Total Synthesis of (–)-Exiguolide via An Organosilane-Based Strategy

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Supporting Information

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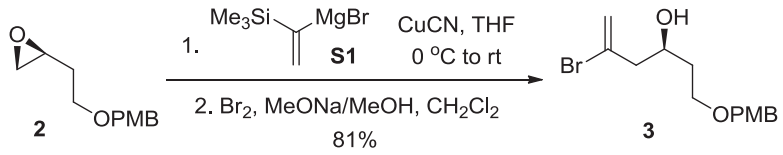
1. General Methods

TLC was performed on glass-backed silica plates and visualized using UV, $KMnO_4$ stains, $H_3PO_4 \cdot 12MoO_3$/EtOH stains, H_2SO_4 (conc.)/anisaldehyde/EtOH stains. Column chromatography was performed using silica gel (300-400 mesh) eluting with EtOAc/petroleum ether and diethyl ether/petroleum ether. ^1H NMR spectra were recorded at 400 MHz (Varian) and 600 MHz (Agilent), and ^{13}C NMR spectra were recorded at 100 MHz (Varian) and 150 MHz (Agilent) using $CDCl_3$ (except where noted) with TMS or residual solvent as standard. Infrared spectra were obtained using KCl plates on a VECTOR22. High-resolution mass spectral analyses performed High-resolution massspectral analyses performed on Waters Q-TOF Premier. CH_2Cl_2, DMF, HMPA, TMEDA, CH_3CN, DMSO and NEt_3 were distilled from CaH_2. Et_2O and THF were distilled from sodium. All spectral data obtained for new compounds are reported here.

2. Experimental Procedures and Spectral Data of Products

Synthesis of 3



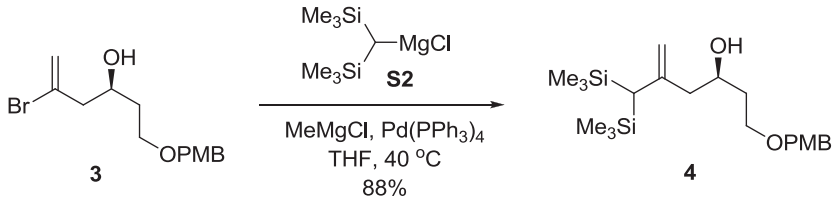
A separate two-necked flask was charged with CuCN (179 mg, 2.0 mmol), **2**[1] (4.16 g, 20.0 mmol) and THF (60 mL). The mixture was cooled to –30 °C before the solution of **S1**[2] (1.0 M in THF, 40.0 mL, 40 mmol) was added via cannula within 5 min. The resulting mixture was stirred at 0 °C for 1 h and at room temperature for 1 h. The reaction was quenched with sat aq NH_4Cl (25 mL) and diluted with hexanes/EtOAc (1:1, 50 mL). The combined organic phases were dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure to give the crude silyl allylic alcohol. This intermediate was used for the next step without any further purification.

To a solution of the above silyl allylic alcohol in CH_2Cl_2 (110 mL) was added a precooled solution of Br_2 (1.37 mL, 26.7 mmol) in CH_2Cl_2 (60 mL) via cannula at –78 °C within 1 min. The

1. M. J. Gaunt, A. S. Jessiman, P. Orsini, H. R. Tanner, D. F. Hook and S. V. Ley, *Org. Lett.* **2003**, *5*, 4819-4822.
2. A. Fürstner, S. Flügge, O. Larionov, Y. Takahashi, T. Kubota, J. Kobayashi, *Chem. Eur. J.* **2009**, *15*, 4011-4012.

resulting mixture was stirred for 5 min before a precooled solution of MeONa (5.14 g, 95.2 mmol) in MeOH (152 mL) was added via cannula within 1 min. The mixture was then allowed to stir at –20 °C for 4 h before AcOH (104 mL) was added and stirring continued at room temperature for 2 h. After evaporation of the solvents under reduced pressure at a bath temperature of 35 °C, the residue was suspended in Sorensen buffer (0.4 M, pH 7, 532 mL) and extracted with CH_2Cl_2 (3 × 100 mL). The combined organic layers were dried over Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-0.5% of EtOAc/petroleum ether) to afford vinyl bromide **3** (5.11 g, 81% yield) as a colorless oil; $[\alpha]^{D}_{20}$ = +8.2 (c 1.01 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.75-1.79 (m, 2H), 2.50 (dd, 1H, J_1 = 4.4 Hz, J_2 = 14.4 Hz), 2.61 (dd, 1H, J_1 = 8.0 Hz, J_2 = 14.4 Hz), 3.15 (s, 1H), 3.62-3.68 (m, 1H), 3.69-3.73 (m, 1H), 3.80 (s, 3H), 4.14 (m, 1H), 4.45 (s, 2H), 5.50 (s, 1H), 5.67 (s, 1H), 6.87 (d, 2H, J = 8.8 Hz), 7.25 (d, 2H, J = 8.8 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 35.3, 49.0, 55.2, 68.4, 68.7, 72.9, 113.8, 119.2, 129.3, 129.8, 130.5, 159.2; IR (neat) cm^{-1} 3435brs, 2935s, 2862s, 1613s, 1513s, 1461m, 1421m, 1363m, 1302m, 1248s, 1176m, 1091s, 1034s, 892m, 821s; HRMS (MALDI, m/z) calcd for $C_{14}H_{19}O_3BrNa$ $(M+Na)^+$: 337.0410, found 337.0414.

Synthesis of 4

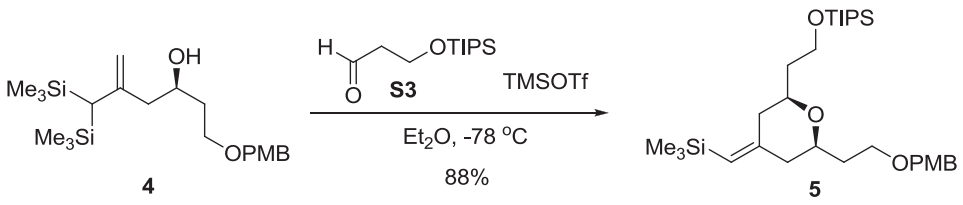


A solution of vinyl bromide **3** (2.0 g, 6.35 mmol) and MeMgCl (3.0 M in THF, 2.12 mL, 6.36 mmol) in THF (40 mL) was stirred for 5 min at 0 °C under argon followed by the addition of $Pd(PPh_3)_4$ (369 mg, 0.32 mmol). After stirring at room temperature for 5 min, **S2**[3] (1.0 M in THF, 9.53 mL, 9.53 mmol) was added via cannulation. The reaction mixture was stirred for 15 min at room temperature and then heated to 40 °C for 10 h. After cooling to room temperature, the reaction was quenched with H_2O (10 mL) and extracted with Et_2O (3 × 30 mL). The combined organic layers were washed with sat aq NaCl, dried over Na_2SO_4, filtered and concentrated under reduced pressure.

3. D. R. Williams, Á. I. Morales-Ramos, C. M. Williams, *Org. Lett*. **2006**, *8*, 4393–4396.

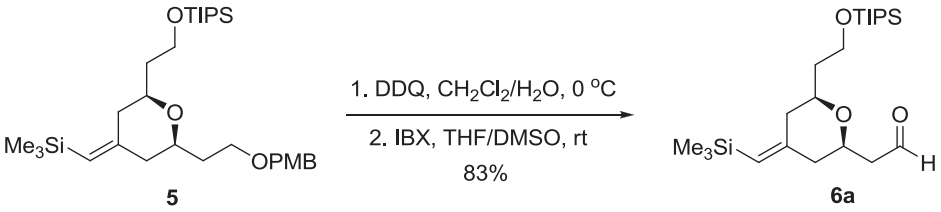
The residue was purified by silica gel chromatography (gradient eluent: 0-5% of EtOAc/petroleum ether) to afford **4** (2.21 g, 88% yield) as a colorless oil; $[\alpha]^{D}_{20}$ = +3.9 (c 1.00 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.07 (s, 9H), 0.09 (s, 9H), 0.88 (s, 1H), 1.71-1.85 (m, 2H), 2.07-2.11 (m, 2H), 2.73 (d, 1H, *J* = 1.2 Hz), 3.60-3.65 (m, 1H), 3.67-3.72 (m, 1H), 3.80 (s, 3H), 3.90-3.92 (m, 1H), 4.47 (s, 2H), 4.59 (s, 1H), 4.77 (s, 1H), 6.88 (d, 2H, *J* = 8.4 Hz), 7.27 (d, 2H, *J* = 8.4 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 0.2, 0.3, 27.9, 36.4, 50.3, 55.1, 67.3, 68.2, 72.8, 109.2, 113.7, 129.2, 130.1, 146.9, 159.1; IR (neat) cm^{-1} 3494brm, 2953s, 2909s, 2860s, 1617s, 1514s, 1462w, 1423w, 1361m, 1301m, 1249s, 1177m, 1093s, 1035s, 879s, 842s; HRMS (MALDI, m/z) calcd for $C_{21}H_{38}O_3Si_2Na$ $(M+Na)^+$: 417.2252, found 417.2250.

Synthesis of 5



To a solution of **4** (1.32 g, 3.34 mmol) and **S3** (1.54 g, 6.68 mmol) in Et_2O (20.0 mL) was added TMSOTf (0.91 mL, 5.01 mmol) at –78 °C under Ar. After stirring at –78 °C for 15 min, the reaction was quenched with sat aq $NaHCO_3$ (10 mL) at 0 °C and extracted with Et_2O (2 × 20 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-10% of EtOAc/petroleum ether) to afford **5** (1.57 g, 88% yield) as a colorless oil; $[\alpha]^{D}_{20}$ = –12.4 (c 1.01 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.09 (s, 9H), 1.05 (d, 18H, *J* = 4.4 Hz), 1.06-1.12 (m, 3H), 1.66-1.86 (m, 4H), 1.90 (t, 1H, *J* = 12.4 Hz), 2.05 (t, 1H, *J* = 12.4 Hz), 2.14 (d, 1H, *J* = 12.8 Hz), 2.40 (d, 1H, *J* = 12.8 Hz), 3.41-3.45 (m, 2H), 3.55 (t, 2H, *J* = 6.4 Hz), 3.80 (s, 3H), 3.81-3.88 (m, 2H), 4.40 (d, 1H, *J* = 11.6 Hz), 4.44 (d, 1H, *J* = 11.6 Hz), 5.20 (s, 1H), 6.87 (d, 2H, *J* = 8.4 Hz), 7.25 (d, 2H, *J* = 8.4 Hz); ^{13}C NMR (100 MHz, CDCl3) δ 0.3, 11.9, 18.0, 36.4, 39.8, 40.4, 45.7, 55.2, 59.7, 66.7, 72.6, 74.9, 75.7, 113.7, 122.7, 129.2, 130.6, 154.1, 159.1; IR (neat) cm^{-1} 2947s, 2920s, 2864s, 1739w, 1620m, 1513m, 1464m, 1249s, 1097s, 1039m, 883m, 841s; HRMS (MALDI, m/z) calcd for $C_{30}H_{54}O_4Si_2Na$ $(M+Na)^+$: 557.3453, found 557.3455.

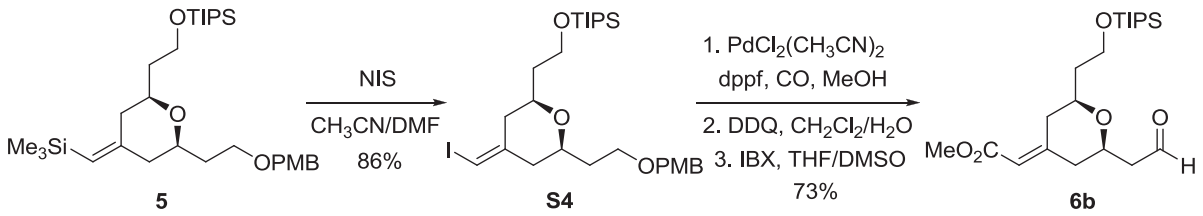
Synthesis of 6a



To a solution of **5** (400 mg, 0.748 mmol) in H_2O/CH_2Cl_2 (1:18, 8.44 mL) was added DDQ (204 mg, 0.897 mmol) in one portion at 0 ºC. After stirring at 0 ºC for 3 h, the reaction was quenched with sat aq $NaHCO_3$ (2 mL) and diluted with H_2O (5 mL). The resulting mixture was stirred vigorously for 1 h before the extraction with CH_2Cl_2 (3 × 10 mL). The combined organic layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-10% of EtOAc/petroleum ether) to afford the alcohol (285 mg, 92% yield) as a colorless oil.

To a solution of the above alcohol (230 mg, 0.555 mmol) in THF/DMSO (3:1, 4 mL) was added IBX (342 mg, 1.221 mmol) portion-wise at 0 °C. The reaction was warmed to room temperature over 30 min before quenching with sat aq $NaHCO_3$ (1 mL)/sat aq $Na_2S_2O_3$ (1 mL) and extraction with Et_2O (3 × 10 mL). The combined organic layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-3% of EtOAc/petroleum ether) to afford aldehyde **6a** (206 mg, 90% yield) as a colorless oil. $[\alpha]^D_{20}$ = –4.2 (c 0.85 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.09 (s, 9H), 1.05 (d, 18H, J = 4.4 Hz), 1.07-1.13 (m, 3H), 1.67-1.79 (m, 2H), 1.93 (t, 1H, J = 12.4 Hz), 2.12 (t, 1H, J = 12.4 Hz), 2.21(dm, 1H, J = 12.8 Hz), 2.43 (dm, 1H, J = 13.2 Hz), 2.49 (ddd, 1H, J_1 = 2.0 Hz, J_2 = 4.8 Hz, J_3 = 16.4 Hz), 2.60 (ddd, 1H, J_1 = 2.8 Hz, J_2 = 8.0 Hz, J_3 = 16.0 Hz), 3.49-3.56 (m, 1H), 3.73-3.81 (m, 2H), 3.82-3.88 (m, 1H), 5.27 (s, 1H), 9.78 (t, 1H, J = 2.4 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 0.2, 11.9, 18.0, 39.6, 40.0, 45.3, 49.7, 59.4, 73.7, 75.2, 123.8, 152.7, 201.2; IR (neat) cm^{-1} 2948s, 2894s, 2867s, 2724w, 1730s, 1624m, 1464m, 1249m, 1099s, 883m, 842s; HRMS (MALDI, m/z) calcd for $C_{22}H_{44}O_3Si_2Na$ $(M+Na)^+$: 435.2721, found 435.2722.

Synthesis of 6b



To a solution of **5** (1.48 g, 2.77 mmol) in CH_3CN/DMF (1:1, 32 mL) protected from light was added NIS (1.56 g, 6.93 mmol) at 0 °C. After stirring at 0 °C for 1.5 h, the reaction was quenched with sat aq $Na_2S_2O_3$ (5 mL) and extracted with Et_2O (3 × 15 mL). The combined organic layers were washed with sat aq NaCl, dried over Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-2% of EtOAc/petroleum ether) to afford vinyl iodide **S4** (1.40 g, 86% yield) as a colorless oil. $[\alpha]^{D}_{20}$ = –38.6 (c 1.01 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.06 (d, 18H, *J* = 4.4 Hz), 1.07-1.12 (m, 3H), 1.70-1.87 (m, 5H), 2.00 (t, 1H, *J* = 12.4 Hz), 2.38 (d, 1H, *J* = 13.6 Hz), 2.67 (d, 2H, *J* = 13.6 Hz), 3.38-3.45 (m, 2H), 3.55 (t, 2H, *J* = 6.4 Hz), 3.80 (s, 3H), 3.81-3.83 (m, 2H), 4.39 (d, 1H, *J* = 11.6 Hz), 4.43 (d, 1H, *J* = 11.6 Hz), 5.89 (s, 1H), 6.87 (d, 2H, *J* = 8.4 Hz), 7.24 (d, 2H, *J* = 8.4 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 11.9, 18.1, 35.9, 39.5, 41.7, 43.0, 55.2, 59.6, 66.5, 72.7, 73.2, 74.0, 74.9, 113.7, 129.2, 130.5, 146.6, 159.1; IR (neat) cm^{-1} 3057w, 2943s, 2864s, 1730m, 1614m, 1513m, 1463m, 1364m, 1299m, 1248s, 1174m, 1098s, 1038m, 883m, 818m; HRMS (MALDI, m/z) calcd for $C_{27}H_{45}IO_4SiNa$ $(M+Na)^+$: 611.2024, found 611.2025.

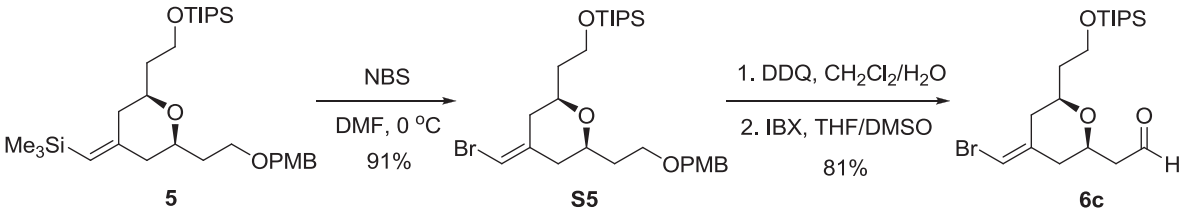
To a solution of DMF/MeOH/Et_3N (4:2:0.06, 23 mL) degassed via freeze-pump-thaw technique were sequentially added **S4** (370 mg, 0.629 mmol), $PdCl_2(CH_3CN)_2$ (24 mg, 0.094 mmol) and dppf (157 mg, 0.283 mmol). The resulting solution was stirred vigorously under CO (1 atm) at 80 °C for 5 h. The reaction was quenched with sat aq NaCl/H_2O (1:1, 20 mL) and extracted with Et_2O (3 × 10 mL). The combined organic layers were dried over Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-8% of EtOAc/petroleum ether) to afford the enoate (305 mg, 93% yield) as a colorless oil.

To a solution of the above enoate (305 mg, 0.586 mmol) in H_2O/CH_2Cl_2 (1:18, 6.33 mL) was added DDQ (160 mg, 0.703 mmol) in one portion at 0 ºC. After stirring at 0 ºC for 3 h, the reaction was quenched with sat aq $NaHCO_3$ (2 mL) and diluted with H_2O (4 mL). The resulting mixture was stirred vigorously for 1 h before the extraction with CH_2Cl_2 (3 × 8 mL). The combined organic

layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by column chromatography (gradient eluent: 15% of EtOAc/petroleum ether) to afford the alcohol (211 mg, 90% yield) as a colorless oil.

To a solution of the above alcohol (204 mg, 0.509 mmol) in THF/DMSO (3:1, 4 mL) was added IBX (314 mg, 1.12 mmol) portion-wise at 0 °C. The reaction was warmed to room temperature over 30 min before quenching with sat aq $NaHCO_3$ (1 mL)/sat aq $Na_2S_2O_3$ (1 mL) and extraction with Et_2O (3 × 10 mL). The combined organic layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-13% of EtOAc/petroleum ether) to afford aldehyde **6b** (177 mg, 87% yield) as a colorless oil. $[\alpha]^{D}_{20}$ = –26.1 (c 0.95 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.05 (d, 18H, *J* = 4.8 Hz), 1.07-1.13 (m, 3H), 1.71-1.83 (m, 2H), 1.88 (t, 1H, *J* = 12.8 Hz), 2.16 (t, 1H, *J* = 12.4 Hz), 2.28 (d, 1H, *J* = 13.2 Hz), 2.54 (ddd, 1H, J_1 = 1.6 Hz, J_2 = 4.8 Hz, J_3 = 16.4 Hz), 2.66 (ddd, 1H, J_1 = 2.4 Hz, J_2 = 7.6 Hz, J_3 = 16.4 Hz), 3.54-3.60 (m, 1H), 3.70 (s, 3H), 3.74-3.87 (m, 3H), 3.88-3.93 (m, 1H), 5.71 (s, 1H), 9.78 (d, 1H, *J* = 2.0 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 11.9, 18.0, 35.7, 39.4, 42.2, 49.6, 51.0, 59.3, 73.0, 74.4, 114.9, 156.2, 166.7, 200.5; IR (neat) cm^{-1} 3435brw, 2943s, 2926s, 2865s, 2726w, 1722s, 1653m, 1464m, 1437m, 1374m, 1260m, 1224m, 1149m, 1099s, 1021m, 1082m, 803s; HRMS (MALDI, m/z) calcd for $C_{21}H_{38}O_5SiNa$ $(M+Na)^+$: 421.2381, found 421.2378.

Synthesis of 6c



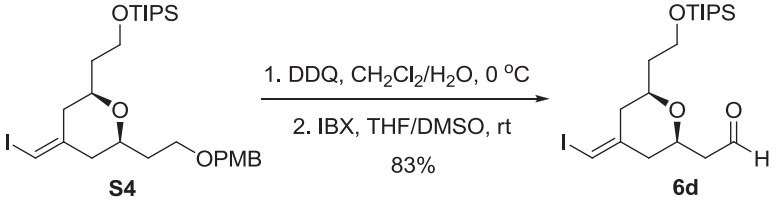
To a solution of **5** (220 mg, 0.411 mmol) in DMF (6 mL) protected from light was added NBS (366 mg, 2.055 mmol) at 0 °C. After stirring at 0 °C for 3 h, the reaction was quenched with sat aq $Na_2S_2O_3$ (3 mL) and extracted with Et_2O (3 × 5 mL). The combined organic layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-2% of EtOAc/petroleum

ether) to afford vinyl bromide **S5** (203 mg, 91% yield).

To a solution of **S5** (200 mg, 0.369 mmol) in H_2O/CH_2Cl_2 (1:18, 4.22 mL) was added DDQ (100 mg, 0.443 mmol) in one portion at 0 ºC. After stirring at 0 ºC for 3 h, the reaction was quenched with sat aq $NaHCO_3$ (1 mL) and diluted with H_2O (2 mL). The resulting mixture was stirred vigorously for 1 h before the extraction with CH_2Cl_2 (3 × 5 mL). The combined organic layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-10% of EtOAc/petroleum ether) to afford the alcohol (143 mg, 92% yield) as a colorless oil.

