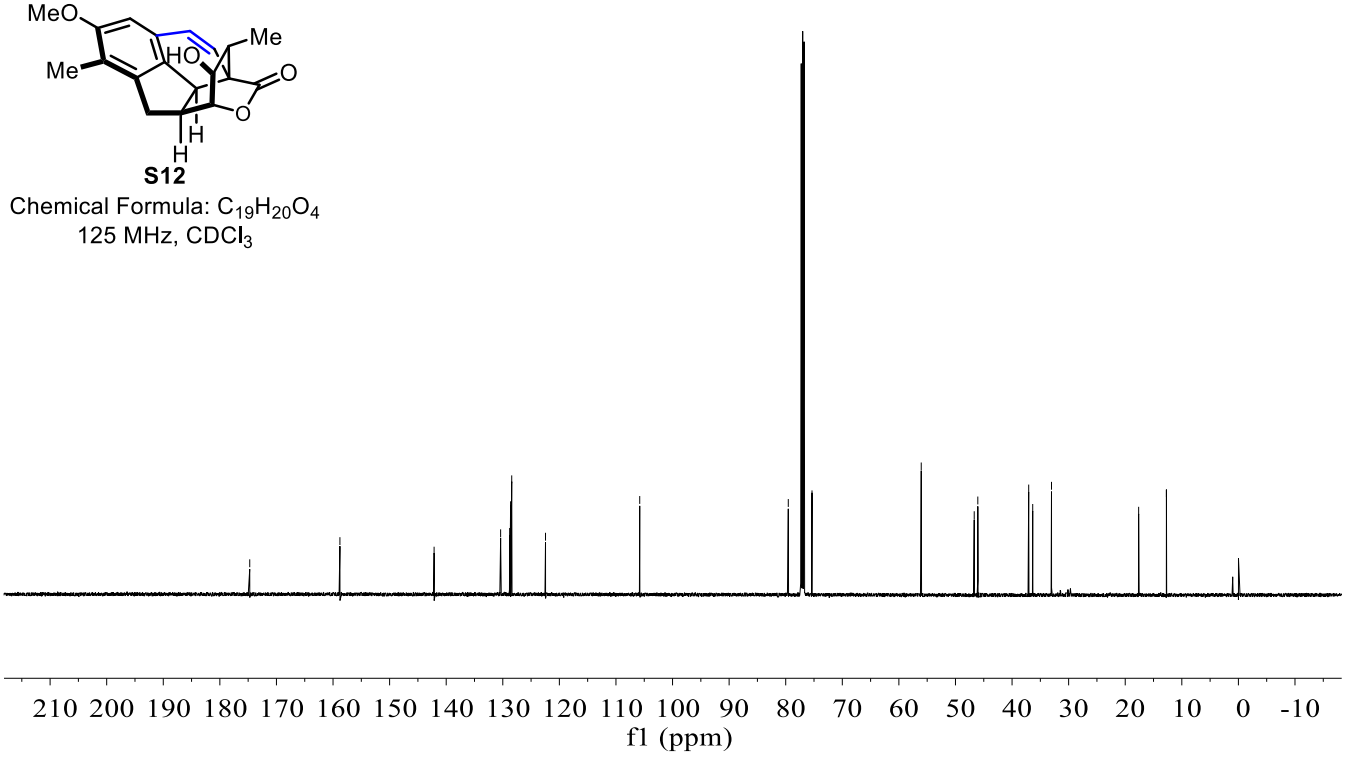




S12

Chemical Formula: $C_{19}H_{20}O_4$

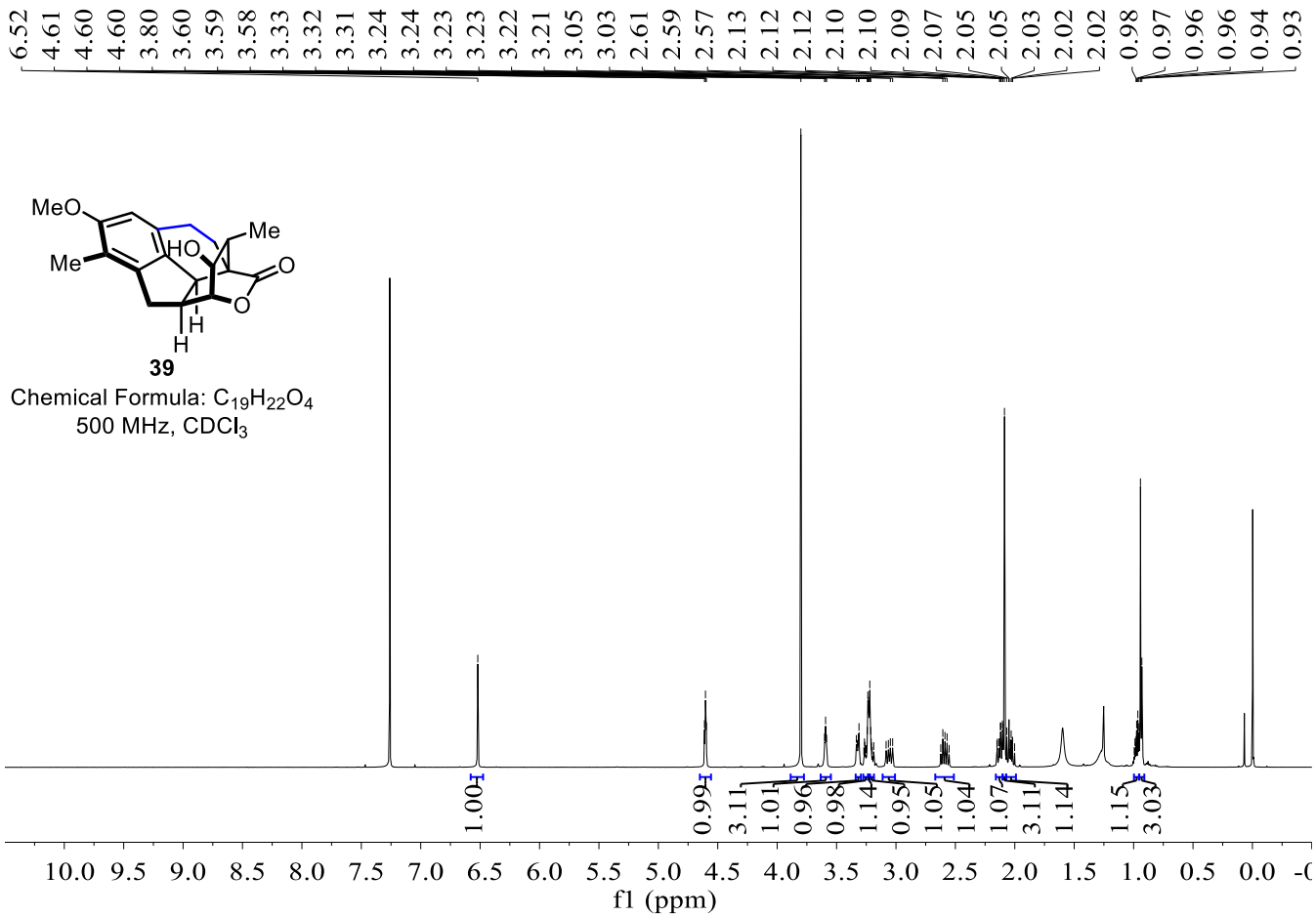
500 MHz, $CDCl_3$

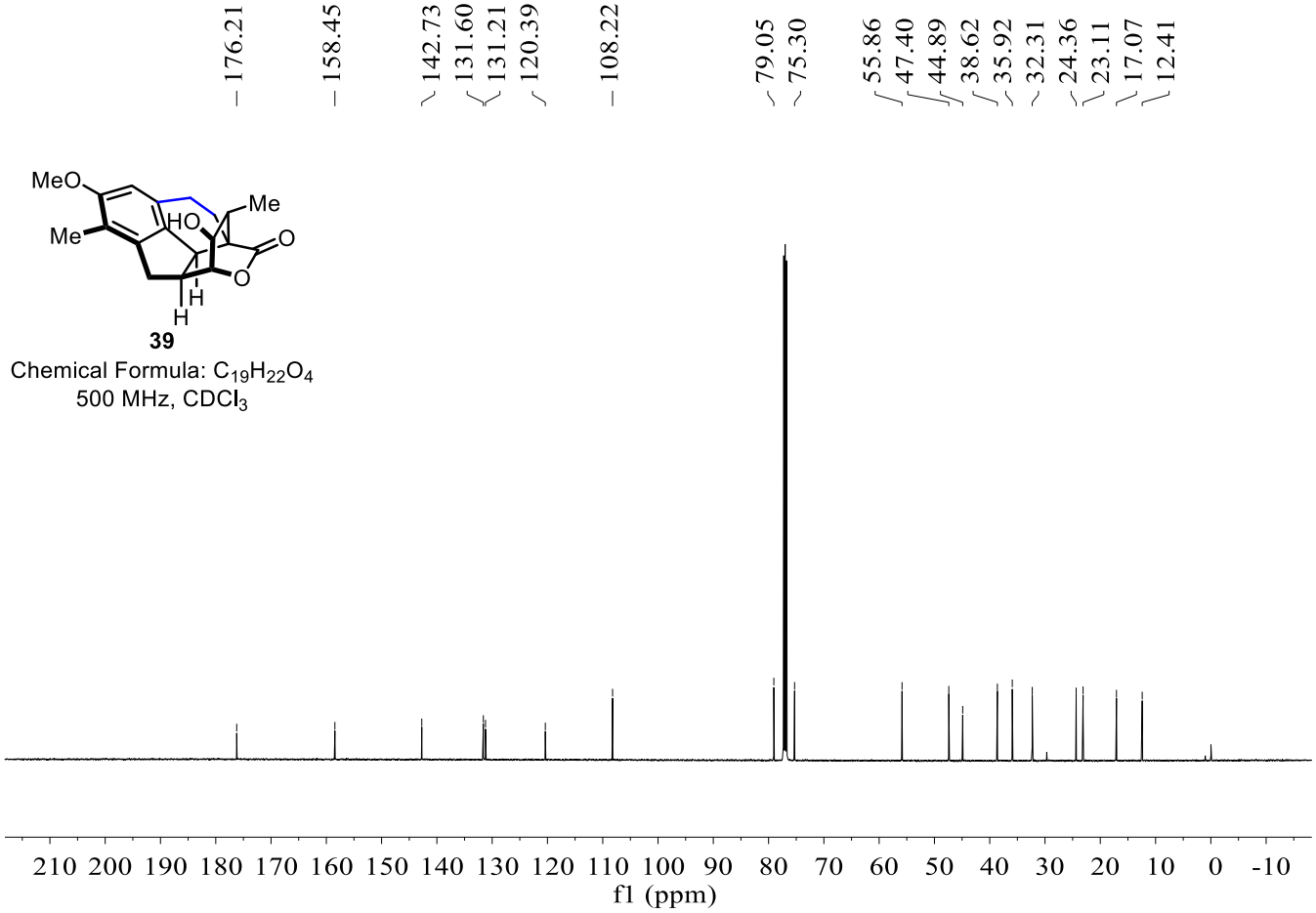


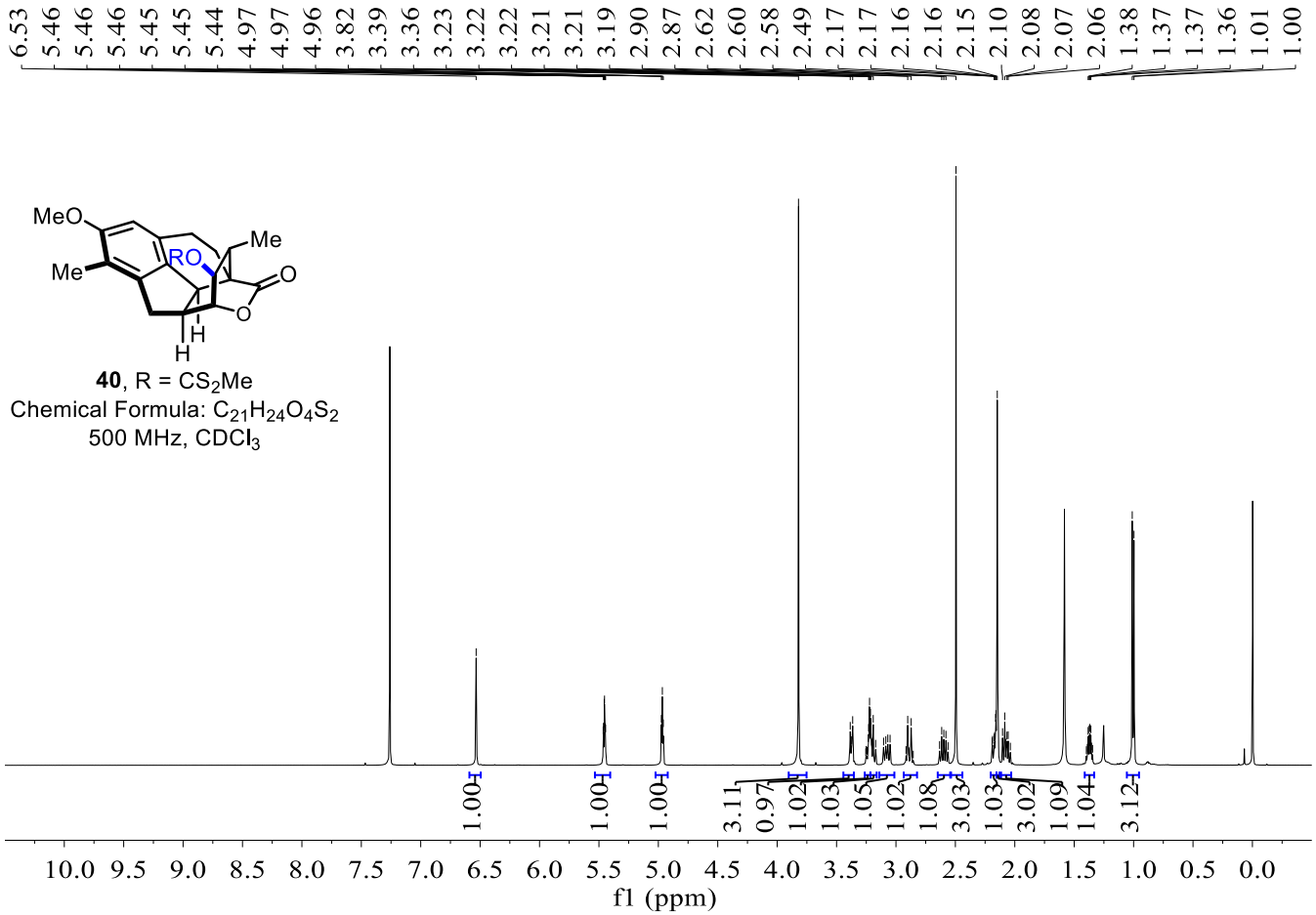
S12

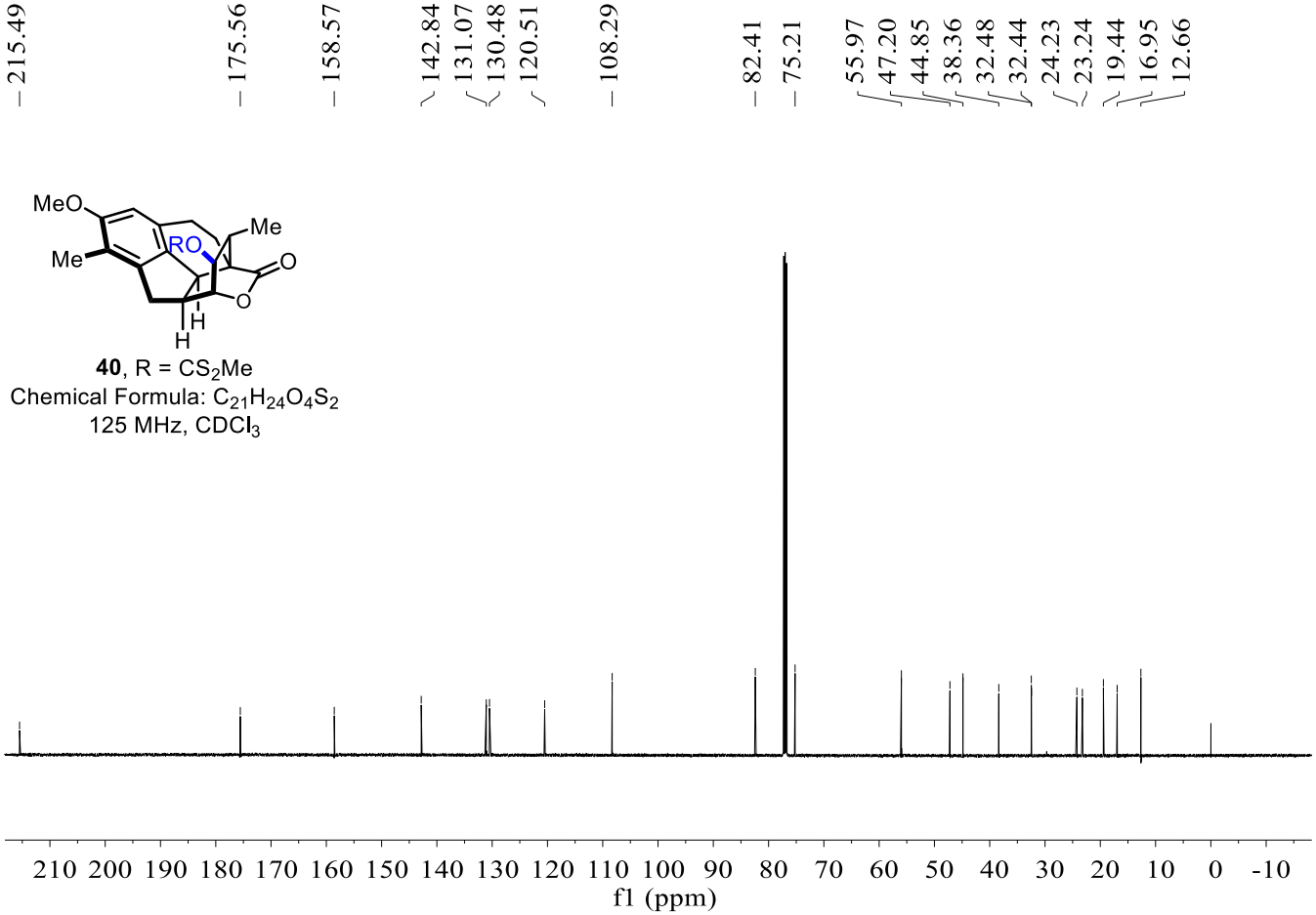