To a solution of the above alcohol (140 mg, 0.333 mmol) in THF/DMSO (3:1, 4 mL) was added IBX (205 mg, 0.733 mmol) portion-wise at 0 °C. The reaction was warmed to room temperature over 30 min before quenching with sat aq $NaHCO_3$ (1 mL)/sat aq $Na_2S_2O_3$ (1 mL) and extraction with Et_2O (3 × 10 mL). The combined organic layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-4% of EtOAc/petroleum ether) to afford aldehyde **6c** (123 mg, 88% yield) as a colorless oil. $[\alpha]^D_{20}$ = –23.8 (c 0.90 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.05 (d, 18H, J = 4.8 Hz), 1.07-1.13 (m, 3H), 1.73-1.80 (m, 3H), 2.01 (t, 1H, J = 12.8 Hz), 2.36 (dm, 1H, J = 13.6 Hz), 2.52 (ddd, 1H, J_1 = 2.0 Hz, J_2 = 5.2 Hz, J_3 = 16.4 Hz), 2.64 (ddd, 1H, J_1 = 2.8 Hz, J_2 = 7.6 Hz, J_3 = 16.4 Hz), 2.86 (dm, 1H, J = 14.0 Hz), 3.50-3.57 (m, 1H), 3.76-3.85 (m, 3H), 6.01 (s, 1H), 9.78 (t, 1H, J = 2.0 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 11.9, 18.0, 36.7, 39.3, 40.5, 49.3, 59.3, 72.8, 74.1, 100.5, 139.4, 200.6; IR (neat) cm^{-1} 2940s, 2865s, 2726w, 1729s, 1464m, 1387w, 1364w, 1250w, 1151m, 1101s, 998w, 883m; HRMS (MALDI, m/z) calcd for $C_{19}H_{35}BrO_3SiNa$ $(M+Na)^+$: 441.1431, found 441.1432.

Synthesis of 6d

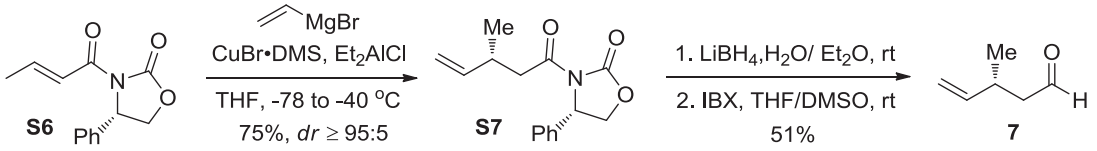


To a solution of vinyl iodide **S4** (1.43 g, 2.43 mmol) in H_2O/CH_2Cl_2 (1/18, 19.0 mL) was added

DDQ (0.66 g, 2.92 mmol) in one portion at 0 ºC. After stirring at 0 ºC for 3 h, the reaction was quenched with sat aq $NaHCO_3$ (5 mL) and diluted with H_2O (5 mL). The resulting mixture was stirred vigorously for 1 h before the extraction with CH_2Cl_2 (3 × 15 mL). The combined organic layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-15% of EtOAc/petroleum ether) to afford the alcohol (1.05 g, 92% yield) as a yellow oil.

To a solution of the above alcohol (1.04 g, 2.21 mmol) in THF/DMSO (3:1, 16 mL) was added IBX (1.36 g, 4.86 mmol) portion-wise at 0 °C. The reaction was warmed to room temperature over 30 min before quenching with sat aq $NaHCO_3$ (5 mL)/sat aq $Na_2S_2O_3$ (5 mL) and extraction with Et_2O (3 × 25 mL). The combined organic layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-2% of EtOAc/petroleum ether) to afford aldehyde **6d** (927 mg, 90% yield) as a colorless oil. $[\alpha]^{D}_{20}$ = –34.7 (c 0.51 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.06 (d, 18H, J = 4.4 Hz), 1.07-1.13 (m, 3H), 1.75-1.80 (m, 2H), 1.85 (t, 1H, J = 12.4 Hz), 2.07 (t, 1H, J = 12.4 Hz), 2.48 (dm, 1H, J = 13.2 Hz), 2.52 (ddd, 1H, J_1 = 1.6 Hz, J_2 = 4.8 Hz, J_3 = 16.4 Hz), 2.64 (ddd, 1H, J_1 = 2.4 Hz, J_2 = 7.6 Hz, J_3 = 16.4 Hz), 2.71 (dm, 1H, J = 14.0 Hz), 3.50-3.56 (m, 1H), 3.75-3.84 (m, 3H), 6.00 (s, 1H), 9.77 (dd, 1H, J_1 = 2.0 Hz, J_2 = 2.4 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 11.9, 18.0, 39.2, 41.3, 42.5, 49.1, 59.3, 72.8, 74.2, 74.3, 145.4, 200.6; IR (neat) cm^{-1} 2941s, 2924s, 2865s, 2725w, 1728s, 1464m, 1264m, 1135m, 1100s, 1015m, 883m; HRMS (MALDI, m/z) calcd for $C_{19}H_{35}IO_3SiNa$ $(M+Na)^+$: 489.1292, found 489.1294.

Synthesis of 7



To a solution of CuBr•DMS (2.06 g, 10 mmol) in anhydrous THF (40 mL) was added vinylmagnesium bromide (1.0 M in THF, 20 mL, 20 mmol) under Ar at –78 °C. The mixture was warmed to –40 ºC and stirred for 1 h before recooling to –78 °C. Et_2AlCl (1.0 M in CH_2Cl_2, 20 mL, 20 mmol) and a solution of **S6** (2.31 g, 10 mmol) in anhydrous THF (10 mL) were added

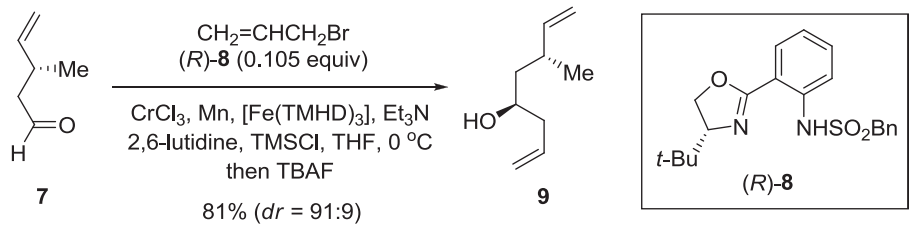
sequentially with stirring at –78 °C for 4 h. The reaction was quenched with sat aq NH_4Cl (10 mL) and extracted with Et_2O (3 × 20 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-2% of EtOAc/petroleum ether) to afford **S7** (1.94 g, 75% yield, mp 83-85 °C) as a white solid. $[\alpha]^D_{20}$ = +49.0 (c 1.04 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.01 (d, 3H, J = 6.8 Hz), 2.67-2.74 (m, 1H), 2.83 (dd, 1H, J_1 = 7.6 Hz, J_2 = 15.6 Hz), 3.08 (dd, 1H, J_1 = 6.4 Hz, J_2 = 15.6 Hz), 4.25 (dd, 1H, J_1 = 3.6 Hz, J_2 = 8.8 Hz), 4.67 (t, 1H, J = 8.8 Hz), 4.89 (d, 1H, J = 10.4 Hz), 4.94 (d, 1H, J = 17.6 Hz), 5,42 (dd, 1H, J_1 = 3.6 Hz, J_2 = 8.4 Hz), 5.76 (ddd, 1H, J_1 = 7.2 Hz, J_2 = 10.4 Hz, J_3 = 17.6 Hz), 7.28-7.29 (d, 2H, J = 6.8 Hz), 7.32-7.39 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 19.5, 33.7, 41.7, 57.5, 69.8, 113.3, 125.9, 128.6, 129.0, 139.0, 142.3, 153.6, 171.4; IR (neat) cm^{-1} 3544w, 3390w, 3073w, 2965s, 2922s, 1778s, 1705s, 1642m, 1457m, 1385s, 1325s, 1201s, 918s, 762s; HRMS (MALDI, m/z) calcd for $C_{15}H_{17}NO_3Na$ $(M+Na)^+$: 282.1101, found 282.1105.

To a solution of **S7** (7.8 g, 30 mmol) in anhydrous Et_2O (50 mL) was added $LiBH_4$ (2.0 M in THF, 16.7 mL, 33.5 mmol) at room temperature. The reaction was stirred for 45 min before quenching with sat aq potassium sodium tartrate (20 mL) and extraction with Et_2O (3 × 30 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-2% of diethyl ether/petroleum ether) to afford the alcohol (2.55 g, 85% yield) as a colorless oil.

To a solution of the above alcohol (2.55 g, 25.5 mmol) in THF/DMSO (3:1, 80 mL) was added IBX (10.7 g, 38.2 mmol) portion-wise at 0 °C. The reaction was warmed to room temperature over 2 h before quenching with sat aq $NaHCO_3$ (15 mL)/sat aq $Na_2S_2O_3$ (15 mL) and extraction with Et_2O (3 × 40 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered and evaporated at 1 atmosphere using Vigreaux column to give aldehyde **7** (1.502 g, 60% yield, bp 63-65 °C, contaminated (^{1}H NMR) with 30 mol % of THF) as a clear oil. $[\alpha]^D_{20}$ = –25.2 (c 0.5 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.09 (d, 3H, J = 6.8 Hz), 2.38 (ddd, 1H, J_1 = 2.0 Hz, J_2 = 6.8 Hz, J_3 = 16.0 Hz), 2.47 (ddd, 1H, J_1 = 2.0 Hz, J_2 = 6.8 Hz, J_3 = 16.4 Hz), 2.74-2.81 (m, 1H), 5.00 (d, 1H, J = 10.4 Hz), 5.04 (d, 1H, J = 17.6 Hz), 5.79 (ddd, 1H, J_1 = 7.2 Hz, J_2 = 10.4 Hz, J_3 = 17.6 Hz), 9.74 (t, 1H, J = 2.0 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 19.9, 32.2, 49.8, 113.6, 142.2, 202.3; IR (neat) cm^{-1} 3400brm, 3080w, 2965s, 2931s, 2876s, 2723w, 1725s, 1642w, 1457w, 1416m,

1374w, 1002s, 916s; HRMS (MALDI, m/z) calcd for $C_6H_{10}ONa$ $(M+Na)^+$: 121.0624, found 121.0627.

Synthesis of 9

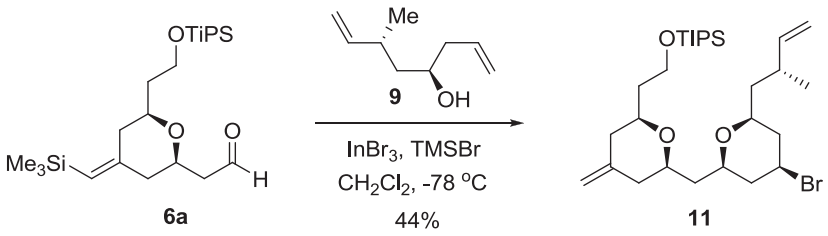


To a mixture of (*R*)-**8**[4] (80 mg, 0.214 mmol), anhydrous $CrCl_3$ (32 mg, 0.204 mmol), Mn (336 mg, 6.114 mmol) and $[Fe(TMHD)_3]$ (25 mg, 0.04 mmol) in anhydrous THF (5 mL) was added Et_3N (368 μL, 2.65 mmol) at room temperature. The reaction was stirred vigorously for 1.5 h before adding 2,6-lutidine (521 μL, 4.5 mmol) and allyl bromide (431 μL, 5.1 mmol). After stirring for 15 min at room temperature and for 10 min at 0 °C, aldehyde **7** (250 mg, 2.04 mmol, contaminated by 30 mol % of THF) and TMSCl (773 μL, 6.11 mmol) were added sequentially with stirring for 18 h at 0 °C. The mixture was diluted with Et_2O (10 mL) and filtered through SiO_2 plug (eluted with Et_2O). The filtrate was concentrated under reduced pressure to give the TMS-protected homoallylic alcohol **9**. To a solution of this crude product in THF (5 mL) was added TBAF (1.0 M in THF, 2 mL, 2 mmol). The reaction was stirred for 10 min before quenching with H_2O (5 mL) and extraction with Et_2O (3 × 10 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 2% of diethyl ether/petroleum ether) to afford **9** (230 mg, 81%, *dr* = 91:9) as a colorless oil. $[\alpha]^D_{20}$ = –18.8 (c 1.01 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.03 (d, 3H, J = 6.8 Hz), 1.35-1.50 (m, 2H), 1.63 (d, 1H, J = 3.6 Hz), 2.12-2.19 (m, 1H), 2.23-2.30 (m, 1H), 2.41-2.44 (m, 1H), 3.66-3.70 (m, 1H), 4.97 (dd, 1H, J_1 = 1.2 Hz, J_2 = 10.4 Hz), 5.04 (d, 1H, 17.2 Hz), 5.12 (d, 1H, J = 11.6 Hz), 5.13 (d, 1H, J = 15.6 Hz), 5.67 (ddd, 1H, J_1 = 8.4 Hz, J_2 = 10.4 Hz, J_3 = 17.2 Hz), 5.82 (dddd, 1H, J_1 = 7.6 Hz, J_2 = 9.6 Hz, J_3 = 11.2 Hz, J_4 = 15.6 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 21.2, 34.7, 42.4, 43.6, 68.5, 113.5, 118.0, 134.8, 144.0; IR (neat) cm^{-1} 3349brs, 3077m, 2959s, 2923s, 1641m, 1262m, 1025m, 995s, 913s, 807w; HRMS (MALDI, m/z) calcd for $C_9H_{16}ONa$

4. M. Kurosu, M. H. Lin, Y. Kishi, *J. Am. Chem. Soc.* **2004**, *126*, 12248-12249.

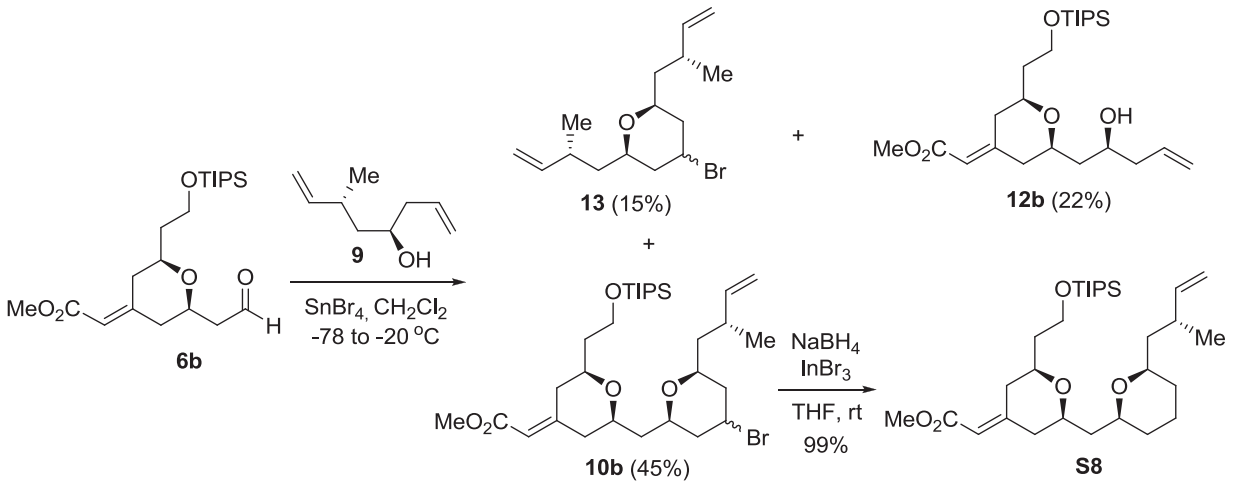
$(M+Na)^+$: 163.1093, found 163.1094.

Synthesis of 11



To a solution of **9** (25 mg, 0.18 mmol) and $InBr_3$ (11 mg, 0.03 mmol) in CH_2Cl_2 (2 mL) were added sequentially trimethylsilylbromide (24 μL, 0.18 mmol) and aldehyde **6a** (55 mg, 0.15 mmol) in CH_2Cl_2 (0.5 mL) at –78 ^oC. The reaction mixture was stirred for 5 h at –78 ^oC before quenching with sat aq Na_2CO_3 (1 mL) and extraction with Et_2O (3 × 5 mL). The combined organic layers were washed sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residual crude product was purified via silica gel chromatography (0-1% of diethyl ether/petroleum ether) to afford **11** (36 mg, 44% yield) as colorless oil. $[\alpha]^D_{20}$ = –2.1 (c 0.35 in $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 0.98 (d, 3H, J = 6.8 Hz), 1.07 (d, 18H, J = 4.4 Hz), 1.08-1.13 (m, 3H), 1.23-1.29 (m, 1H), 1.50-1.55 (m, 2H), 1.62-1.79 (m, 4H), 1.88-1.97 (m, 3H), 2.15 (dt, 1H, J_1 = 2.0 Hz, J_2 = 12.4 Hz), 2.23 (m, 3H), 2.39-2.41 (m, 1H), 3.28 (tm, 1H, J = 10.4 Hz), 3.38-3.45 (m, 3H), 3.75-3.84 (m, 2H), 4.07-4.16 (m, 1H), 4.71 (s, 1H), 4.72 (s, 1H), 4.93 (d, 1H, J = 10.0 Hz), 4.96 (d, 1H, J = 17.2 Hz), 5.59 (ddd, 1H, J_1 = 8.4 Hz, J_2 = 10.4 Hz, J_3 = 17.2 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 12.0, 18.0, 21.1, 34.4, 39.5, 40.4, 41.0, 42.2, 42.7, 43.3, 43.8, 46.9, 59.8, 73.9, 74.5, 75.2, 75.3, 108.5, 113.6, 143.7, 144.6; IR (neat) cm^{-1} 3360brw, 3075w, 2925s, 2863s, 1652m, 1463m, 1369w, 1260w, 1099s, 998w, 886m; HRMS (MALDI, m/z) calcd for $C_{28}H_{51}BrO_3SiNa$ $(M+Na)^+$: 565.2683, found 565.2684.

Synthesis of 10b, 12b, 13 and S8



To a solution of **9** (25 mg, 0.18 mmol) and aldehyde **6b** (60 mg, 0.15 mmol) in CH_2Cl_2 (2 mL) was added $SnBr_4$ (0.33 mL, 1.0 M in CH_2Cl_2, 0.33 mmol) at –78 °C under Ar. The reaction was stirred at –78 °C for 2 h and at –20 °C for another 2 h. The mixture was quenched with sat aq Na_2CO_3 (1 mL) and extracted with CH_2Cl_2 (3 × 2 mL). The combined organic layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by via silica gel column chromatography (gradient eluent: 0-30% of EtOAc/petroleum ether) to afford **13** (7 mg, 15% yield, *dr* = 7:3) as a colorless oil, **12b** (15 mg, 22% yield) as a colorless oil, and **10b** (41 mg, 45% yield, *dr* = 3:2) as a colorless oil.

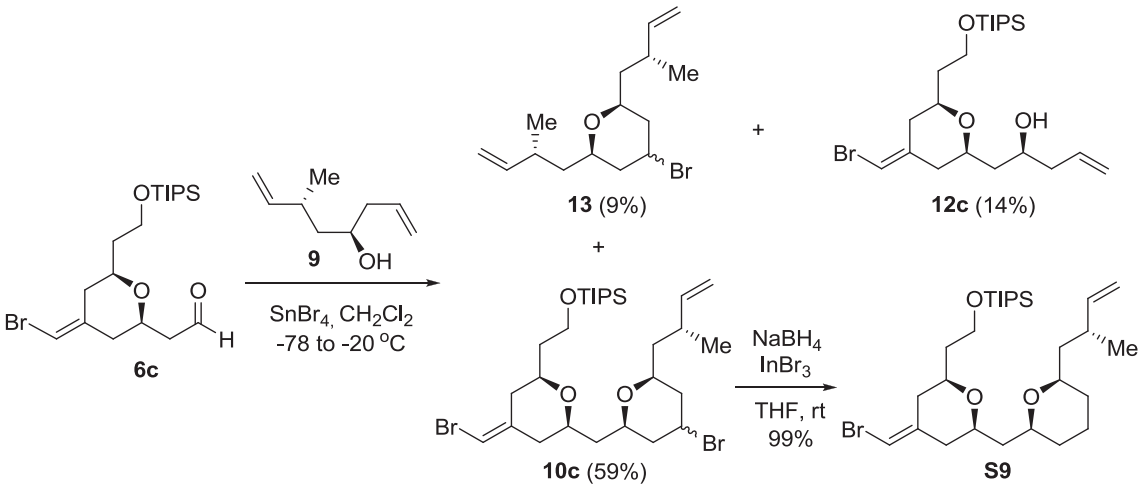
To a solution of **10b** (41 mg, 0.068 mmol) in anhydrous THF (1 mL) was added $InBr_3$ (36 mg, 0.102 mmol) and $NaBH_4$ (5 mg, 0.136 mmol) under Ar at room temperature. After stirring for 2 h, the mixture was quenched with H_2O (0.5 mL) and extracted with Et_2O (3 × 1 mL). The combined organic layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residual crude product was purified via silica gel chromatography (0-2% of diethyl ether/petroleum ether) to afford **S8** (36 mg, 99% yield) as colorless oil. $[\alpha]^{D}_{20}$ = –23.5 (c 1.50 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.98 (d, 3H, *J* = 6.8 Hz), 1.05 (d, 18H, *J* = 4.4 Hz), 1.06-1.12 (m, 3H), 1.16-1.29 (m, 3H), 1.43-1.57 (m, 5H), 1.76-1.83 (m, 3H), 1.86-1.94 (m, 2H), 2.09 (t, 1H, *J* = 12.0 Hz), 2.25 (dm, 1H, *J* = 13.6 Hz), 2.34-2.45 (m, 1H), 3.27 (tm, 1H, *J* = 10.8 Hz), 3.37-3.43 (m, 1H), 3.45-3.51 (m, 1H), 3.52-3.58 (m, 1H), 3.69 (s, 3H), 3.77-3.82 (m, 3H), 4.94 (d, 1H, *J* = 10.4 Hz), 4.95 (d, 1H, *J* = 18.4 Hz), 5.64 (ddd, 1H, J_1 = 8.4 Hz, J_2 = 10.4 Hz, J_3 = 18.4 Hz), 5.67 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 12.0, 18.0, 21.1, 23.7, 31.6, 32.0, 34.3, 36.2, 39.7, 42.4, 42.8, 43.4, 50.9, 59.7, 73.9, 74.2, 74.6, 75.5, 113.1, 114.1,

144.3, 158.0, 166.9. IR (neat) cm^{-1} 3362brw, 3075w, 2959s, 2927s, 2863s, 1721s, 1650m, 1462m, 1437m, 1372m, 1263s, 1147s, 1099s, 1018s, 879m, 795s; HRMS (MALDI, m/z) calcd for $C_{30}H_{54}O_5SiNa$ $(M+Na)^+$: 545.3633, found 545.3635.

12b: $[\alpha]^D_{20}$ = –28.9 (c 0.28 in $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 1.05 (d, 18H, *J* = 4.8 Hz), 1.07-1.13 (m, 3H), 1.66 (t, 2H, *J* = 6.4 Hz), 1.80 (q, 2H, *J* = 6.0 Hz), 1.90 (tm, 1H, *J* = 12.8 Hz), 2.13-2.29 (m, 4H), 3.43 (s, 1H), 3.58-3.66 (m, 2H), 3.69 (s, 3H), 3.77-3.83 (m, 3H), 3.87-3.93 (m, 1H), 5.09 (d, 1H, *J* = 9.2 Hz), 5.10 (d, 1H, *J* = 18.8 Hz), 5.67 (s, 1H), 5.82 (dddd, 1H, J_1 = 7.2 Hz, J_2 = 10.4 Hz, J_3 = 14.4 Hz, J_4 = 17.2 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 11.9, 18.0, 35.7, 39.4, 41.8, 42.0, 42.9, 51.0, 59.4, 70.7, 74.7, 78.7, 114.5, 117.4, 134.8, 156.6, 166.7; IR (neat) cm^{-1} 3362w, 3196w, 2923s, 2855s, 1721s, 1653s, 1464m, 1436m, 1371m, 1261m, 1149m, 1099s, 1019m, 881m, 801s; HRMS (MALDI, m/z) calcd for $C_{24}H_{44}O_5SiNa$ $(M+Na)^+$: 463.2850, found 463.2854.

13 (major isomer): $[\alpha]^D_{20}$ = –7.1 (c 0.45 in $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 0.99 (d, 6H, *J* = 6.8 Hz), 1.22-1.31 (m, 1H), 1.52-1.60 (m, 2H), 1.62-1.74 (m, 3H), 2.12-2.22 (m, 2H), 2.38-2.43 (m, 2H), 3.25-3.32 (m, 2H), 4.10-4.18 (m, 1H), 4.91-5.00 (m, 4H), 5.59 (ddd, 1H, J_1 = 8.4 Hz, J_2 = 10.4 Hz, J_3 = 18.4 Hz), 5.75 (ddd, 1H, J_1 = 7.2 Hz, J_2 = 10.4 Hz, J_3 = 17.2 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 19.1, 21.1, 33.4, 34.4, 42.3, 42.7, 43.7, 43.8, 47.1, 75.0, 75.3, 112.4, 113.6, 143.8, 144.4; IR (neat) cm^{-1} 3358w, 3077w, 2958s, 2921s, 2852s, 1723w, 1639m, 1461s, 1371m, 1261s, 1151m, 1086s, 1028s, 913s, 802s; HRMS (MALDI, m/z) calcd for $C_{15}H_{25}BrONa$ $(M+Na)^+$: 323.0981, found 323.0984.

Synthesis of 10c, 12c, 13 and S9



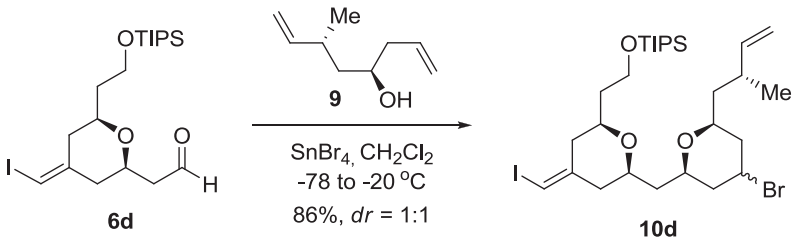
To a solution of homoallylic alcohol **9** (25 mg, 0.18 mmol) and aldehyde **6c** (63 mg, 0.15 mmol) in CH_2Cl_2 (2 mL) was added $SnBr_4$ (0.33 mL, 1.0 M in CH_2Cl_2, 0.33 mmol) at –78 °C under Ar. The reaction was stirred at –78 °C for 2 h and at –20 °C for another 2 h. The mixture was quenched with sat aq Na_2CO_3 (1 mL) and extracted with CH_2Cl_2 (3 × 2 mL). The combined organic layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by via silica gel column chromatography (gradient eluent: 0-20% of EtOAc/petroleum ether) to afford **13** (4 mg, 9% yield, *dr* = 6:4) as a colorless oil, **12c** (10 mg, 14% yield) as a colorless oil, and **10c** (55 mg, 59% yield, *dr* = 2:1) as a colorless oil.

To a solution of **10c** (55 mg, 0.088 mmol) in anhydrous THF (1 mL) was added $InBr_3$ (47 mg, 0.132 mmol) and $NaBH_4$ (7 mg, 0.176 mmol) under Ar at room temperature. After stirring for 2 h, the mixture was quenched with H_2O (0.5 mL) and extracted with Et_2O (3 × 1 mL). The combined organic layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residual crude product was purified via silica gel chromatography (0-1% of diethyl ether/petroleum ether) to afford **S9** (47 mg, 99% yield) as a colorless oil. $[\alpha]^{D}_{20}$ = –27.1 (c 0.38 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.98 (d, 3H, *J* = 7.2 Hz), 1.05 (d, 18H, *J* = 4.4 Hz), 1.06-1.12 (m, 3H), 1.16-1.29 (m, 3H), 1.46-1.57 (m, 5H), 1.72-1.83 (m, 4H), 1.86-1.96 (m, 2H), 2.34 (d, 1H, *J* = 13.6 Hz), 2.36-2.43 (m, 1H), 2.82 (d, 1H, *J* = 14.0 Hz), 3.26 (t, 1H, *J* = 9.6 Hz), 3.35-3.49 (m, 3H), 3.81 (t, 2H, *J* = 6.4 Hz), 4.92 (d, 1H, *J* = 10.0 Hz), 4.94 (d, 1H, *J* = 17.6 Hz), 5.63 (ddd, 1H, J_1 = 8.0 Hz, J_2 = 10.0 Hz, J_3 = 17.2 Hz), 5.94 (s, 1H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 12.0, 18.0, 21.1, 23.7, 31.6, 32.0, 34.3, 37.1, 39.5, 40.5, 42.5, 43.4, 59.8, 73.9, 74.0, 74.4, 75.5, 99.4, 113.0, 140.7, 144.3; IR (neat) cm^{-1} 3360w, 3073w, 2927s, 2863s, 1637w, 1462m, 1372w, 1255w, 1200w, 1097s, 912w, 883m; HRMS (MALDI, m/z) calcd for $C_{28}H_{51}BrO_3SiNa$ $(M+Na)^+$: 565.2683, found 565.2678.

12c: $[\alpha]^{D}_{20}$ = –14.0 (c 0.25 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.05 (d, 18H, *J* = 4.8 Hz), 1.07-1.13 (m, 3H), 1.63 (t, 2H, *J* = 6.0 Hz), 1.73-1.83 (m, 3H), 2.01 (tm, 1H, *J* = 12.8 Hz), 2.17-2.28 (m, 3H), 2.86 (dm, 1H, *J* = 14.0 Hz), 3.50 (s, 1H), 3.51-3.60 (m, 2H), 3.80 (t, 1H, *J* = 5.6 Hz), 3.86-3.92 (m, 1H), 5.08 (d, 1H, *J* = 10.0 Hz), 5.09 (d, 1H, *J* = 17.6 Hz), 5.82 (dddd, 1H, J_1 = 7.2 Hz, J_2 = 10.4 Hz, J_3 = 14.4 Hz, J_4 = 17.2 Hz), 5.96 (s, 1H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 11.9, 18.0, 36.7, 39.3, 41.1, 41.7, 41.8, 59.4, 70.8, 74.5, 78.6, 100.1, 117.3, 134.8, 139.6; IR (neat) cm^{-1} 3392w, 3190w, 2957s, 2922s, 2853s, 1736m, 1646m, 1463s, 1377w, 1261m, 1100s, 1015m, 914w,

881m, 800s; HRMS (MALDI, m/z) calcd for $C_{22}H_{41}BrO_3SiNa$ $(M+Na)^+$: 483.1901, found 483.1902.

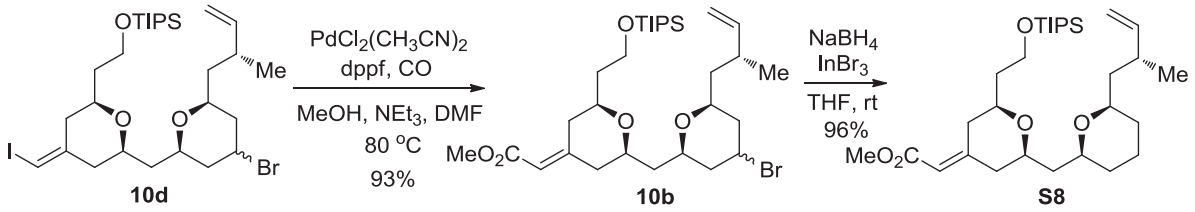
Synthesis of 10d



To a solution of homoallylic alcohol **9** (25 mg, 0.18 mmol) and aldehyde **6d** (70 mg, 0.15 mmol) in CH_2Cl_2 (2 mL) was added $SnBr_4$ (0.33 mL, 1.0 M in CH_2Cl_2, 0.33 mmol) at –78 °C under Ar. The reaction was stirred at –78 °C for 2 h and at –20 °C for another 2 h. The mixture was quenched with sat aq Na_2CO_3 (1 mL) and extracted with CH_2Cl_2 (3 × 2 mL). The combined organic layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by via silica gel column chromatography (gradient eluent: 0-20% of EtOAc/petroleum ether) to afford **10d** (86 mg, 86% yield, *dr* = 1:1) as a colorless oil. **10d (β-Br isomer)**: $[\alpha]^D_{20}$ = –38.9 (c 1.05 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.98 (d, 3H, J = 6.8 Hz), 1.07 (d, 18H, J = 4.4 Hz), 1.08-1.13 (m, 3H), 1.22-1.30 (m, 1H), 1.51-1.57 (m, 2H), 1.68 (dq, 2H, J_1 = 4.8 Hz, J_2 = 12.4 Hz), 1.75-1.86 (m, 3H), 1.91 (dt, 1H, J_1 = 7.2 Hz, J_2 = 14.0 Hz), 2.01 (t, 1H, J = 12.0 Hz), 2.13-2.22 (m, 2H), 2.34 (m, 1H), 2.41 (d, 1H, J = 13.6 Hz), 2.68 (d, 1H, J = 13.6 Hz), 3.28 (t, 1H, J = 10.4 Hz), 3.38-3.47 (m, 3H), 3.82 (t, 2H, J = 6.0 Hz), 4.06-4.14 (m, 1H), 4.93 (d, 1H, J = 12.4 Hz), 4.94 (d, 1H, J = 15.2 Hz), 5.59 (dt, 1H, J_1 = 8.4 Hz, J_2 = 17.6 Hz), 5.92 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 12.0, 18.1, 21.1, 34.4, 39.4, 41.5, 41.6, 42.5, 42.6, 43.2, 43.7, 46.6, 59.6, 73.3, 73.8, 74.0, 74.1, 75.3, 113.6, 143.7, 146.4; IR (neat) cm^{-1} 3392w, 3186w, 3074w, 2945s, 2924s, 2864s, 1738w, 1644m, 1463s, 1370m, 1329m, 1264m, 1138m, 1098s, 997m, 914m, 883m; HRMS (MALDI, m/z) calcd for $C_{28}H_{50}BrIO_3SiNa$ $(M+Na)^+$: 691.1649, found 691.1646; **10d (α-Br isomer)**: $[\alpha]^D_{20}$ = –30.8 (c 0.60 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.00 (d, 1H, J = 6.8 Hz), 1.06 (d, 18H, J = 4.4 Hz), 1.07-1.13 (m, 3H), 1.22-1.31 (m, 1H), 1.48-1.56 (m, 2H), 1.67-1.94 (m, 8H), 2.01 (t, 1H, J = 12.4 Hz), 2.41 (m, 1H), 2.49 (dm, 1H, J = 13.6 Hz), 2.68 (dm, 1H, J = 13.6 Hz), 3.43-3.51 (m, 2H), 3.78-3.88 (m, 3H), 3.91-3.97 (m, 1H), 4.71 (m, 1H), 4.97 (d, 1H, J = 11.2

Hz), 4.98 (d, 1H, J = 16.4 Hz), 5.66 (dt, 1H, J_1 = 8.0 Hz, J_2 = 17.6 Hz), 5.95 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 12.0, 18.1, 21.1, 34.3, 39.5, 39.7, 40.0, 41.4, 41.7, 42.4, 42.5, 50.7, 59.9, 68.6, 70.0, 73.3, 74.2, 74.3, 113.5, 143.8, 146.5; IR (neat) cm^{-1} 3360w, 3190w, 3073w, 2945s, 2924s, 2863s, 1737w, 1637m, 1463s, 1375m, 1324w, 1262s, 1195w, 1097s, 1024s, 914m, 883m, 802s; HRMS (MALDI, m/z) calcd for $C_{28}H_{50}BrIO_3SiNa$ $(M+Na)^+$: 691.1649, found 691.1646.

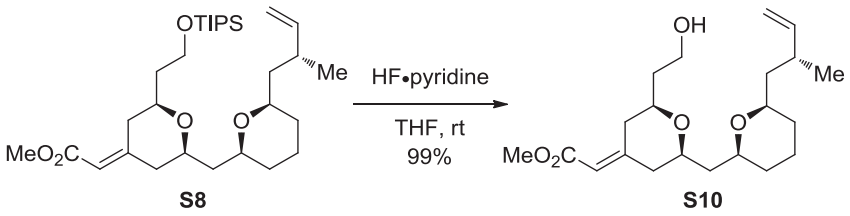
Synthesis of S8



To a solution of DMF/MeOH/Et_3N (4:2:0.06, 9.09 mL) degassed via freeze-pump-thaw technique was sequentially added **10d** (191 mg, 0.284 mmol), $PdCl_2(CH_3CN)_2$ (11 mg, 0.043 mmol) and dppf (71 mg, 0.128 mmol). The resulting solution was stirred vigorously under CO (1 atm) at 80 ^{o}C for 5 h. The The reaction was quenched with sat aq NaCl/H_2O (1:1, 10 mL) and extracted with Et_2O (3 × 10 mL). The combined organic layers were dried over Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-8% of EtOAc/petroleum ether) to afford **10b** (159 mg, 93% yield) as a colorless oil.

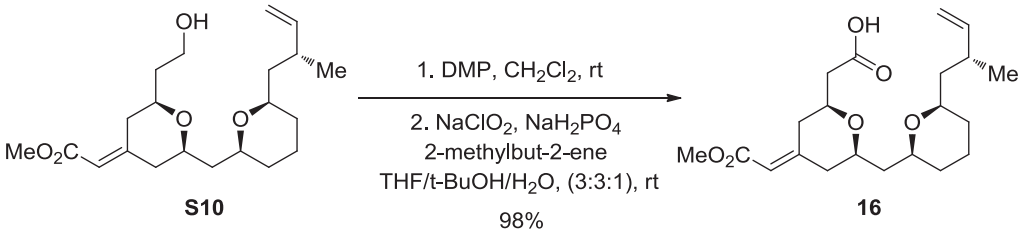
To a solution of **10b** (159 mg, 0.264 mmol) in anhydrous THF (2 mL) was added $InBr_3$ (140 mg, 0.396 mmol) and $NaBH_4$ (20 mg, 0.528 mmol) under Ar at room temperature. After stirring for 2 h, the mixture was quenched with H_2O (1 mL) and extracted with Et_2O (3 × 2 mL). The combined organic layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (0-2% of diethyl ether/petroleum ether) to afford **S8** (132 mg, 96% yield) as a colorless oil.

Synthesis of S10



To a solution of **S8** (170 mg, 0.325 mmol) in THF (6 mL) was added HF•pyridine (1.5 mL, 70% HF) at 0 °C. The reaction was stirred at room temperature for 1 h before quenching with sat aq $NaHCO_3$ (3 mL) and extraction with Et_2O (3 × 5 mL). The combined organic layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-20% of EtOAc/petroleum ether) to afford **S10** (118 mg, 99% yield) as a colorless oil. $[\alpha]^{D}_{20}$ = –31.0 (c 0.55 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.99 (d, 3H, *J* = 6.8 Hz), 1.14-1.29 (m, 3H), 1.43-1.58 (m, 5H), 1.78-1.86 (m, 3H), 1.88-1.97 (m, 2H), 2.11 (t, 1H, *J* = 12.0 Hz), 2.29 (dm, 1H, *J* = 13.2 Hz), 2.33-2.44 (m, 1H), 2.67 (brs, 1H), 3.25-3.30 (tm, 1H, *J* = 10.8 Hz), 3.33-3.38 (m, 1H), 3.57-3.61 (m, 1H), 3.62-3.68 (m, 1H), 3.69 (s, 3H), 3.78-3.84 (m, 3H), 4.94 (d, 1H, *J* = 12.4 Hz), 4.95 (d, 1H, *J* = 14.8 Hz), 5.64 (dddd, 1H, J_1 = 8.0 Hz, J_2 = 9.6 Hz, J_3 = 13.2 Hz, J_4 = 17.6 Hz), 5.69 (s, 1H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 21.2, 23.6, 31.8, 31.9, 34.4, 35.9, 38.0, 41.8, 42.8, 43.3, 51.0, 61.5, 73.9, 75.3, 75.6, 78.3, 113.2, 114.5, 144.3, 157.0, 166.9; IR (neat) cm^{-1} 3445brm, 3075w, 2925s, 2854s, 1718s, 1649s, 1437m, 1373m, 1203m, 1150m, 1088m, 912m, 863m; HRMS (MALDI, m/z) calcd for $C_{21}H_{34}O5Na$ $(M+Na)^+$: 389.2298, found 389.2296.

Synthesis of 16

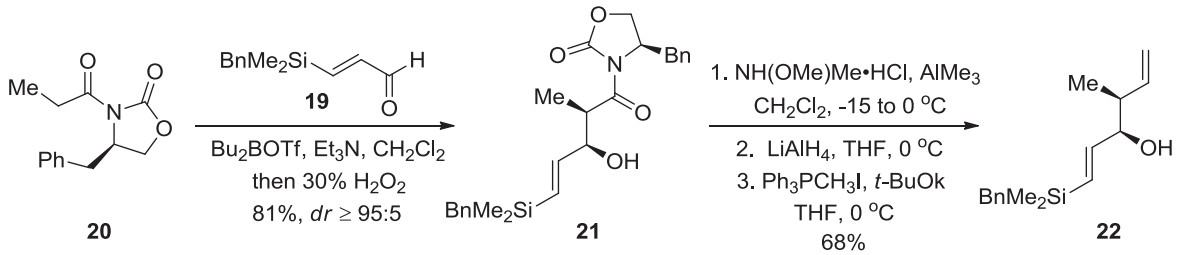


To a solution of alcohol **S10** (200 mg, 0.546 mmol) in CH_2Cl_2 (5 mL) was added Dess-Martin periodinane (463 mg, 1.09 mmol) portion-wise at 0 °C. The reaction was warmed to room temperature over 1 h before quenching with sat aq $NaHCO_3$ (1.5 mL)/sat aq $Na_2S_2O_3$ (1.5 mL) and extraction with CH_2Cl_2 (3 × 5 mL). The combined organic layers were washed with sat aq NaCl,

dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure to give the crude aldehyde. This intermediate was used for the next step without any further purification.

To a solution of the above aldehyde, 2-methylbut-2-ene (2.0 mL) and NaH_2PO_4 (228 mg, 1.9 mmol) in THF/t-BuOH/H_2O (3:3:1, 14 mL) was added $NaClO_2$ (172 mg, 1.9 mmol) at 0 °C. The reaction was warmed to room temperature over 1 h before quenching with $Na_2S_2O_3$ (5 mL) and extraction with EtOAc (4 × 8 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-20% of EtOAc/petroleum ether) to afford acid **16** (205 mg, 98% yield) as a colorless oil. $[\alpha]^D_{20}$ = –42.7 (c 1.68 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.98 (d, 3H, *J* = 6.8 Hz), 1.15-1.29 (m, 3H), 1.43-1.58 (m, 5H), 1.78-1.81 (m, 1H), 1.91 (t, 1H, *J* = 12.4 Hz), 1.92 (t, 1H, *J* = 14.0 Hz), 2.12 (t, 1H, *J* = 12.4 Hz), 2.29 (d, 1H, *J* = 13.6 Hz), 2.33-2.44 (m, 1H), 2.58 (dd, J_1 = 4.4 Hz, J_2 = 15.6 Hz), 2.63 (dd, J_1 = 8.0 Hz, J_2 = 15.6 Hz), 3.25-3.30 (m, 1H), 3.34-3.41 (m, 1H), 3.64-3.69 (m, 1H), 3.70 (s, 3H), 3.78-3.83 (m, 1H), 3.91 (d, 1H, *J* = 14.0 Hz), 4.94 (d, 1H, *J* = 11.6 Hz), 4.95 (d, 1H, *J* = 16.0 Hz), 5.64 (dt, 1H, J_1 = 8.4 Hz, J_2 = 17.6 Hz), 5.71 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 21.1, 23.5, 31.5, 31.9, 34.2, 35.1, 41.0, 41.6, 42.3, 43.3, 51.0, 73.7, 73.8, 75.1, 75.5, 113.1, 114.9, 144.2, 156.2, 166.7, 175.9; IR (neat) cm^{-1} 3074w, 2930s, 2859m, 1717s, 1652m, 1437m, 1372m, 1259m, 1204m, 1158s, 1089s, 1020m, 912m, 801m; HRMS (MALDI, m/z) calcd for $C_{21}H_{32}O_6Na$ $(M+Na)^+$: 403.2091, found 403.2087.