Chemical Formula: $C_{19}H_{20}O_4$

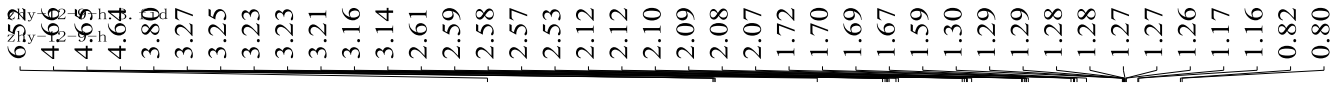
125 MHz, $CDCl_3$

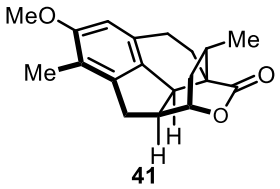

6.52 4.61 4.60 4.60 3.80 3.60 3.59 3.58 3.33 3.32 3.31 3.24 3.24 3.23 3.23 3.22 3.21 3.05 3.03 2.61 2.59 2.57 2.13 2.12 2.12 2.10 2.10 2.09 2.07 2.05 2.05 2.03 2.02 2.02 0.98 0.97 0.96 0.96 0.94 0.93
MeO
Me
HO
Me
O
O
H
H
39
Chemical Formula: C19H22O4
500 MHz, CDCl3
1.00 0.99 3.11 1.01 0.96 0.98 1.14 0.95 1.05 1.04 1.07 3.11 1.14 1.15 3.03
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


176.21 158.45 142.73 131.60 131.21 120.39 108.22 79.05 75.30 55.86 47.40 44.89 38.62 35.92 32.31 24.36 23.11 17.07 12.41
MeO
Me
HO
Me
O
O
H
H
39
Chemical Formula: C19H22O4
500 MHz, CDCl3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


6.53 5.46 5.46 5.46 5.45 5.45 5.44 4.97 4.97 4.96 3.82 3.39 3.36 3.23 3.22 3.22 3.21 3.21 3.19 2.90 2.87 2.62 2.60 2.58 2.49 2.17 2.17 2.16 2.16 2.15 2.10 2.08 2.07 2.06 1.38 1.37 1.37 1.36 1.01 1.00
MeO
Me
RO
Me
O
O
H
H
40, R = CS2Me
Chemical Formula: C21H24O4S2
500 MHz, CDCl3
1.00 1.00 1.00 3.11 0.97 1.02 1.03 1.05 1.02 1.08 3.03 1.03 3.02 1.09 1.04 3.12
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

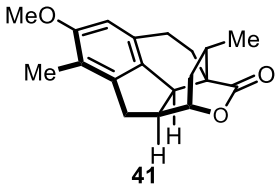

215.49 175.56 158.57 142.84 131.07 130.48 120.51 108.29 82.41 75.21 55.97 47.20 44.85 38.36 32.48 32.44 24.23 23.24 19.44 16.95 12.66
MeO
Me
RO
Me
O
O
H
H
40, R = CS2Me
Chemical Formula: C21H24O4S2
125 MHz, CDCl3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)





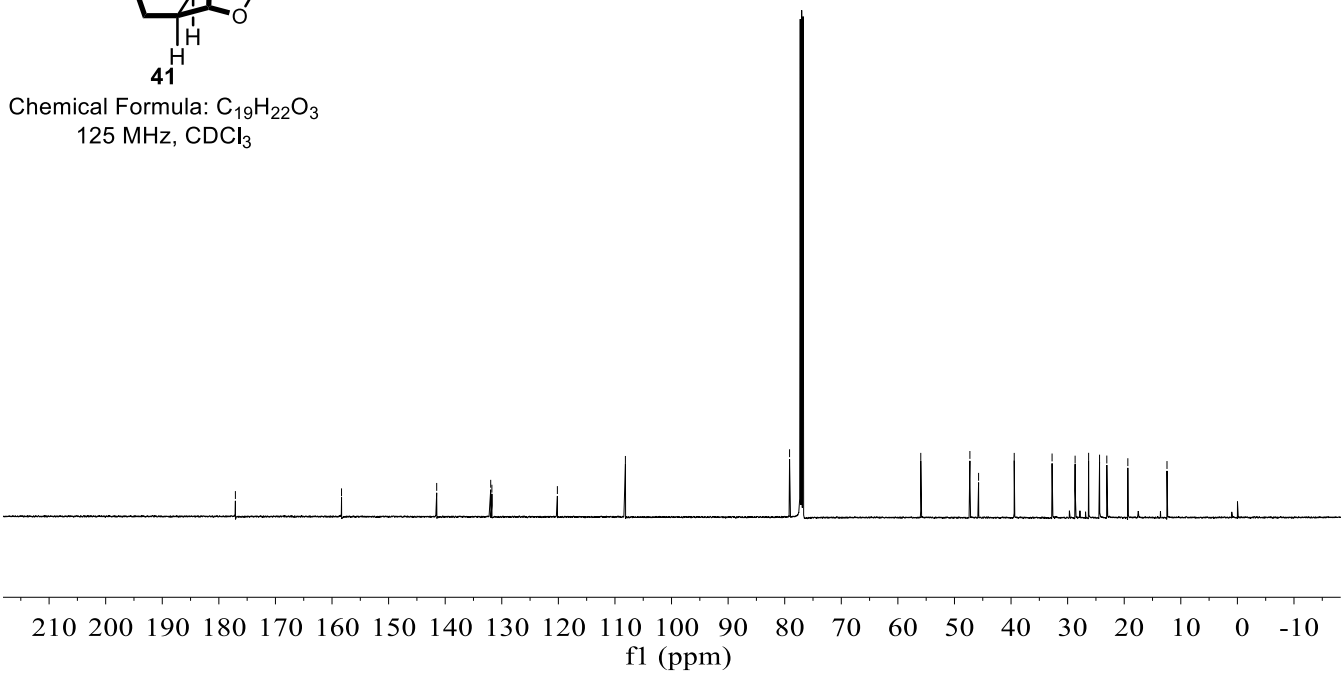
41

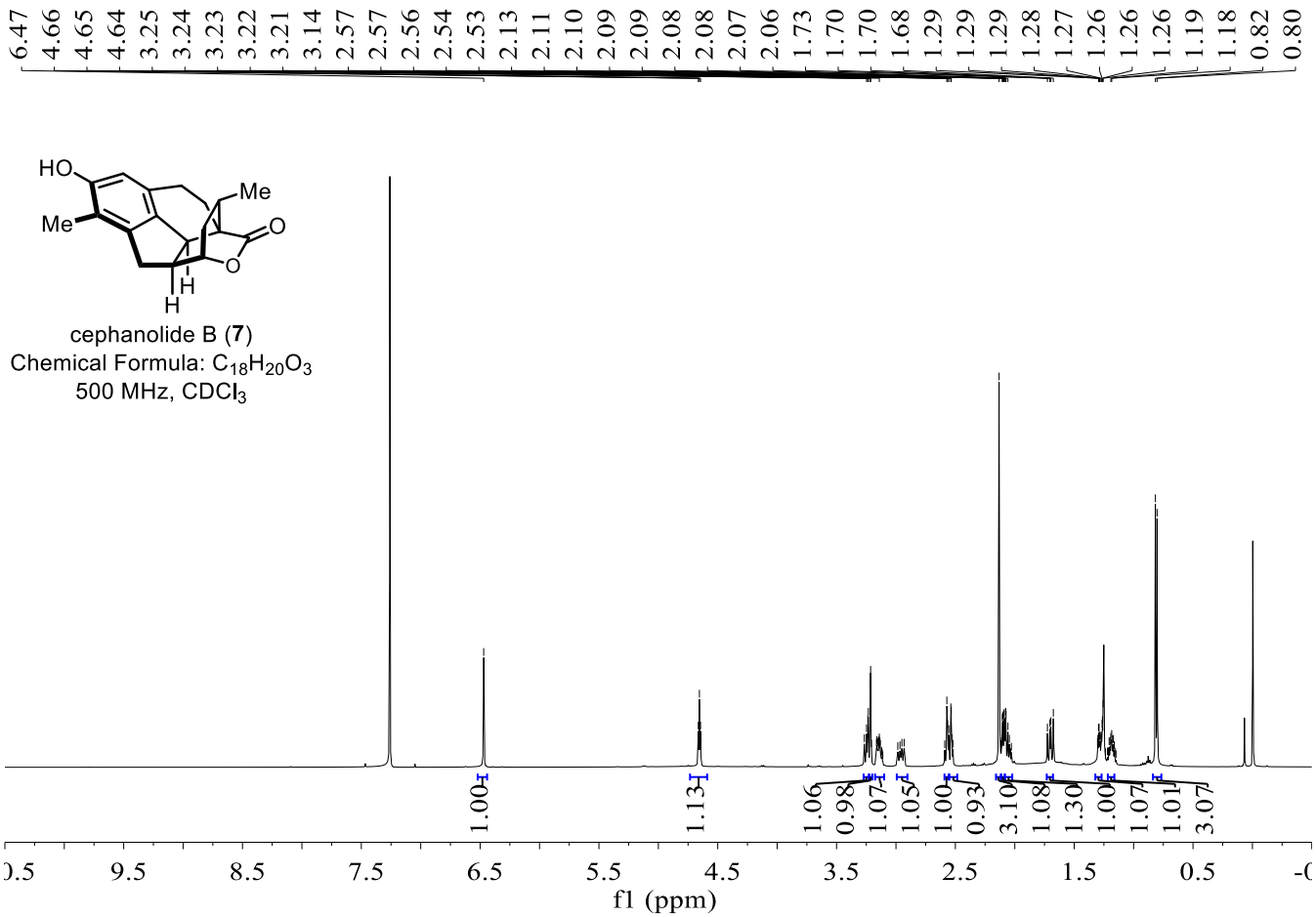
Chemical Formula: $C_{19}H_{22}O_3$
500 MHz, $CDCl_3$