Synthesis of 22



To a solution of **20** (2.28 g, 9.78 mmol) in CH_2Cl_2 (20 mL) was added slowly Bu_2BOTf (1.0 M in CH_2Cl_2, 9.78 mL, 9.78 mmol) at –78 °C under Ar. NEt_3 (1.56 mL, 11.25 mmol) was added to the orange solution where the color dissipated following the addition. The resulting yellow solution was allowed to stir for an additional 50 min at –78 °C, then at 0 °C for 15 min. The mixture was then

recooled to –78 °C and aldehyde **19**[5] (1.0 g, 4.89 mmol) in CH_2Cl_2 (5 mL) was added slowly via syringe. The resulting yellow solution was slowly warmed to –20 °C over 2 h and stirred at –15 °C for another 1 h. The solution was then warmed to –5 °C and quenched with phosphate buffer (25 mL, pH 7) in one portion. To this vigorously stirred mixture was added 30% H_2O_2 while maintaining the temperature below 5 °C. The addition of H_2O_2 was continued until the internal temperature was no longer affected by excess oxidant. The resulting mixture was stirred for 45 min while slowly warming to room temperature. The mixture was then quenched with sat aq $NaHCO_3$ (30 mL) and extracted with CH_2Cl_2 (3 × 30 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography **21** (1.73 g, 81% yield, *dr* ≥ 95:5) as a colorless, viscous oil. $[\alpha]^{D}_{20}$ = –44.9 (c 0.67 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.07 (s, 6H), 1.19 (d, 3H, J = 6.8 Hz), 2.15 (s, 2H), 2.80 (dd, 1H, J_1 = 9.6 Hz, J_2 = 13.2 Hz), 3.02 (d, 1H, J = 2.8 Hz), 3.26 (dd, 1H, J_1 = 2.8 Hz, J_2 = 13.6 Hz), 3.81-3.86 (m, 1H), 4.18-4.24 (m, 2H), 4.51 (d, 1H, J = 2.8 Hz), 4.67-4.72 (m, 1H), 5.95 (dd, 1H, J_1 = 2.8 Hz, J_2 = 18.8 Hz), 6.01 (d, 1H, J = 18.8 Hz), 7.00 (d, 2H, J = 7.2 Hz), 7.06 (t, 1H, J = 7.2 Hz), 7.19-7.22 (m, 4H), 7.27-7.37 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ -3.5, -3.4, 10.4, 25.9, 37.7, 42.2, 55.1, 66.2, 73.3, 124.0, 127.4, 128.1, 128.2, 128.9, 129.0, 129.4, 134.9, 139.7, 145.7, 153.0, 176.8; IR (neat) cm^{-1} 3510brm, 3026m, 2956s, 2924s, 1780s, 1697s, 1601m, 1493m, 1453m, 1386s, 1289m, 1243s, 1210s, 1111m, 997m, 835s; HRMS (MALDI, m/z) calcd for $C_{25}H_{31}NO_4SiNa$ $(M+Na)^+$: 460.1915, found 460.1918.

To a solution of NH(OMe)Me•HCl (45 mg, 0.46 mmol) in CH_2Cl_2 (1 mL) was added $AlMe_3$ (2.5 M in hexanes, 184 μL, 0.46 mmol) slowly at 0 °C. The reaction mixture was stirred at room temperature for 1 h and then cooled to –15 °C. After a solution of **21** (100 mg, 0.23 mmol) in CH_2Cl_2 (0.5 mL) was added dropwise, the mixture was warmed to 0 °C over 1 h. The reaction was quenched with sat aq potassium sodium tartrate (2 mL) and extracted with Et_2O (3 × 2 mL). The combined organic layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-20% of EtOAc/petroleum ether) to afford the amide (65 mg, 88% yield) as a colorless oil.

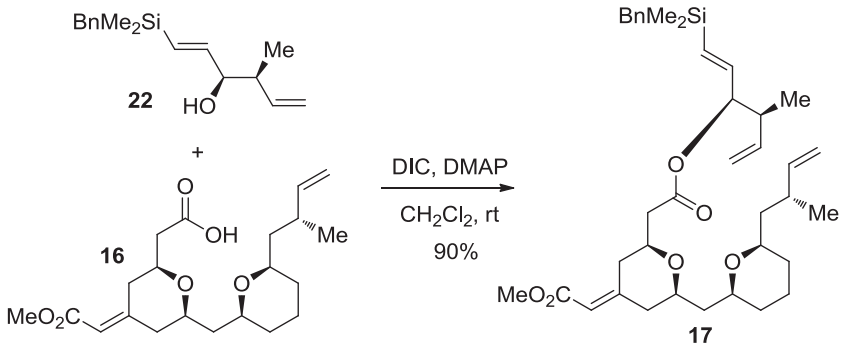
To a solution of the above amide (65 mg, 0.2 mmol) in anhydrous THF (1 mL) was added

5. S. E. Denmark, S. Fujimori, *J. Am. Chem. Soc.* **2005**, *127*, 8971–8973.

$LiAlH_4$ (15 mg, 0.40 mmol) at 0 °C. The reaction was stirred at 0 °C for 20 min before quenching with sat aq potassium sodium tartrate (1 mL) and extraction with Et_2O (3 × 2 mL). The combined organic layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-5% of EtOAc/petroleum ether) to afford the aldehyde (50 mg, 95% yield) as a colorless oil.

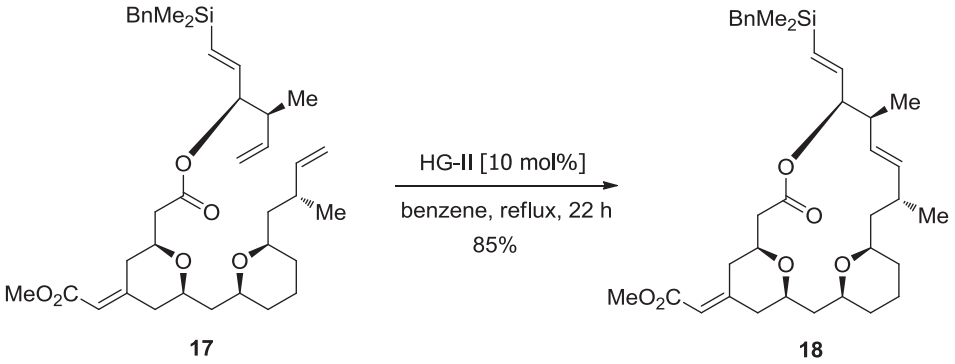
To a suspension of Ph_3PCH_3I (230 mg, 0.57 mmol) in anhydrous THF (2 mL) was added *t*-BuOK (64 mg, 0.57 mmol) under Ar at 0 °C. After stirring for 1 h, the above aldehyde (50 mg, 0.19 mmol) in anhydrous THF (0.5 ml) was added at –78 °C. The resulting mixture was warmed to room temperature and stirred for another 2 h. The reaction was quenched with sat aq NH_4Cl (1.5 mL) and extracted with Et_2O (3 × 3 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-4% of EtOAc/petroleum ether) to afford **22** (40 mg, 81% yield) as a colorless oil. $[\alpha]^D_{20}$ = –2.1 (c 0.90 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.09 (s, 6H), 1.02 (d, 3H, J = 7.2 Hz), 1.83 (d, 1H, J = 4.0 Hz), 2.17 (s, 2H), 2.35-2.40 (m, 1H), 4.03-4.04 (m, 1H), 5.11 (d, 1H, J = 16.8 Hz), 5.12 (d, 1H, J = 10.4 Hz), 5.77 (ddd, 1H, J_1 = 8.0 Hz, J_2 = 9.6 Hz, J_3 = 18.4 Hz), 5.86 (d, 1H, J = 18.8 Hz), 6.04 (dd, 1H, J_1 = 4.8 Hz, J_2 = 18.8 Hz), 7.02 (d, 2H, J = 7.2 Hz), 7.09 (t, 1H, J = 7.2 Hz), 7.22 (t, 2H, J = 7.6 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ -3.4, -3.3, 14.4, 26.0, 43.4, 77.0, 115.8, 124.0, 128.1, 128.2, 128.4, 139.8, 140.0, 147.2; IR (neat) cm^{-1} 3392brm, 3079m, 3024m, 2960s, 2926s, 2893m, 1601w, 1493m, 1455m, 1415m, 1250s, 1207m, 1154m, 994s, 912m, 835s; HRMS (MALDI, m/z) calcd for $C_{16}H_{24}OSiK$ $(M+K)^+$: 299.1228, found 299.1224.

Synthesis of 17



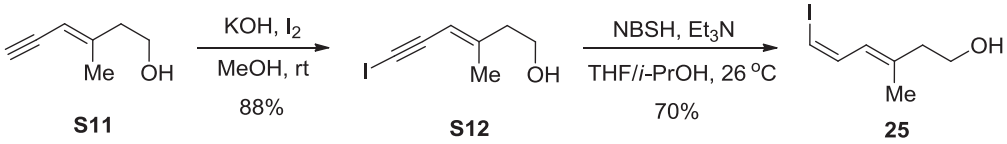
To a solution of **16** (95 mg, 0.25 mmol) and alcohol **22** (85 mg, 0.325 mmol) in CH_2Cl_2 (2 mL) was added DIC (47 mg, 0.375 mmol) and DMAP (3 mg, 0.025 mmol) at 0 °C. After stirring for 4 h at room temperature, the reaction was quenched with sat aq NH_4Cl (1.5 mL) and extracted with EtOAc (3 × 3 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-7% of EtOAc/petroleum ether) to afford **17** (140 mg, 90% yield) as a colorless oil. $[\alpha]^D_{20}$ = –21.2 (c 0.60 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.04 (s, 6H), 0.97 (d, 3H, J = 6.8 Hz), 0.99 (d, 3H, J = 6.4 Hz), 1.14-1.22 (m, 3H), 1.44-1.54 (m, 5H), 1.78-1.80 (m, 1H), 1.89 (t, 1H, J = 14.0 Hz), 1.91 (t, 1H, J = 12.8 Hz), 2.11 (t, 1H, J = 12.8 Hz), 2.13 (s, 2H), 2.28 (d, 1H, J = 12.8), 2.33-2.40 (m, 1H), 2.45 (dd, 1H, J_1 = 6.8 Hz, J_2 = 13.2 Hz), 2.53 (dd, 1H, J_1 = 4.4 Hz, J_2 = 15.2 Hz), 2.62 (dd, 1H, J_1 = 8.4 Hz, J_2 = 14.8 Hz), 3.25 (tm, 1H, J = 10.0 Hz), 3.34-3.39 (m, 1H), 3.61-3.65 (m, 1H), 3.69 (s, 3H), 3.80-3.86 (m, 1H), 3.90 (d, 1H, J = 14.0 Hz), 4.94 (d, 1H, J = 10.8 Hz), 4.95 (d, 1H, J = 16.4 Hz), 5.02 (d, 1H, J = 18.0 Hz), 5.03 (d, 1H, J = 10.0 Hz), 5.18 (t, 1H, J = 5.6 Hz), 5.63 (ddd, 1H, J_1 = 8.4 Hz, J_2 = 10.8 Hz, J_3 = 16.8 Hz), 5.66-5.75 (m, 2H), 5.78 (d, 1H, J = 18.8 Hz), 5.88 (dd, 1H, J_1 = 5.2 Hz, J_2 = 18.8 Hz), 6.98 (d, 2H, J = 7.6 Hz), 7.06 (t, 1H, J = 7.2 Hz), 7.19 (t, 2H, J = 7.6 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ -3.5, 15.2, 21.2, 23.6, 25.9, 31.6, 32.0, 34.3, 35.3, 41.3, 41.6, 41.7, 42.5, 43.4, 51.0, 73.6, 74.2, 74.9, 75.4, 78.9, 113.1, 114.7, 115.4, 124.0, 128.1, 128.2, 130.4, 139.3, 139.7, 142.7, 144.3, 156.8, 166.8, 170.0; IR (neat) cm^{-1} 2959s, 2920s, 2851s, 1718s, 1654m, 1519w, 1462m, 1374m, 1260s, 1155s, 1088s, 1021s, 912m, 802s; HRMS (MALDI, m/z) calcd for $C_{37}H_{54}O_6SiNa$ $(M+Na)^+$: 645.3582, found 645.3578.

Synthesis of 18



A solution of ester **17** (76 mg, 0.122 mmol) and Hoveyda-Grubbs 2nd generation catalyst (HG-II) (8 mg, 0.012 mmol) in benzene (25 ml) was reflux for 22 h. After the reaction was cooled to room temperature, the solvent was removed under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-5% of EtOAc/petroleum ether) to afford macrocycle **18** (62 mg, 85% yield) as a colorless oil. $[\alpha]^{D}_{20}$ = –30.7 (c 0.38 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.04 (s, 3H), 0.05 (s, 3H), 0.94 (d, 3H, *J* = 6.8 Hz), 0.95 (d, 3H, *J* = 6.8 Hz), 1.02-1.21 (m, 3H), 1.35-1.56 (m, 5H), 1.74-1.80 (m, 2H), 1.99 (t, 1H, *J* = 12.4 Hz), 2.10-2.15 (m, 3H), 2.34 (t, 1H, *J* = 12.4 Hz), 2.31-2.35 (m, 1H), 2.49-2.56 (m, 1H), 2.57-2.63 (m, 2H), 3.16-3.23 (m, 2H), 3.29 (t, 1H, *J* = 10.0 Hz), 3.70 (s, 3H), 3.79-3.85 (m, 1H), 3.89 (d, 1H, *J* = 13.6 Hz), 5.07 (dd, 1H, J_1 = 9.6 Hz, J_2 = 14.8 Hz), 5.17-5.18 (m, 1H), 5.50 (dd, 1H, J_1 = 9.6 Hz, J_2 = 15.2 Hz), 5.68 (d, 1H, *J* = 18.8 Hz), 5.70 (s, 1H), 5.87 (dd, 1H, J_1 = 4.4 Hz, J_2 = 18.8 Hz), 6.98 (d, 2H, *J* = 7.2 Hz), 7.07 (t, 1H, *J* = 7.2 Hz), 7.20 (t, 2H, *J* = 7.2 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ -3.5, -3.4, 14.2, 21.8, 23.9, 26.0, 31.6, 32.4, 33.0, 34.8, 41.3, 41.4, 42.5, 43.1, 44.0, 51.0, 74.2, 74.8, 75.3, 76.0, 79.9, 115.0, 124.0, 128.1, 128.2, 128.3, 132.7, 135.3, 139.7, 144.0, 156.8, 166.8, 170.5; IR (neat) cm^{-1} 2961s, 2919s, 2851s, 1738s, 1722s, 1653m, 1458m, 1437m, 1374m, 1260s, 1154s, 1089s, 1019s, 800s; HRMS (MALDI, m/z) calcd for $C_{35}H_{50}O_6SiNa$ $(M+Na)^+$: 617.3269, found 617.3270.

Synthesis of 25



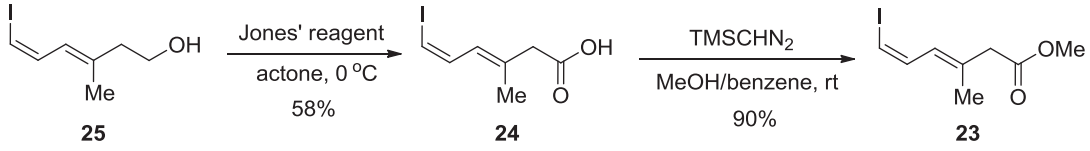
To a solution of **S11**[6] (220 mg, 2.0 mmol) in MeOH (5 mL) was added sequentially a solution of

6. M. S. Kwon, S. K. Woo, S. W. Na, E. Lee, *Angew. Chem.* **2008**, *120*, 1757–1759; *Angew. Chem. Int. Ed.* **2008**, *47*, 1733–1735.

KOH (281 mg, 5.0 mmol) in H_2O (1 mL) and I_2 (661 mg, 2.6 mmol) at 0 °C. After stirring at room temperature for 3 h, the reaction was diluted with H_2O (3 mL) and extracted with Et_2O (3 × 5 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-10% of diethyl ether/petroleum ether) to afford **S12** (415 mg, 88% yield) as a yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.96 (s, 3H), 2.35 (t, 2H, J = 6.4 Hz), 3.72 (t, 2H, J = 6.4 Hz), 5.48 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 7.1, 19.3, 41.3, 60.2, 91.9, 107.6, 151.2; IR (neat) cm^{-1} 3444brs, 2974s, 2933s, 1718s, 1381m, 1218s, 1172s, 1077s, 759s; HRMS (MALDI, m/z) calcd for $C_7H_{10}IO$ $(M+H)^+$: 236.9771, found 236.9773.

To a solution of **S12** (100 mg, 0.424 mmol) in THF/*i*-PrOH (1:1, 3 mL) were added Et_3N (95 μL, 0.68 mmol) and *o*-nitrobenzenesulfonyl hydrazide (NBSH) (166 mg, 0.763 mmol) at room temperature. After stirring in dark at room temperature for 15 h, the reaction was diluted with H_2O (2 mL) and sat aq NaCl (2 mL), and extracted with Et_2O (2 × 5 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-10% of diethyl ether/petroleum ether) to afford **25** (71 mg, 70 % yield) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.85 (s, 3H), 2.40 (t, 2H, J = 6.4 Hz), 3.77 (t, 2H, J = 6.4 Hz), 6.05 (d, 1H, J = 10.0 Hz), 6.23 (d, 1H, J = 7.6 Hz), 6.92 (dd, 1H, J_1 = 7.6 Hz, J_2 = 10.0 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 17.9, 42.9, 60.4, 81.9, 127.4, 134.1, 140.8; IR (neat) cm^{-1} 3447brs, 2953s, 2924s, 2855s, 1644m, 1461m, 1368m, 1285m, 1262m, 1030m, 800m; HRMS (MALDI, m/z) calcd for $C_7H_{11}IONa$ $(M+Na)^+$: 260.9747, found 260.9743.

Synthesis of 23

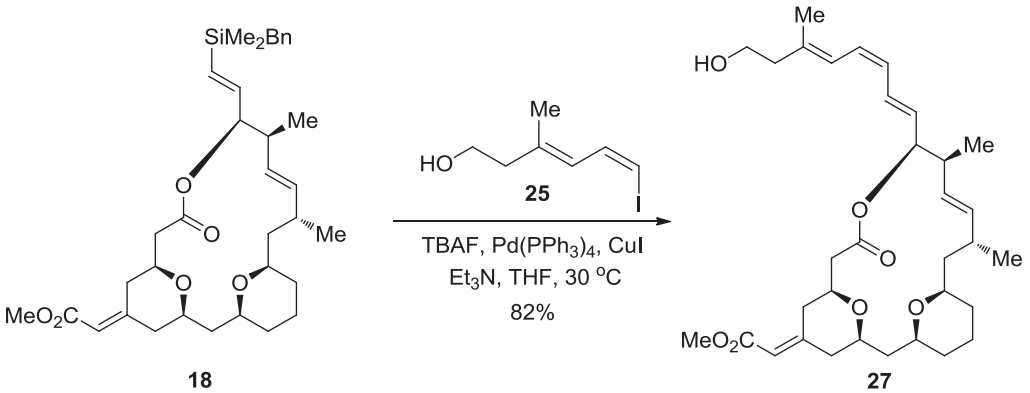


To a solution of **25** (70 mg, 0.294 mmol) in acetone (3 mL) was added freshly prepared Jones' reagent (2.23 M, 435 μL, 0.97 mmol) at 0 °C. The reaction was stirred for 20 min at 0 °C before quenching with *i*-PrOH (0.2 ml). The resulting mixture was diluted with H_2O (1.5 mL) and

extracted with Et_2O (3 × 3 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-8% of diethyl ether/petroleum ether) to afford acid **24** (43 mg, 58% yield) as a yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.90 (s, 3H), 3.18 (s, 2H), 6.10 (d, 1H, J = 10.0 Hz), 6.31 (d, 1H, J = 7.6 Hz), 6.91 (dd, 1H, J_1 = 8.0 Hz, J_2 = 10.0 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 18.2, 44.7, 83.5, 129.5, 133.9, 135.7, 176.9; IR (neat) cm^{-1} 3069m, 2922s, 2852m, 1707s, 1645m, 1412m, 1287s, 1238m, 1214m, 1167m, 1018w, 931m; HRMS (MALDI, m/z) calcd for $C_7H_9IO_2K$ $(M+K)^+$: 290.9279, found 290.9280.

To a solution of **24** (42 mg, 0.167 mmol) in MeOH (330 μL) and benzene (1.19 mL) was added $TMSCHN_2$ (2.0 M in hexanes, 167 μL, 0.334 mmol) at 0 °C. After stirring for 10 min at room temperature, AcOH was added dropwise until yellow color dissipated to a colorless solution. This reaction was diluted with H_2O (2.5 mL) and extracted with Et_2O (3 × 4 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-1% of diethyl ether/petroleum ether) to afford ester **23** (40 mg, 90% yield) as a yellow oil. ^{1}H NMR (600 MHz, $CDCl_3$) δ 1.88 (s, 3H), 3.15 (s, 2H), 3.71 (s, 3H), 6.08 (d, 1H, J = 10.2 Hz), 6.29 (d, 1H, J = 7.8 Hz), 6.91 (dd, 1H, J_1 = 7.8 Hz, J_2 = 9.6 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 18.2, 45.0, 52.0, 83.1, 129.0, 134.0, 136.5, 171.2; IR (neat) cm^{-1} 3067m, 2920s, 2849m, 1727s, 1643m, 1412m, 1287s, 1248m, 1166m, 1025m; HRMS (MALDI, m/z) calcd for $C_8H_{11}IO_2Na$ $(M+Na)^+$: 288.9696, found 288.9698.

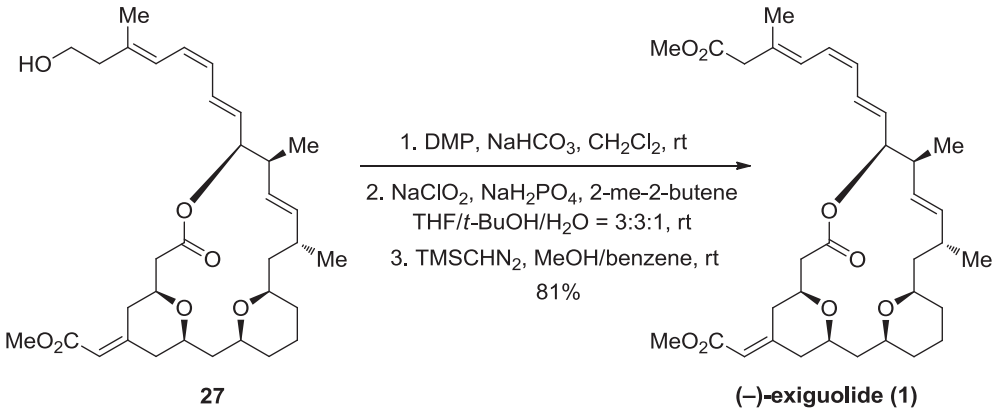
Synthesis of 27



To a solution of **18** (25 mg, 0.042 mmol) in anhydrous THF (1 mL) was added TBAF (1.0 M in

THF, 126 μL, 0.126 mmol) at 0 ^{o}C under Ar. The reaction was stirred at 0 ^{o}C for 20 min before the sequential addition of $Pd(PPh_3)_4$ (5 mg, 0.0042 mmol), CuI (8 mg, 0.042 mmol), Et_3N (17 μL, 0.126 mmol) and **26** (15 mg, 0.063 mmol) in anhydrous THF (0.5 mL). The reaction was allowed to warm to 30 ^{o}C and stirred for 3 h. The solvent was removed under reduced pressure and the residue was purified by silica gel chromatography (gradient eluent: 0-30% of EtOAc/petroleum ether) to afford **27** (19 mg, 82% yield) as a colorless, viscous oil. $[\alpha]^{D}_{20}$ = –69.1 (c 0.25 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.94 (d, 3H, *J* = 6.4 Hz), 1.06 (d, 3H, *J* = 6.8 Hz), 1.07-1.28 (m, 3H), 1.37-1.62 (m, 4H), 1.67 (d, 1H, *J* = 4.4 Hz), 1.73-1.80 (m, 2H), 1.81 (s, 3H), 1.94-2.04 (m, 2H), 2.12 (dm, 1H, *J* = 13.2 Hz), 2.20-2.28 (m, 1H), 2.33-2.41 (m, 3H), 2.48-2.61 (m, 3H), 3.17-3.25 (m, 2H), 3.30 (dd, 1H, J_1 = 9.2 Hz, J_2 = 10.0 Hz), 3.70 (s, 3H), 3.73-3.82 (m, 3H), 3.87 (dm, 1H, *J* = 14.0 Hz), 5.08 (dd, 1H, J_1 = 9.6 Hz, J_2 = 15.2 Hz), 5.26 (dm, 1H, *J* = 6.8 Hz), 5.53 (dd, 1H, J_1 = 9.6 Hz, J_2 = 15.2 Hz), 5.66 (dd, 1H, J_1 = 6.8 Hz, J_2 = 15.2 Hz), 5.70 (s, 1H), 5.93 (dd, 1H, J_1 = 10.8 Hz, J_2 = 11.2 Hz), 6.19 (t, 1H, *J* = 11.2 Hz), 6.37 (dm, 1H, *J* = 11.6 Hz), 6.69 (dd, 1H, J_1 = 11.2 Hz, J_2 = 14.8 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.4, 16.3, 21.8, 23.9, 31.6, 32.5, 33.0, 34.8, 41.6, 42.2, 42.5, 43.1, 43.4, 44.1, 51.1, 60.4, 74.2, 74.9, 75.3, 76.0, 78.7, 115.0, 122.8, 125.7, 127.1, 127.6, 131.0, 132.5, 135.4, 136.5, 156.8, 166.8, 170.7; IR (neat) cm^{-1} 3434brm, 2956s, 2858s, 1723s, 1654m, 1441m, 1373m, 1242s, 1156s, 1094s, 979m, 863m, 801m; HRMS (MALDI, m/z) calcd for $C_{33}H_{48}O_7Na$ $(M+Na)^+$: 579.3292, found 579.3296.

Synthesis of (–)-Exiguolide (1)



To a mixture of alcohol **27** (10 mg, 0.018 mmol) and $NaHCO_3$ (15 mg, 0.18 mmol) in CH_2Cl_2 (1.0 mL) was added Dess-Martin periodinane (DMP) (16 mg, 0.036 mmol) at 0 °C under Ar. The

reaction was warmed to room temperature over 1 h before quenching with sat aq $Na_2S_2O_3$ (0.3 mL) and extraction with CH_2Cl_2 (3 × 2 mL). The combined organic layers were washed with sat aq NaCl, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure to give the crude aldehyde. This intermediate was used for the next step without any further purification.

To a solution of the above aldehyde, 2-methylbut-2-ene (100 μL) and NaH_2PO_4 (7.6 mg, 0.063 mmol) in THF/t-BuOH/H_2O (3:3:1, 0.7 mL) was added $NaClO_2$ (5.7 mg, 0.063 mmol) at 0 ^oC. The reaction mixture was warmed to room temperature over 1 h before quenching with sat aq $Na_2S_2O_3$ (0.5 mL) and extraction with EtOAc (3 × 1 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure to give the crude acid. This intermediate was used for the next step without any further purification.

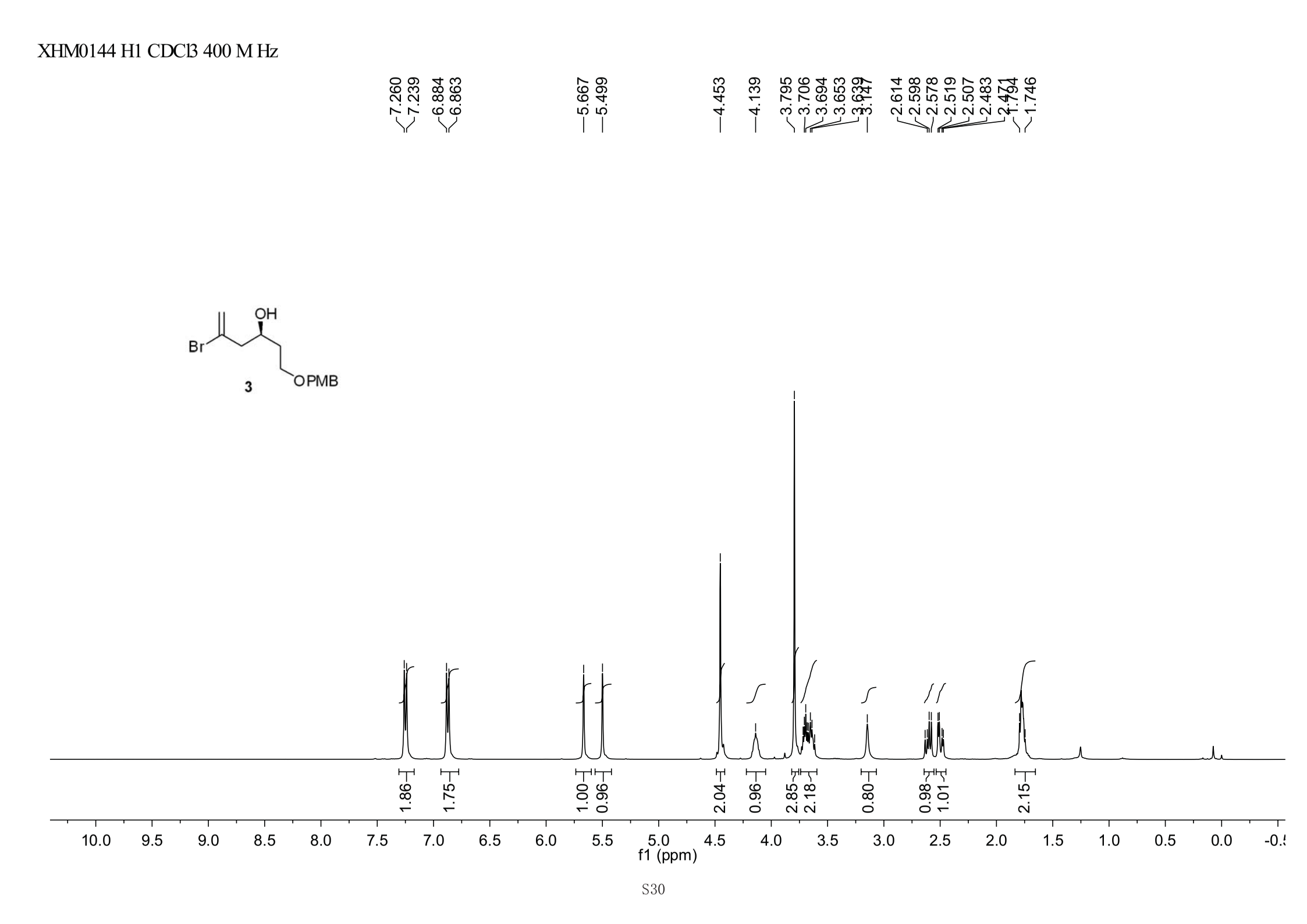
To a solution of the above acid in MeOH (100 μL) and benzene (0.4 mL) was added $TMSCHN_2$ (2.0 M in hexanes, 18 μL, 0.036 mmol) at 0 ^oC. After stirring for 10 min at room temperature, the reaction was quenched with AcOH (5 μL)/H_2O (0.5 mL) and extracted with EtOAc (3 × 1 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (gradient eluent: 0-12% of EtOAc/petroleum ether) to afford (–)-exiguolide (**1**) (8.4 mg, 81% yield) as a viscous oil. $[\alpha]^D_{20}$ = –84.6 (c 0.09 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.94 (d, 3H, J = 6.4 Hz), 1.05 (d, 3H, J = 7.2 Hz), 1.07-1.28 (m, 3H), 1.37-1.62 (m, 5H), 1.75-1.81 (m, 2H), 1.85 (s, 3H), 1.97 (dd, 1H, J_1 = 12.8 Hz, J_2 = 13.6 Hz), 2.12 (dm, 1H, J = 13.2 Hz), 2.23 (dd, 1H, J_1 = 11.2 Hz, J_2 = 12.8 Hz), 2.34 (dq, 1H, J_1 = 7.2 Hz, J_2 = 10.0 Hz), 2.48-2.58 (m, 3H), 3.13 (s, 2H), 3.18-3.21 (m, 2H), 3.30 (dd, 1H, J_1 = 9.2 Hz, J_2 = 9.6 Hz), 3.70 (s, 3H), 3.70 (s, 3H), 3.79 (m, 1H), 3.87 (dm, 1H, J = 14.0 Hz), 5.07 (dd, 1H, J_1 = 10.0 Hz, J_2 = 15.2 Hz), 5.26 (dm, 1H, J = 7.2 Hz), 5.52 (dd, 1H, J_1 = 9.6 Hz, J_2 = 14.8 Hz), 5.66 (dd, 1H, J_1 = 6.8 Hz, J_2 = 15.2 Hz), 5.70 (s, 1H), 5.97 (dd, 1H, J_1 = 10.8 Hz, J_2 = 11.2 Hz), 6.19 (dd, 1H, $J_1 = J_2$ = 11.2 Hz), 6.38 (dm, 1H, J = 11.2 Hz), 6.67 (dd, 1H, J_1 = 11.2 Hz, J_2 = 14.8 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.4, 16.8, 21.8, 23.9, 31.6, 32.4, 33.0, 34.7, 41.6, 42.1, 42.4, 43.1, 44.1, 45.4, 51.1, 51.9, 74.1, 74.9, 75.3, 76.0, 78.6, 114.9, 124.1, 125.5, 127.6, 128.0, 131.3, 132.5, 135.4, 156.8, 166.8, 170.7, 171.8; IR (neat) cm^{-1} 3341m, 2950s, 2920s, 2842s, 1731m, 1650m, 1430m, 1367m, 1235m, 1150m, 1088m, 970m, 852m; HRMS (MALDI, m/z) calcd for $C_{34}H_{48}O_8Na$ $(M+Na)^+$: 607.3241, found 607.3246.

3. Comparison of NMR Spectral Data of Isolated and Synthetic (-)-Exiguolide

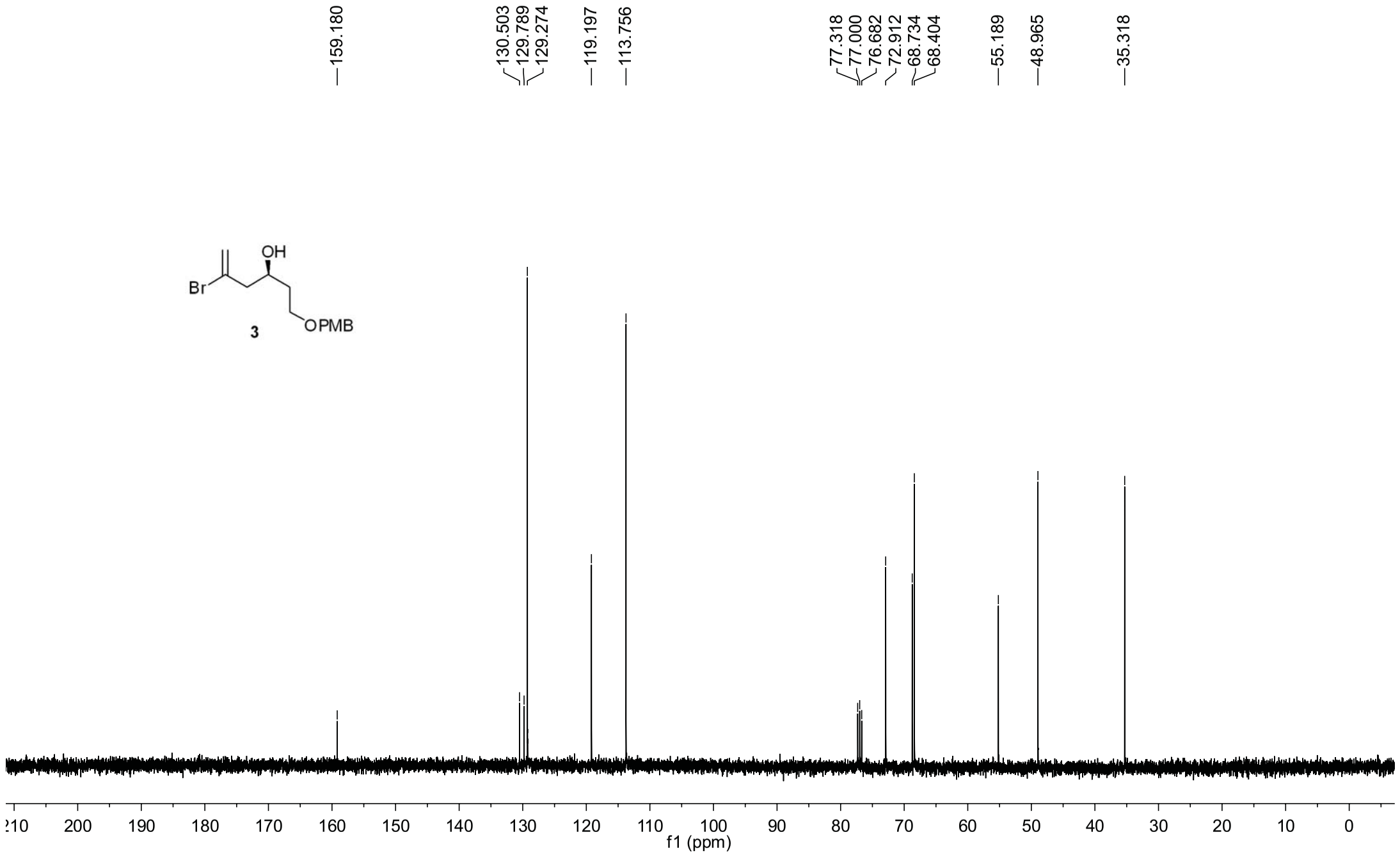
^{13}C NMR of Isolated (–)-Exiguolide	*^{13}C NMR of Synthetic (–)-Exiguolide*
171.8	171.8
170.7	170.7
166.8	166.8
156.7	156.8
135.5	135.4
132.5	132.5
131.4	131.3
128.0	128.0
127.6	127.6
125.5	125.5
124.1	124.1
115.0	114.9
78.6	78.6
76.0	76.0
75.4	75.3
74.9	74.9
74.2	74.1
51.9	51.9
51.0	51.1
45.4	45.4
44.1	44.1
43.1	43.1
42.5	42.4
42.1	42.1
41.6	41.6
34.8	34.7
33.1	33.0
32.5	32.4
31.6	31.6
23.9	23.9
21.8	21.8
16.8	16.8
14.4	14.4

^{1}H NMR of Isolated (–)-Exiguolide	^{1}H NMR of Synthetic (–)-Exiguolide
6.67 (dd, J = 15.3, 11.6 Hz, 1H)	6.67 (dd, J_1 = 11.2 Hz, J_2 = 14.8 Hz, 1H)
6.38 (br d, J = 11.6 Hz, 1H)	6.38 (dm, J = 11.2 Hz, 1H)
6.19 (dd, J = 11.6, 11.0 Hz, 1H)	6.19 (dd, J_1 = J_2 = 11.2 Hz, 1H)
5.97 (dd, J = 11.6, 11.0 Hz, 1H)	5.97 (dd, J_1 = 10.8 Hz, J_2 = 11.2 Hz, 1H)
5.70 (s, 1H))	5.70 (s, 1H)
5.66 (dd, J = 15.3, 7.3 Hz, 1H)	5.66 (dd, J_1 = 6.8 Hz, J_2 = 15.2 Hz, 1H)
5.52 (dd, J = 15.3, 9.8 Hz, 1H)	5.52 (dd, J_1 = 9.6 Hz, J_2 = 14.8 Hz, 1H)
5.26 (br d, J = 7.3 Hz, 1H)	5.26 (dm, J = 7.2 Hz, 1H)
5.08 (dd, J = 15.3, 9.8 Hz, 1H)	5.07 (dd, J_1 = 10.0 Hz, J_2 = 15.2 Hz, 1H)
3.87 (br d, J = 13.4 Hz, 1H)	3.87 (dm, J = 14.0 Hz, 1H)
3.79 (dddd, J = 12.8, 11.0, 4.3, 2.4 Hz, 1H)	3.79 (m, 1H)
3.69 (s, 3H)	3.70 (s, 3H)
3.70 (s, 3H)	3.70 (s, 3H)
3.30 (br dd, J = 11.0, 8.5 Hz, 1H)	3.30 (dd, J_1 = 9.2 Hz, J_2 = 9.6 Hz, 1H)
3.21 (br t, J = 11.0, 1H)	3.18-3.21 (m, 2H)
3.19(br dd, J = 11.3, 9.2 Hz, 1H))	
3.13 (s, 2H)	3.13 (s, 2H)
2.57 (dd, J = 14.0, 11.0 Hz, 1H)	2.48-2.58 (m, 3H)
2.55 (dd, J = 14.0, 2.4 Hz, 1H)	
2.53 (m, 1H)	
2.34 (br dq, J = 9.8, 7.3 Hz, 1H)	2.34 (dq, J_1 = 7.2 Hz, J_2 = 10.0 Hz, 1H)
2.23 (br dd, J = 12.8, 11.3 Hz, 1H)	2.23 (dd, J_1 = 11.2 Hz, J_2 = 12.8 Hz, 1H)
2.12 (br d, J = 12.8 Hz, 1H)	2.12 (dm, J = 13.2 Hz, 1H)
1.97 (dd, J = 13.4, 12.8 Hz, 1H)	1.97 (dd, J_1 = 12.8 Hz, J_2 = 13.6 Hz, 1H)
1.85 (s, 3H)	1.85 (s, 3H)
1.78 (br dd, J = 13.4, 9.2 Hz, 1H)	1.75-1.81 (m, 2H)
1.77 (br d, J = 12.8 Hz, 1H)	
1.62 (br d, J = 12.8 Hz, 1H)	1.37-1.62 (m, 5H)
1.56 (br dd, J = 13.4, 8.5 Hz, 1H)	
1.51 (m, 1H)	
1.47 (ddd, J = 14.0, 11.0, 3.1 Hz, 1H)	
1.41(br d, J = 12.8 Hz, 1H)	
1.21 (br dddd, J = 12.8, 11.0, 11.0, 3.7 Hz, 1H)	1.07-1.28 (m, 3H)
1.12 (br ddd, J = 12.8, 11.0, 11.0 Hz, 1H)	
1.09 (br dd, J = 14.0, 12.2 Hz, 1H)	
1.05 (d, J = 7.3 Hz, 3H)	1.05 (d, J = 7.2 Hz, 3H)
0.94 (d, J = 6.7 Hz, 3H)	0.94 (d, J = 6.4 Hz, 3H)