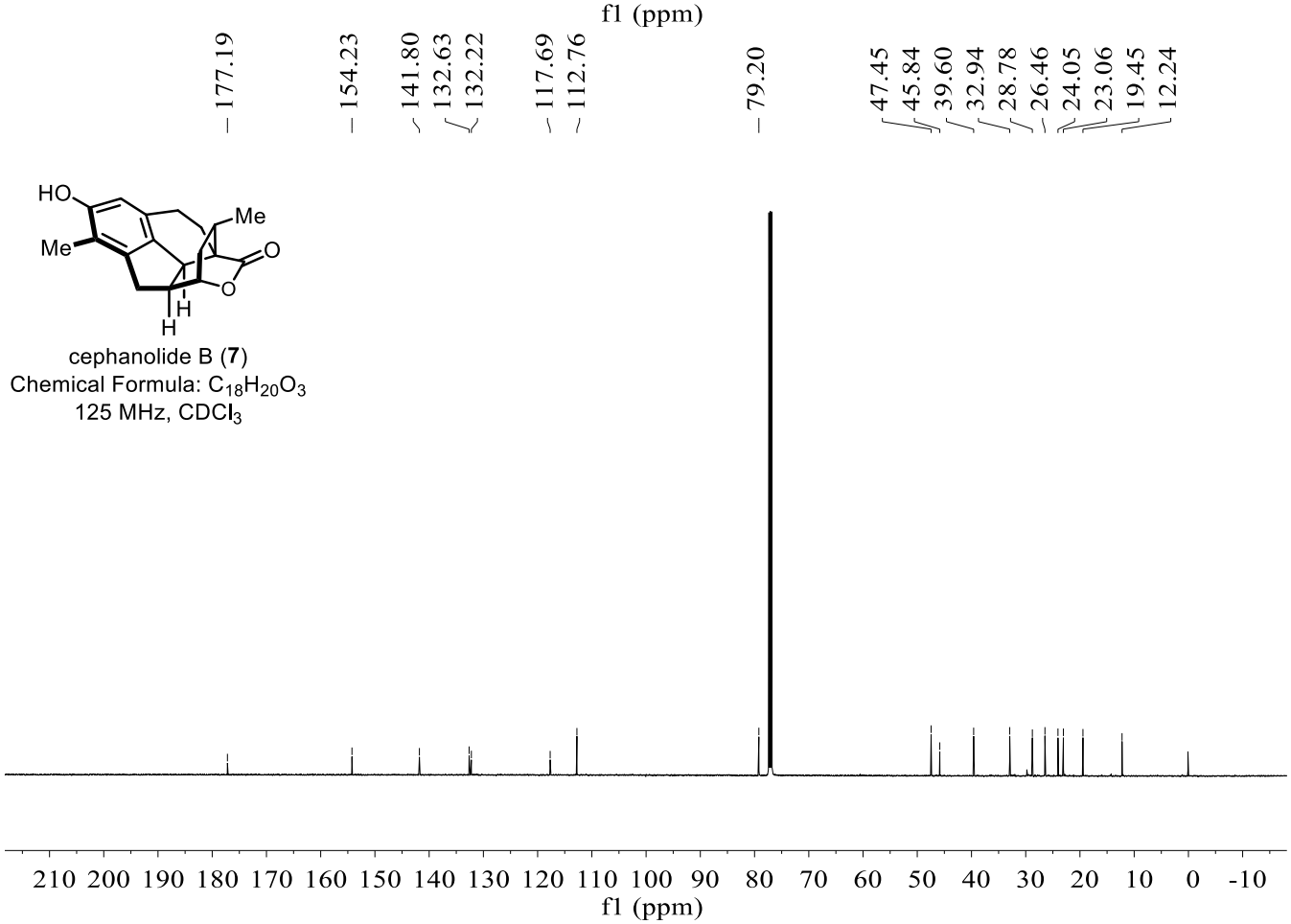


41

Chemical Formula: $C_{19}H_{22}O_3$
125 MHz, $CDCl_3$




6.47 4.66 4.65 4.64 3.25 3.24 3.23 3.22 3.21 3.14 2.57 2.57 2.56 2.54 2.53 2.13 2.11 2.10 2.09 2.09 2.08 2.08 2.07 2.06 1.73 1.70 1.70 1.68 1.29 1.29 1.29 1.28 1.27 1.26 1.26 1.26 1.19 1.18 0.82 0.80
HO
Me
Me
O
O
H
H
cephanolide B (7)
Chemical Formula: C18H20O3
500 MHz, CDCl3
1.00 1.13 1.06 0.98 1.07 1.05 1.00 0.93 3.10 1.08 1.30 1.00 1.07 1.01 3.07
f1 (ppm)


177.19 154.23 141.80 132.63 132.22 117.69 112.76 79.20 47.45 45.84 39.60 32.94 28.78 26.46 24.05 23.06 19.45 12.24
HO
Me
Me
O
O
H
H
cephanolide B (7)
Chemical Formula: C18H20O3
125 MHz, CDCl3
f1 (ppm)