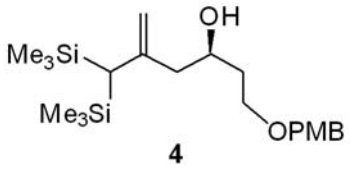
XHM0144 H1 CDCl3 400 M Hz



XHM0144 C13 CDCl3 100 M Hz

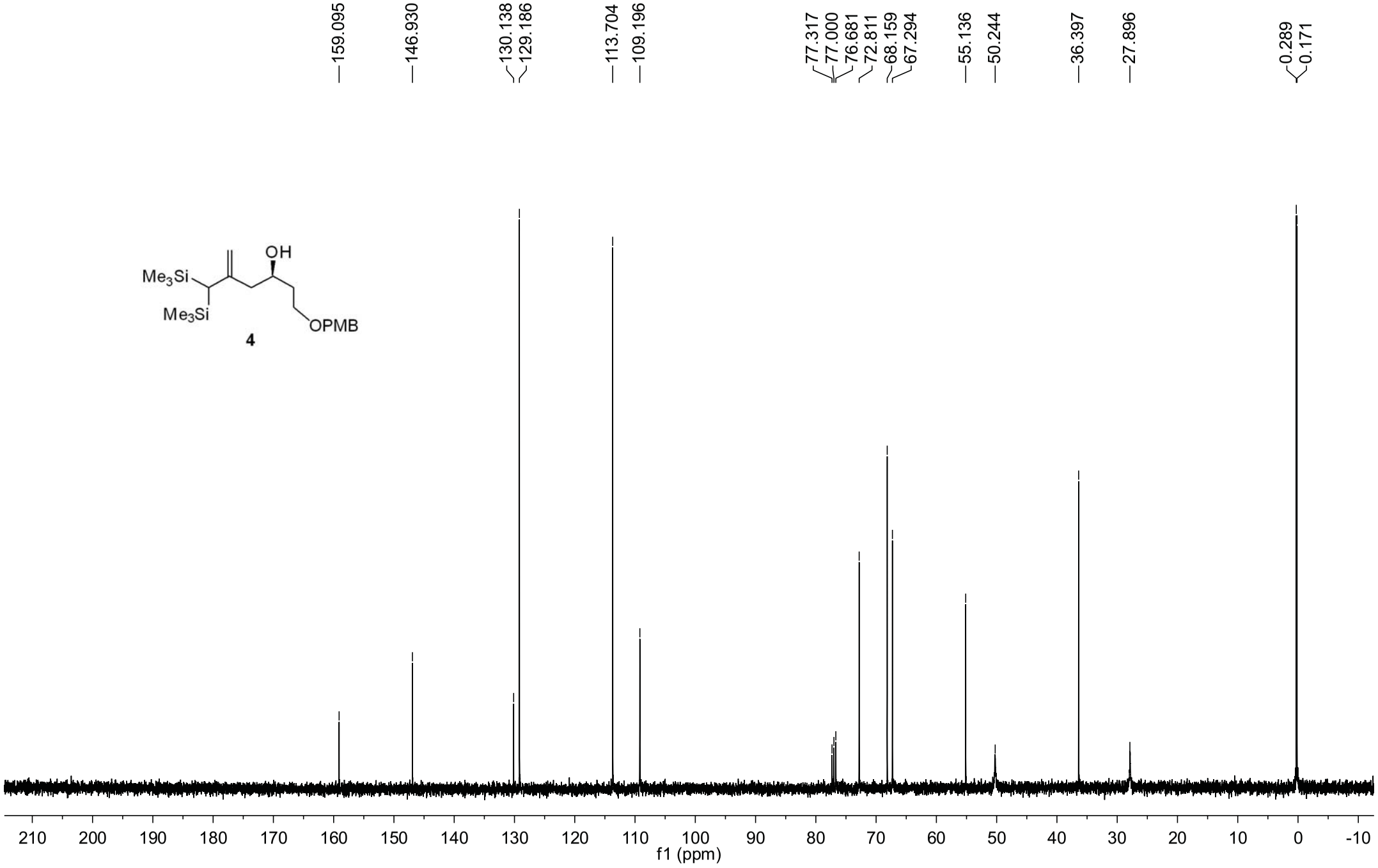


XHM0219 H1 CDCl3 400 M Hz

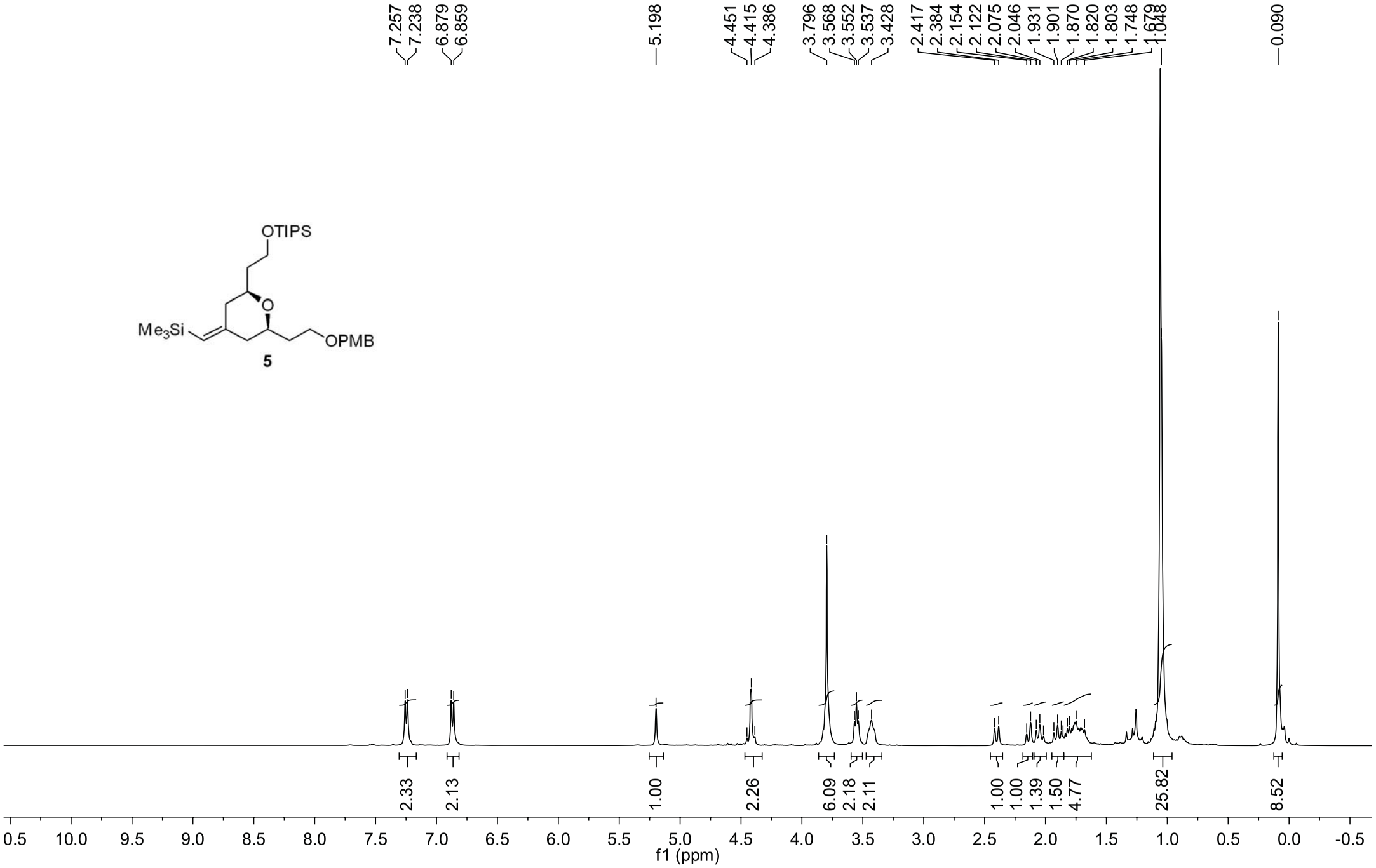


4

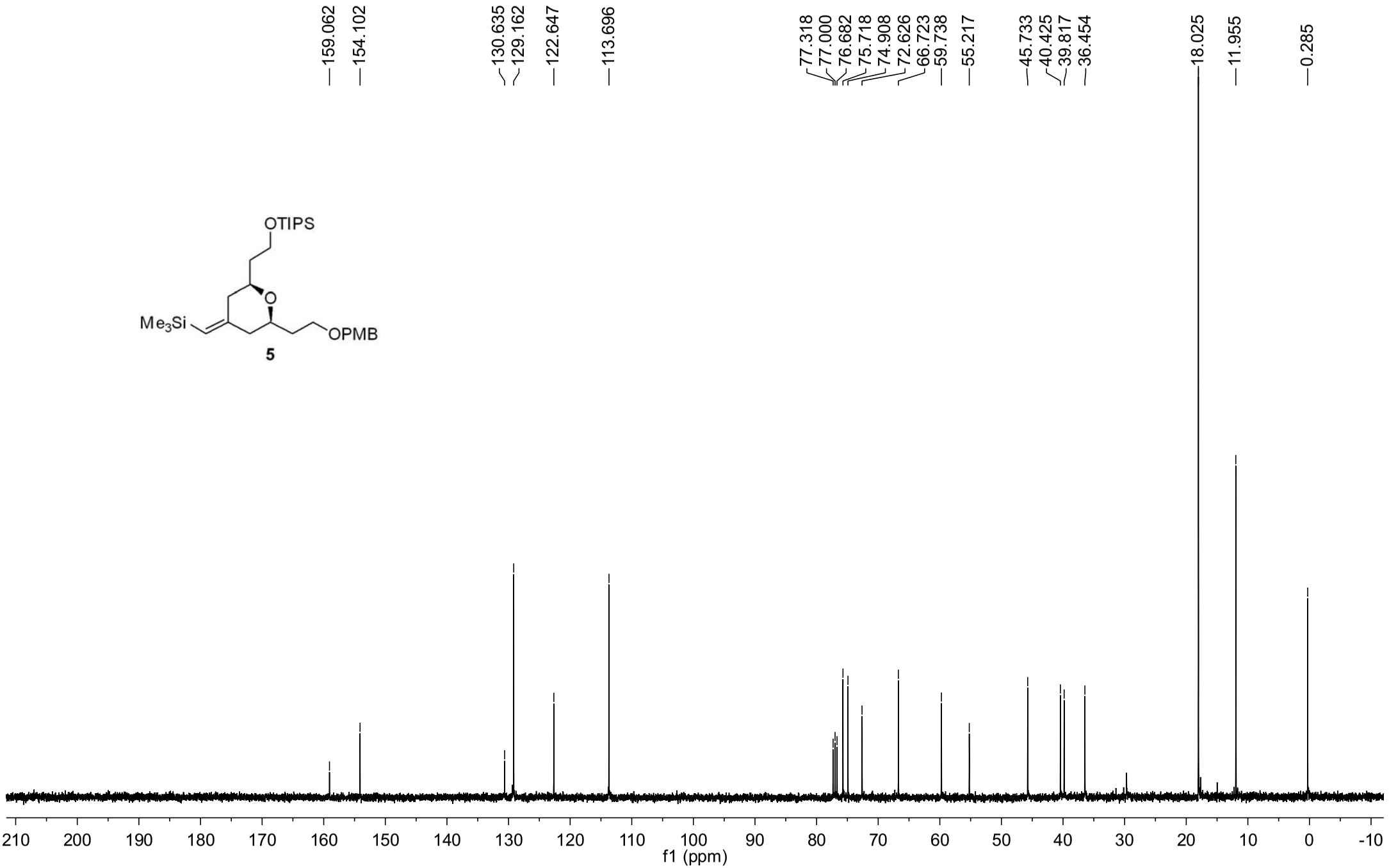
XHM0219 C13 CDCl3 100 M Hz



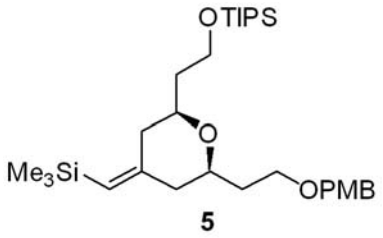
LHZ0558 H1 CDCl3 400 M Hz



LHZ0558 C13 CDCl3 100 M Hz



LHZ0558 gCOSY CDCl3 400 M Hz



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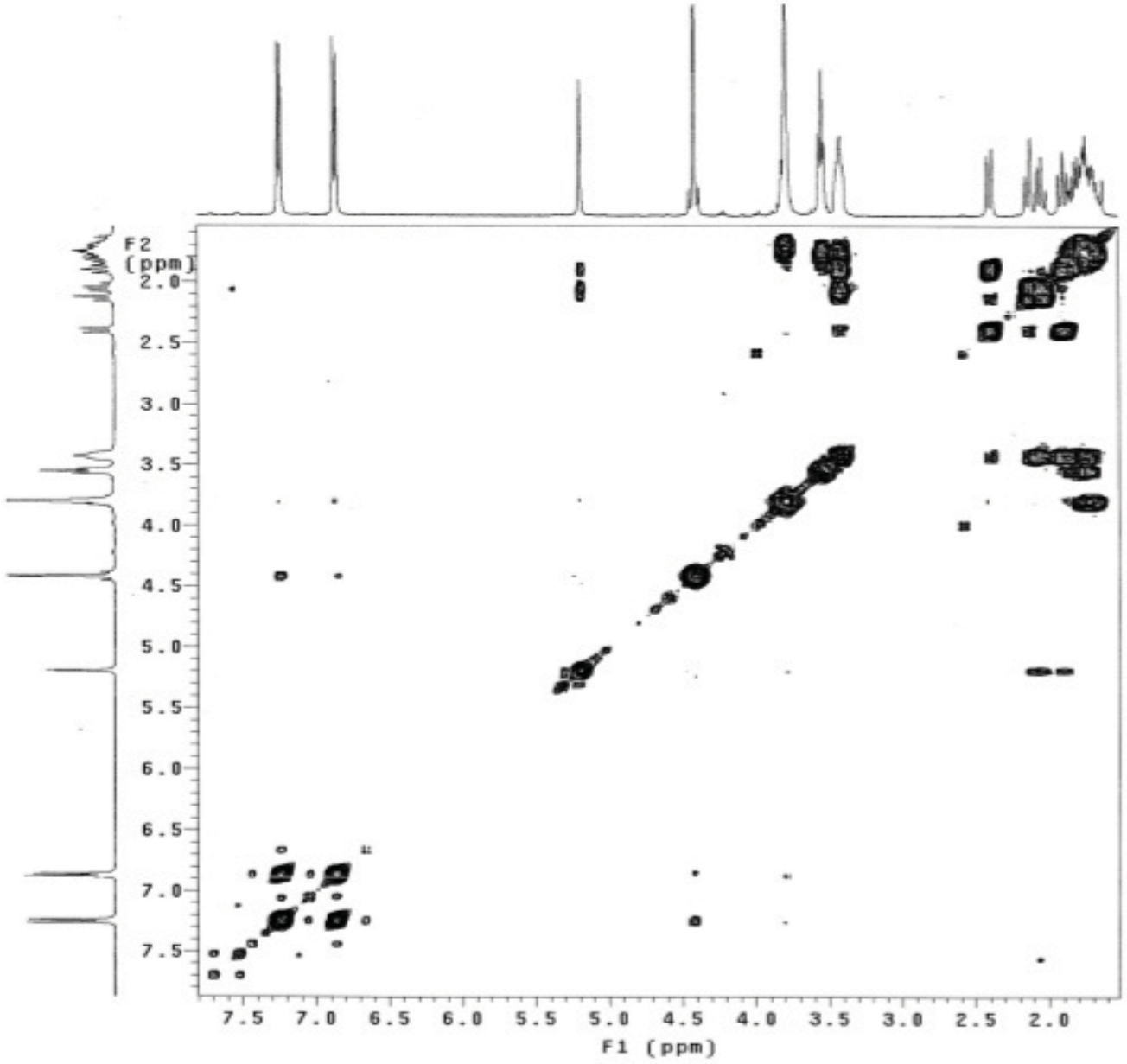
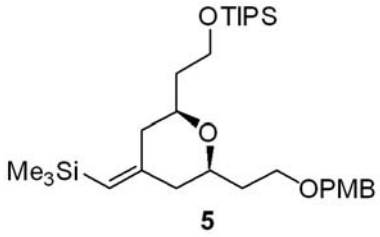


LHZ0558 gCOSY CDCl3 400 M Hz



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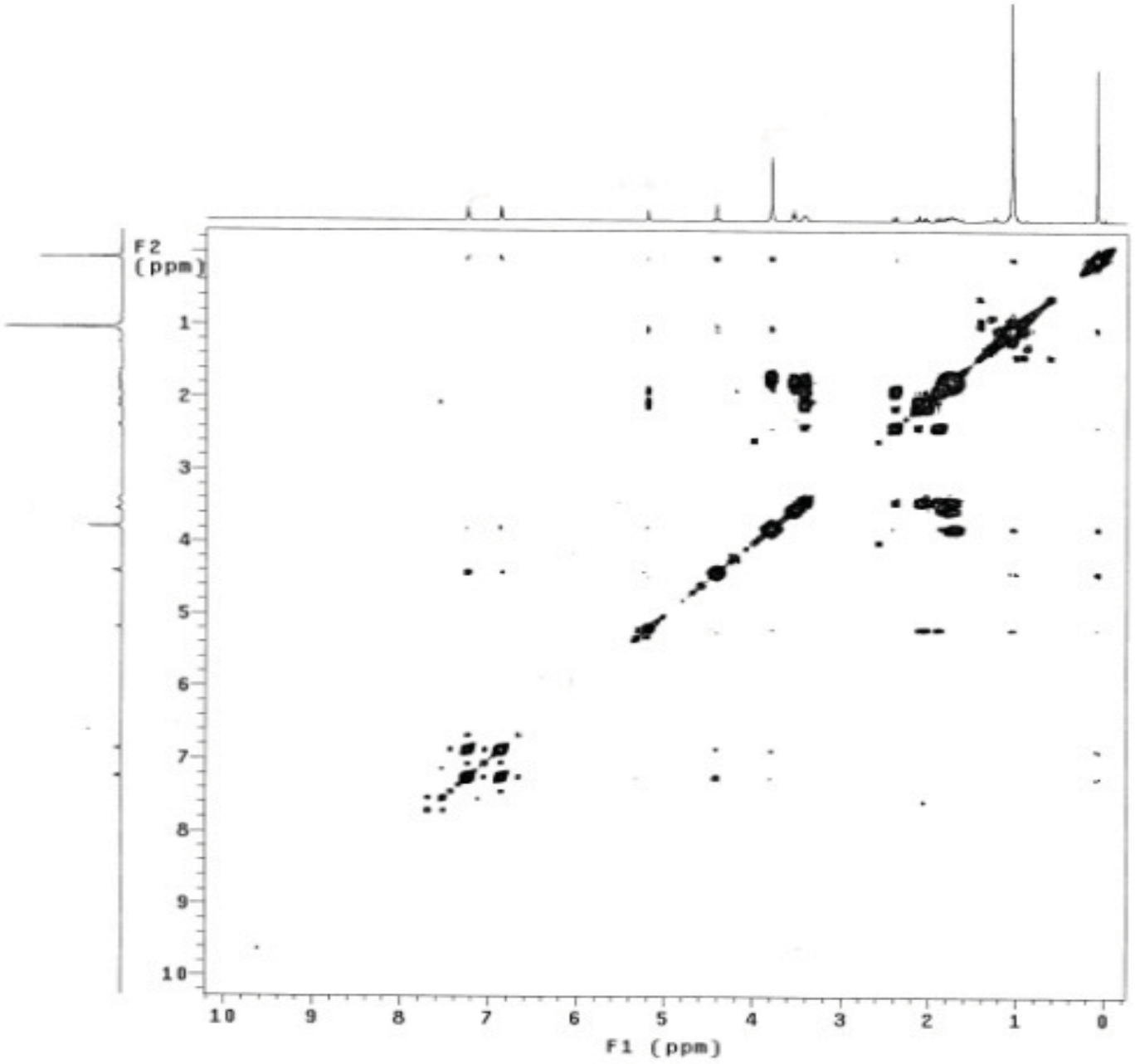
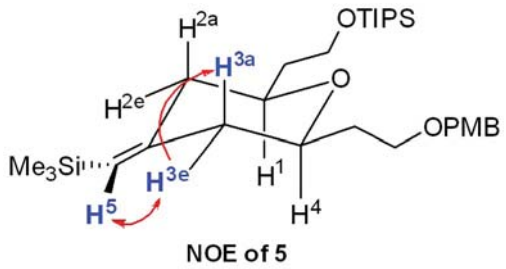
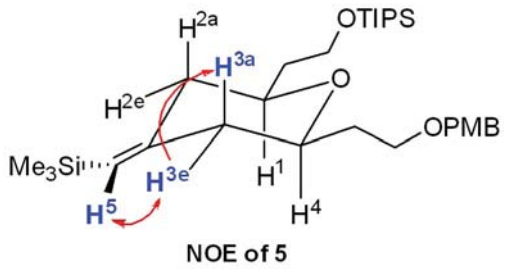


LHZ0558 NOEDS CDCl3 5.20 600 M Hz



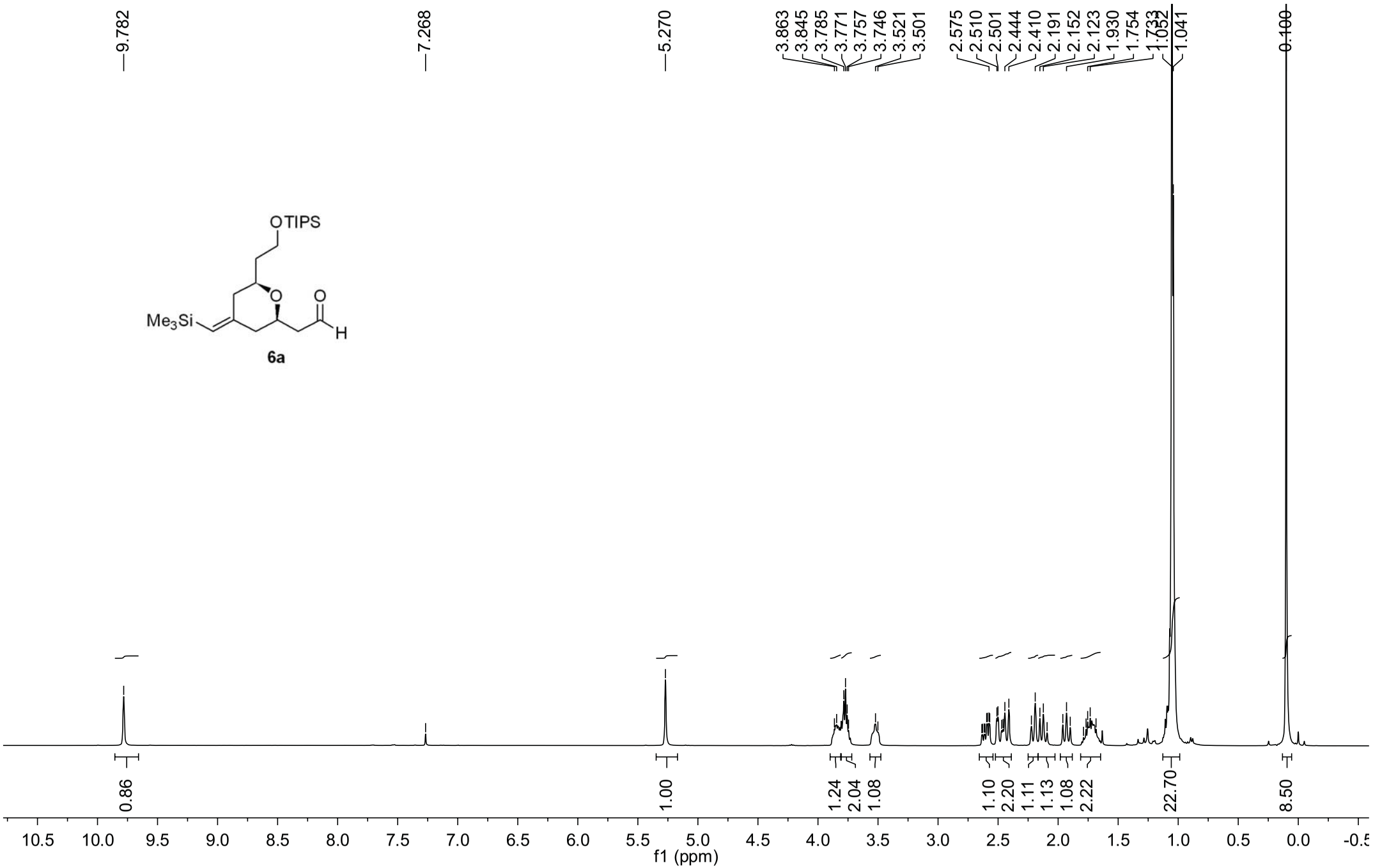
NOE of 5

LHZ0558 NOEDS CDCl3 2.14 600 M Hz

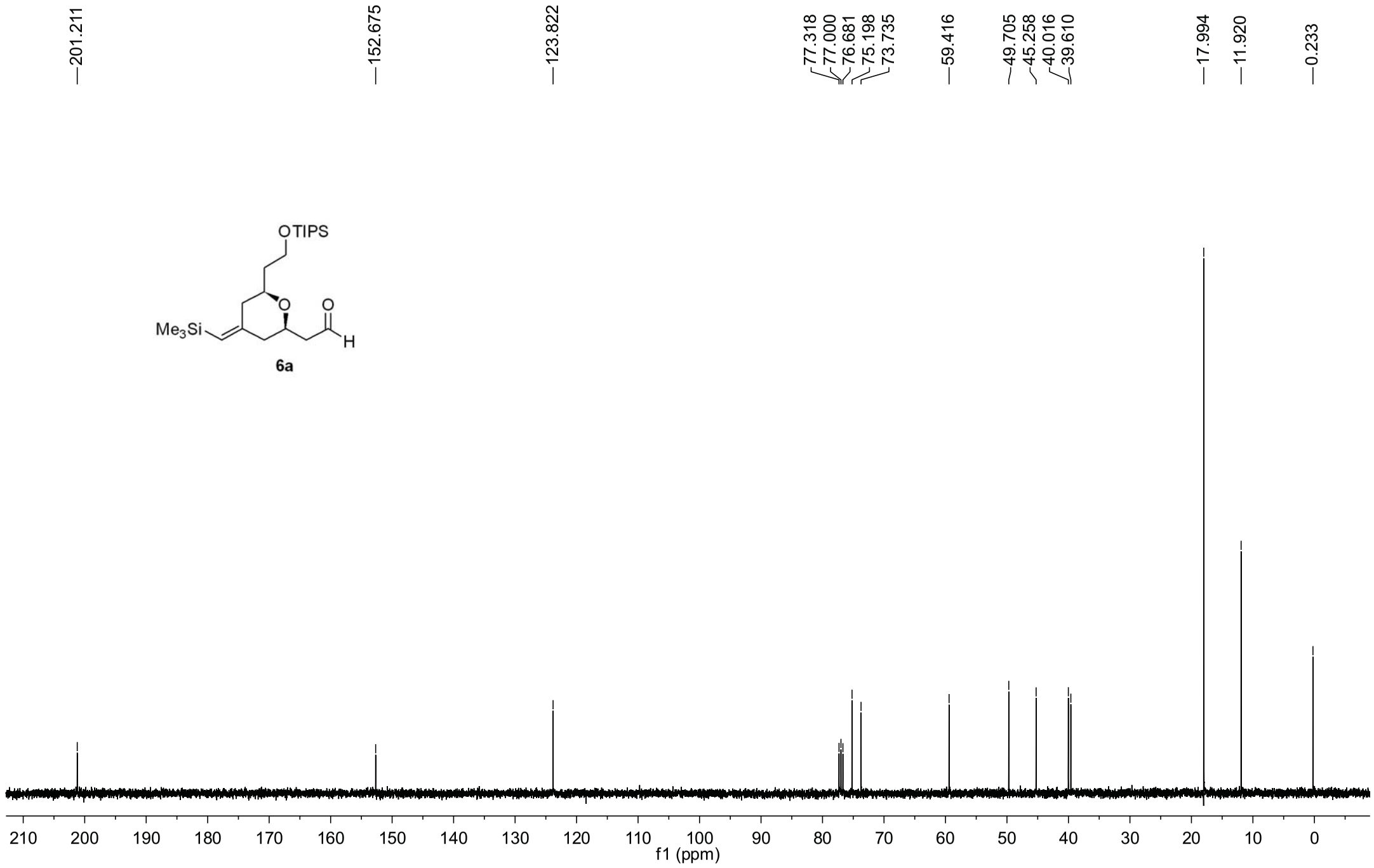


NOE of 5

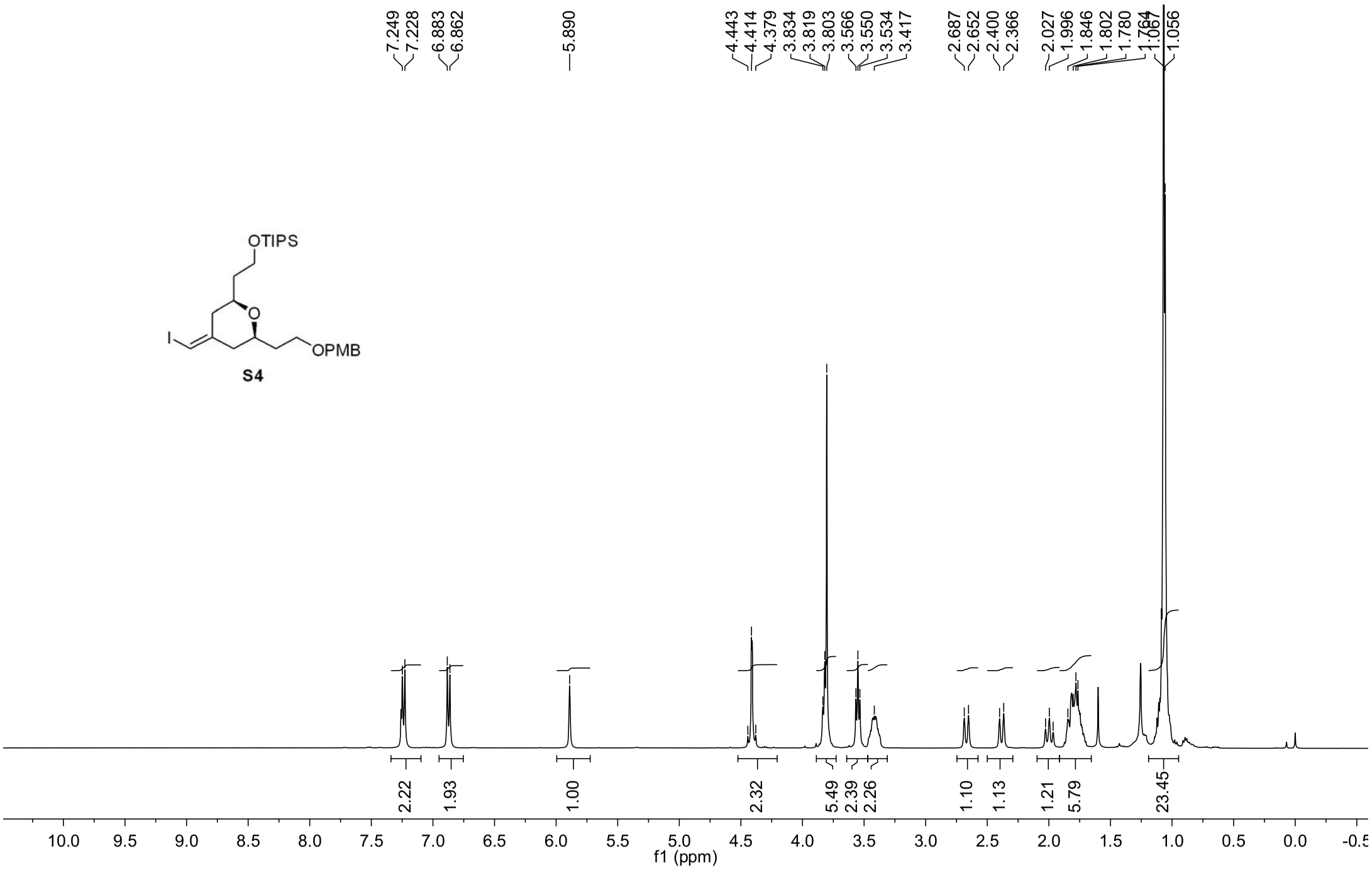
LHZ0683B H1 CDCl3 400 M Hz



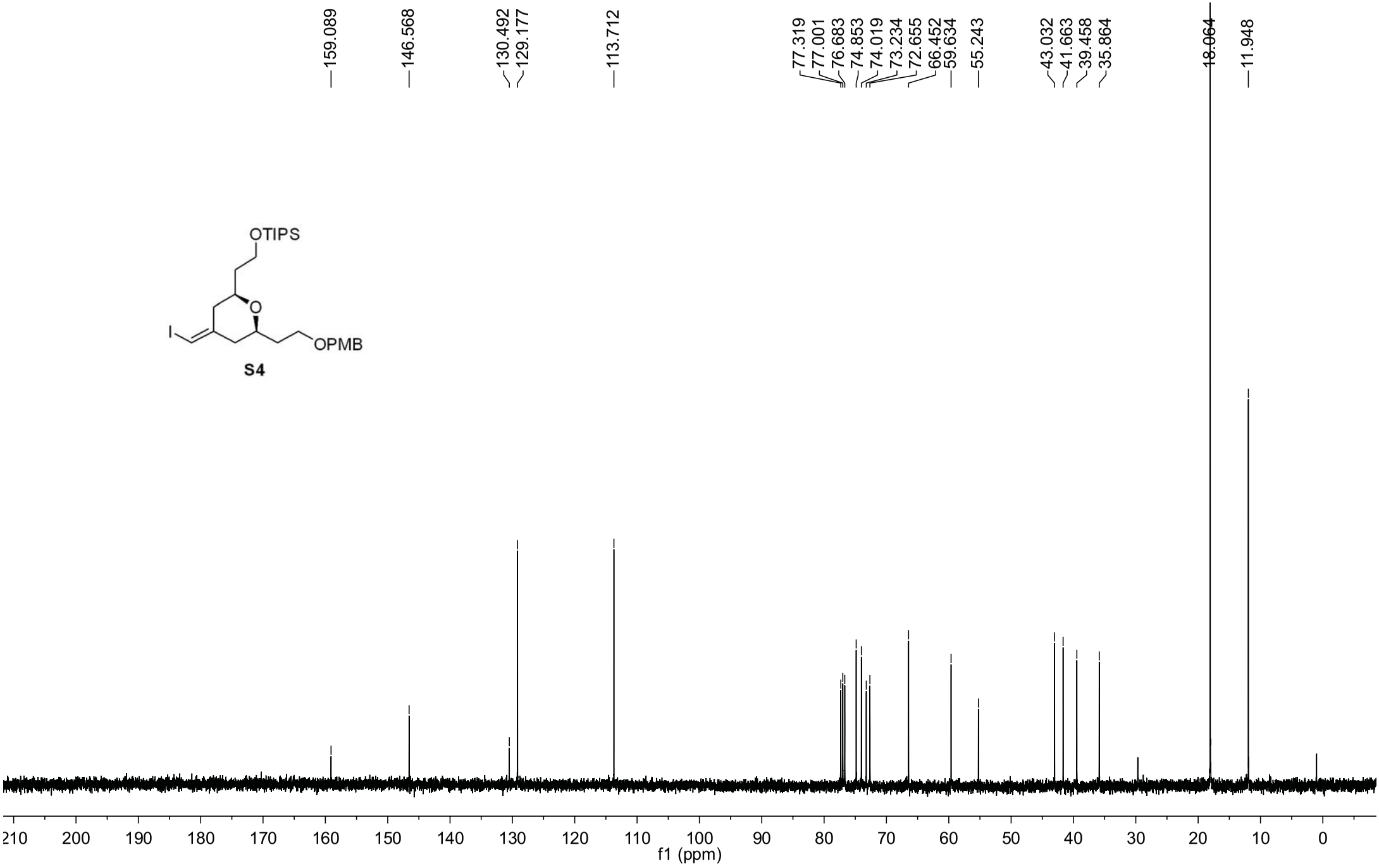
LHZ0683B C13 CDCl3 100 M Hz



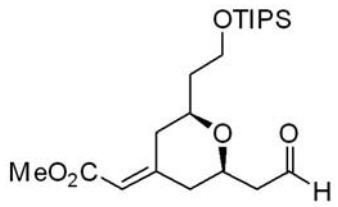
XHM0223 H1 CDCl3 400 M Hz



XHM0223 C13 CDCl3 100 M Hz

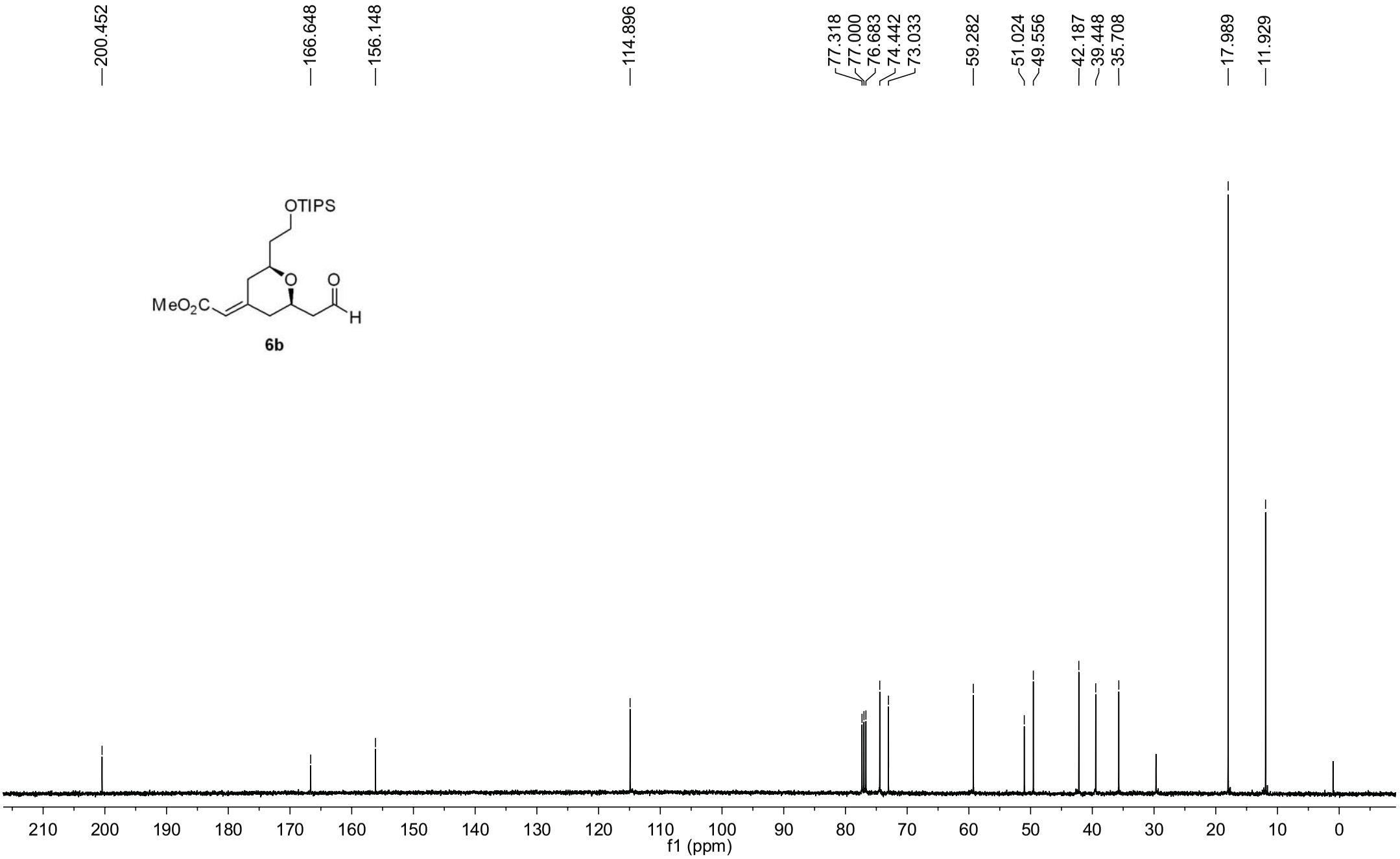


LHZ0563 H1 CDCl3 400 M Hz

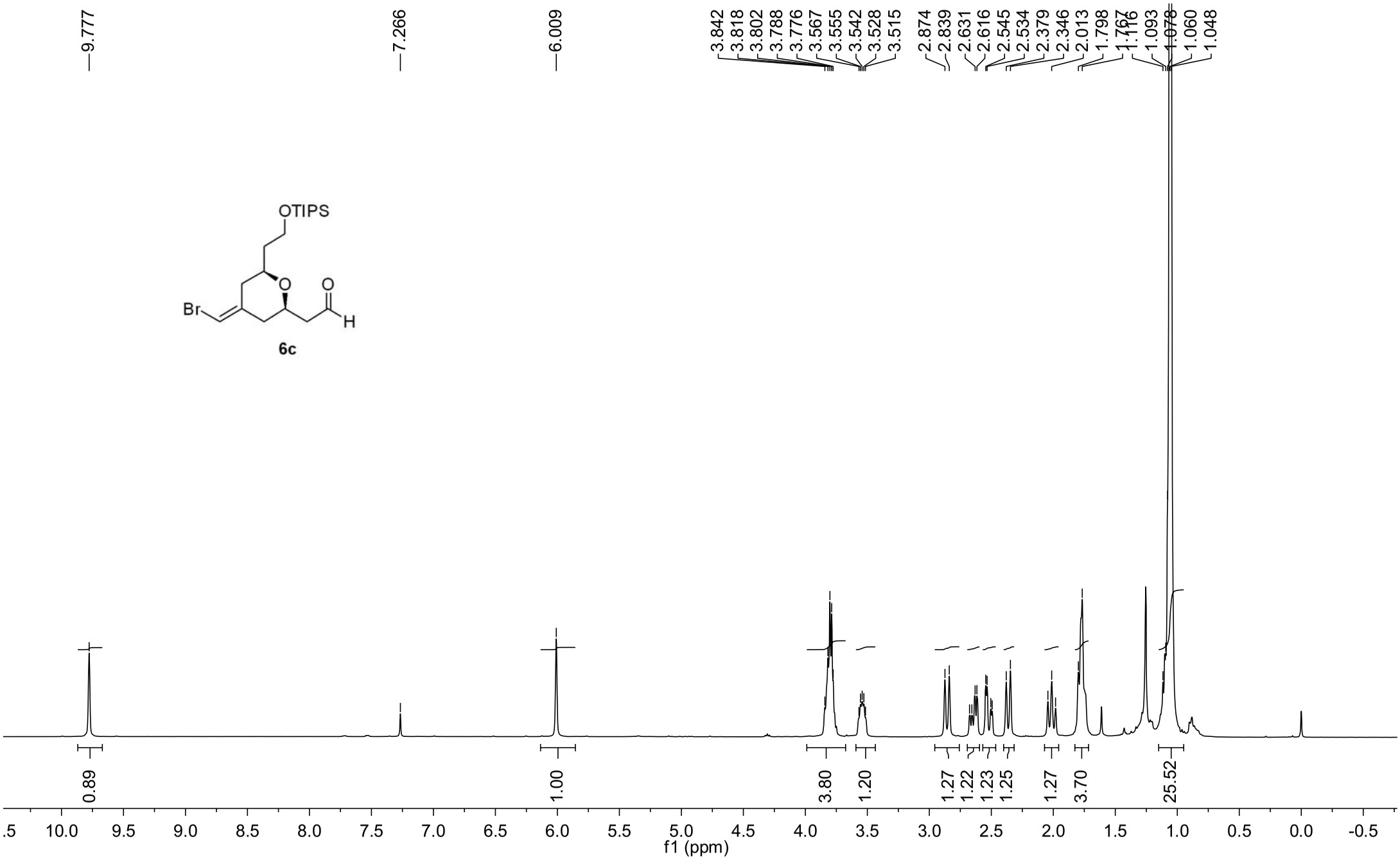


6b

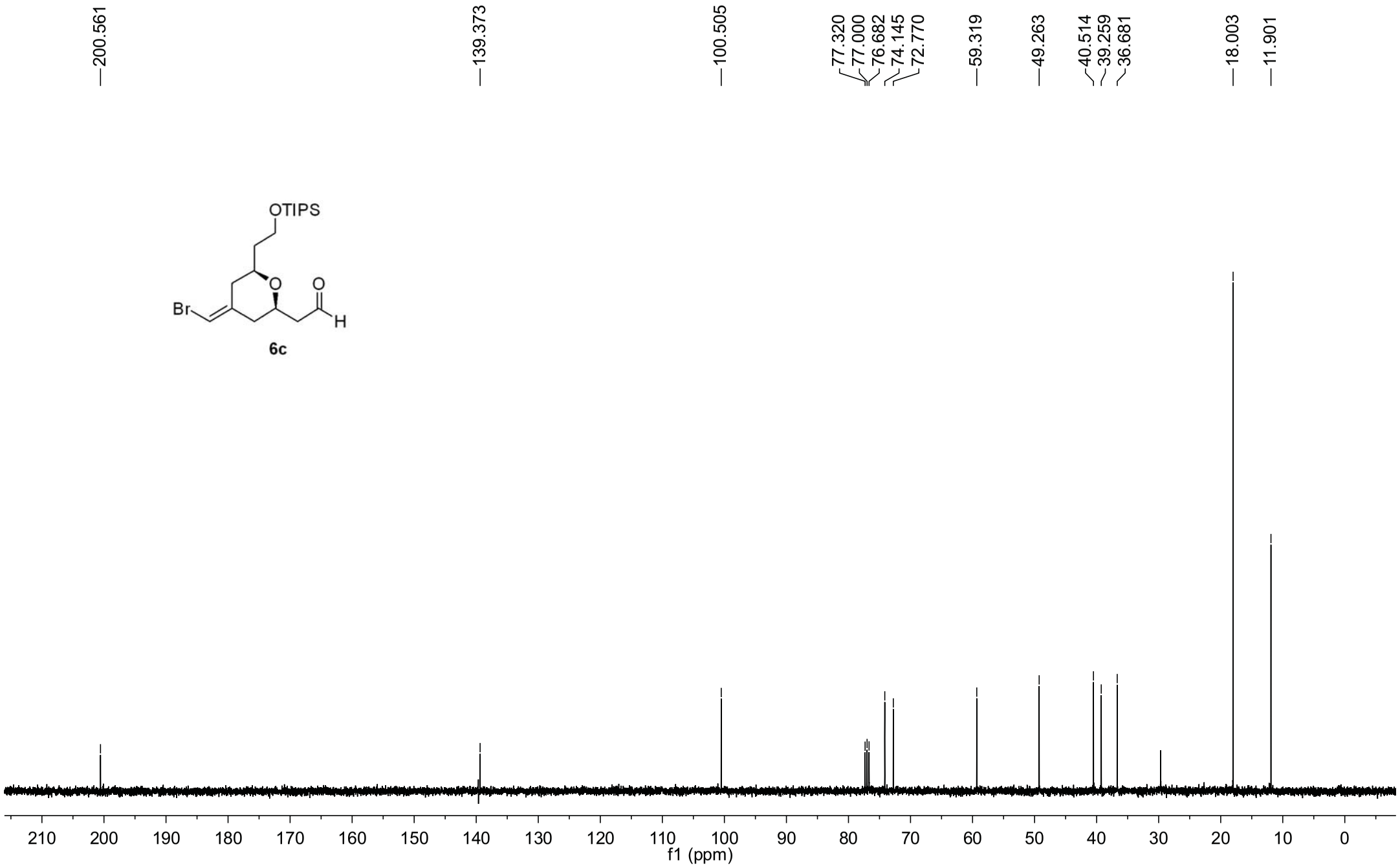
LHZ0563 C13 CDCl3 100 M Hz



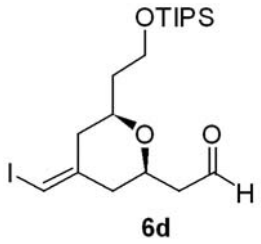
LHZ0682B H1 CDCl3 400 M Hz



LHZ0682B C13 CDCl3 100 M Hz

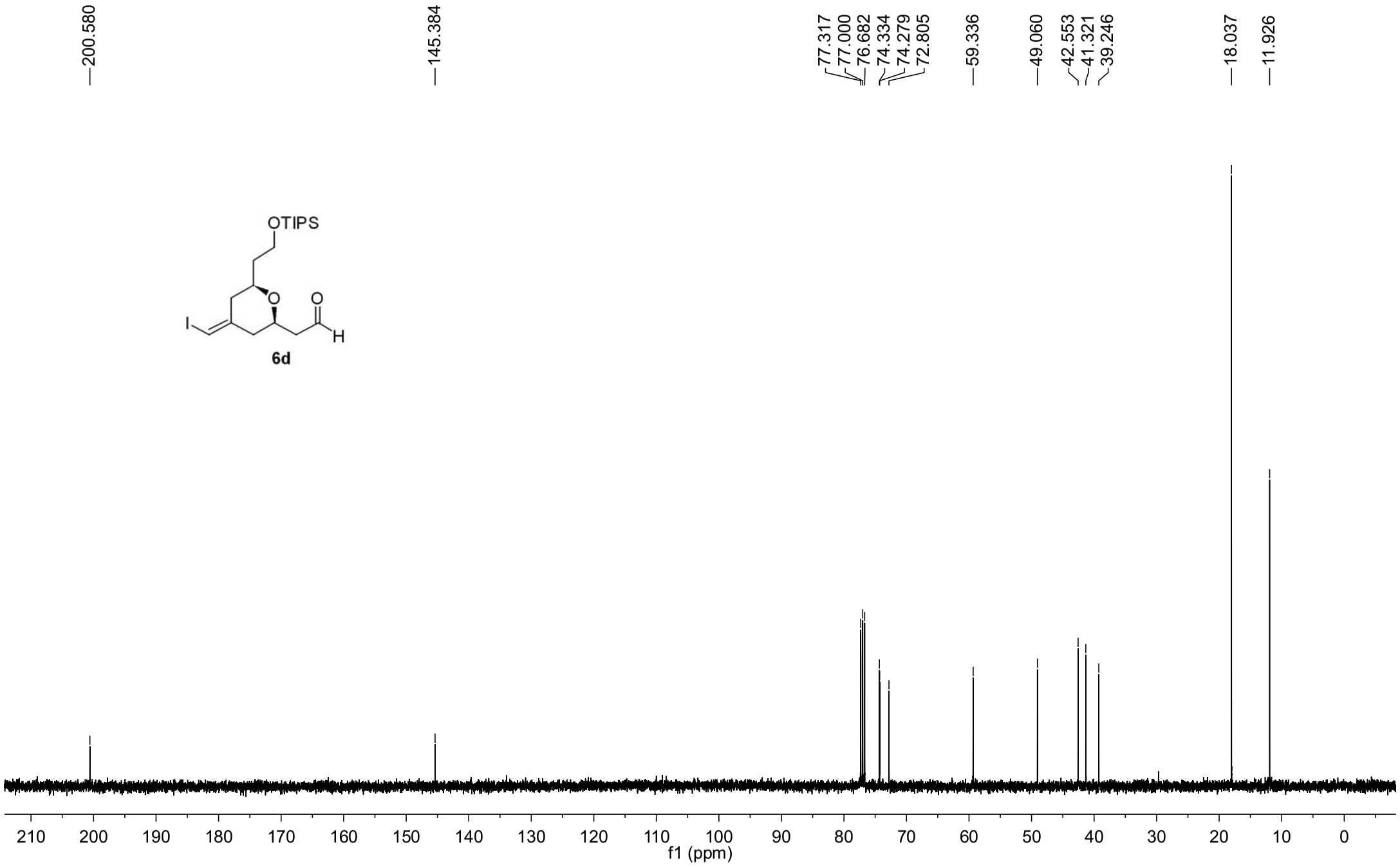


XHM-0226-1 H1 CDCl3 400 M Hz

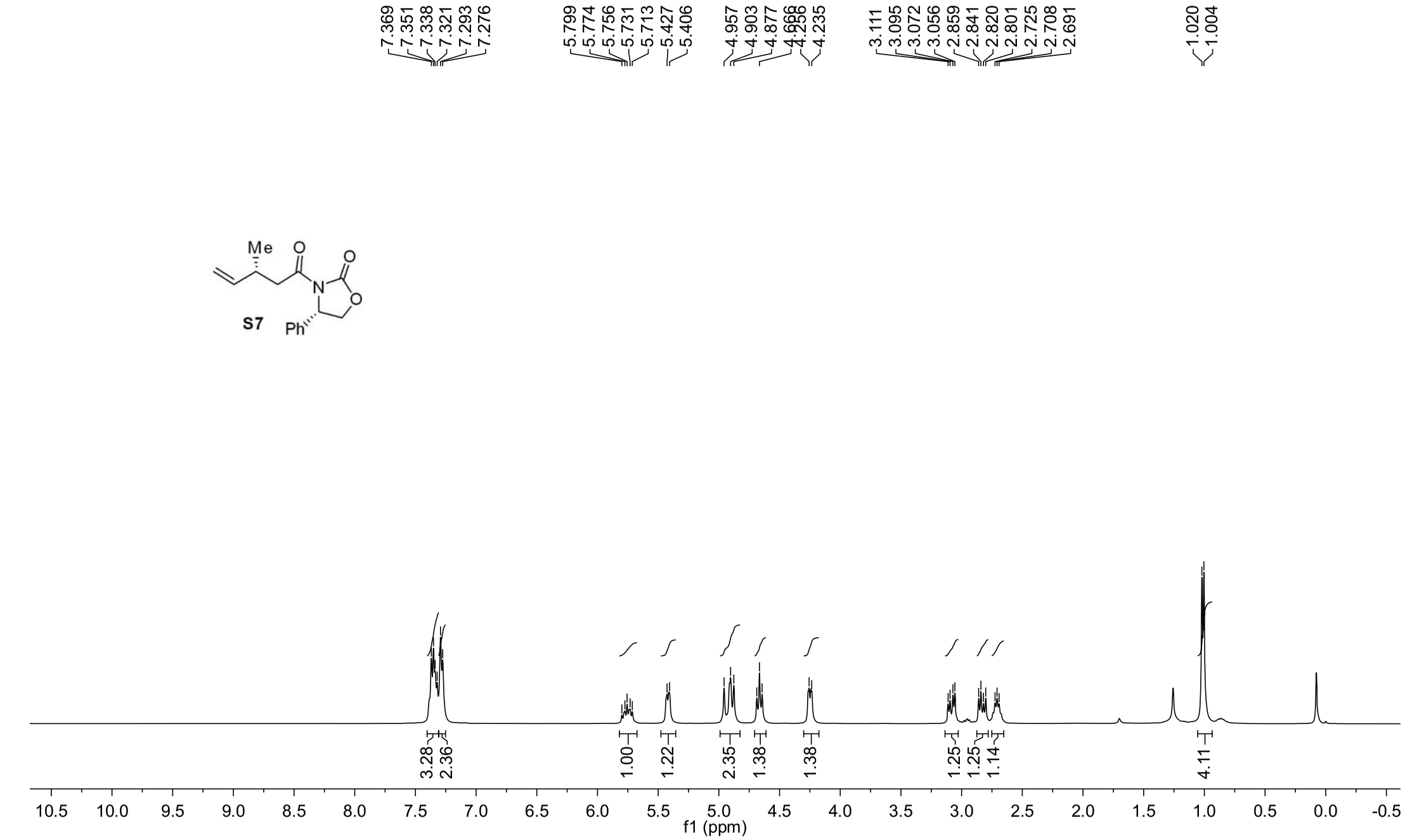


6d

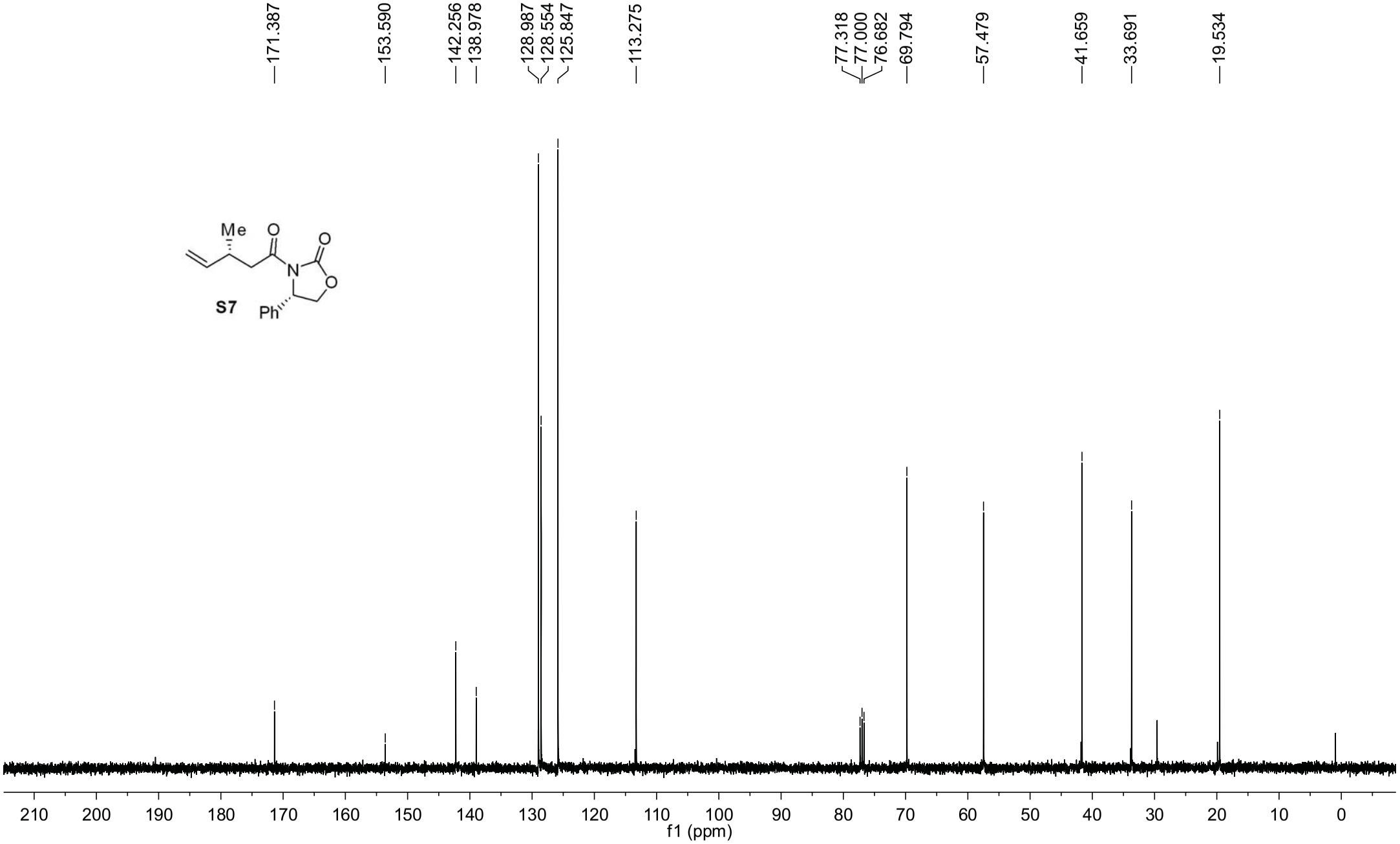
XHM0226-1 C13 CDCl3 100 M Hz



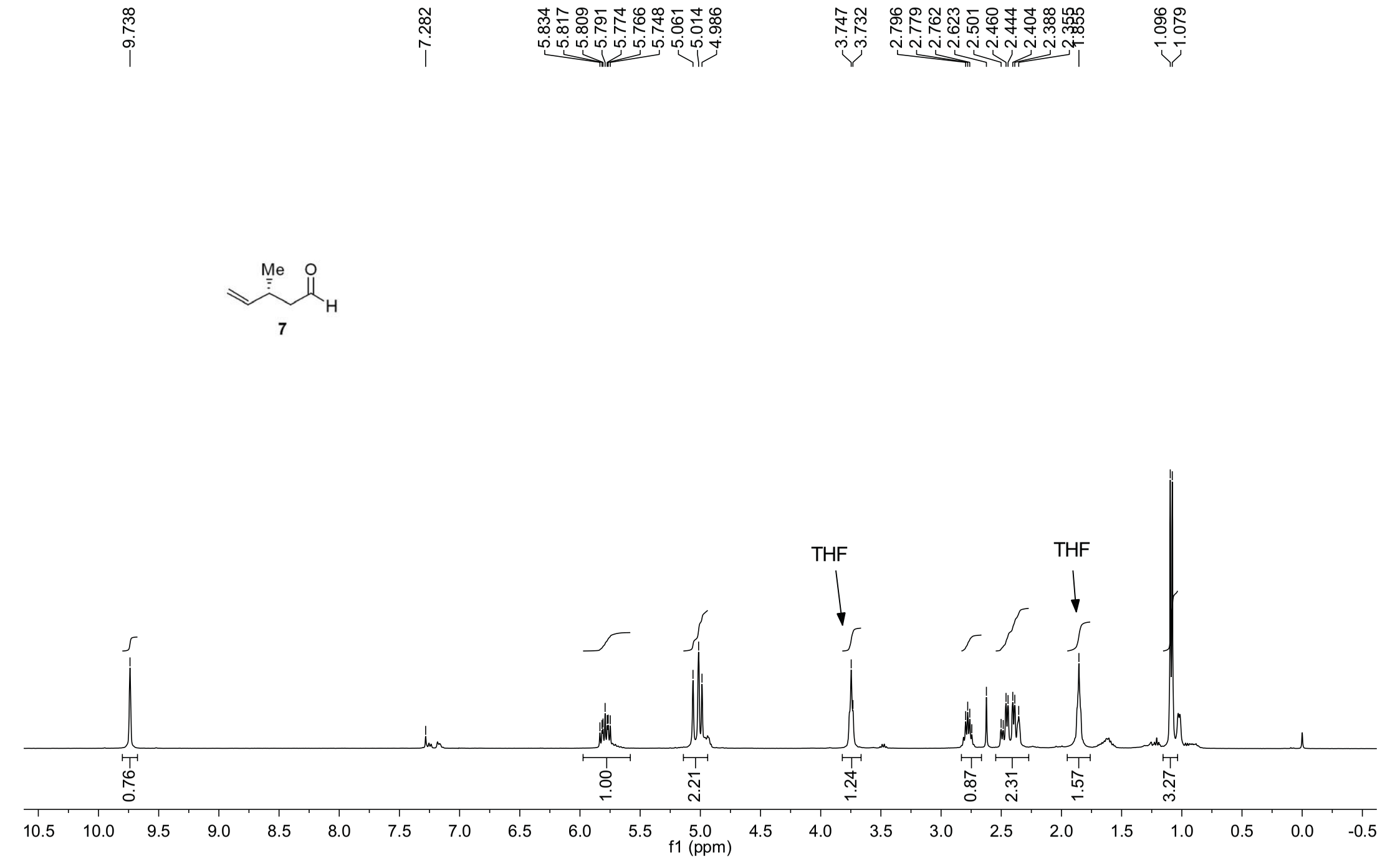
ZZG-12-11 H1 CDCl3 400 M Hz



ZZG-12-11 C13 CDCl3 100 M Hz

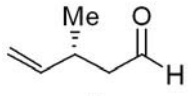


ZZG-12-3-2 H1 CDCl3 400 M Hz

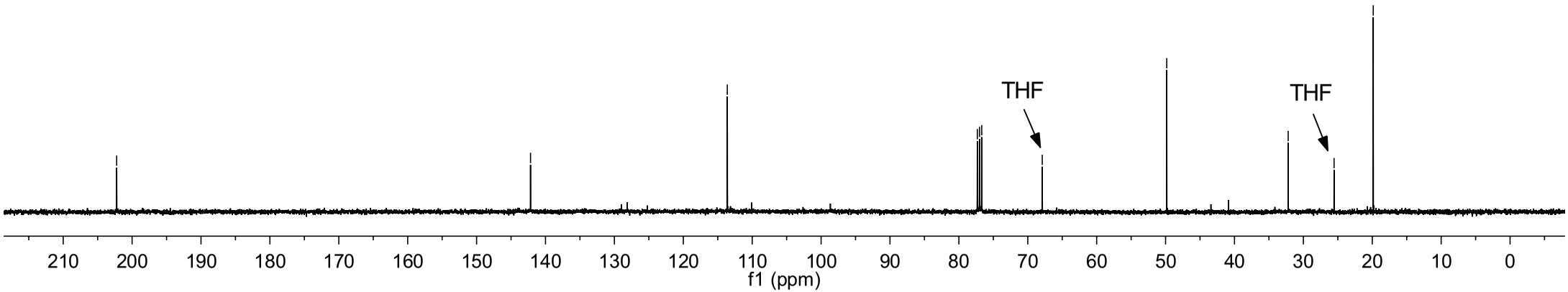


ZZG-12-3-2 C13 CDCl3 100 M Hz

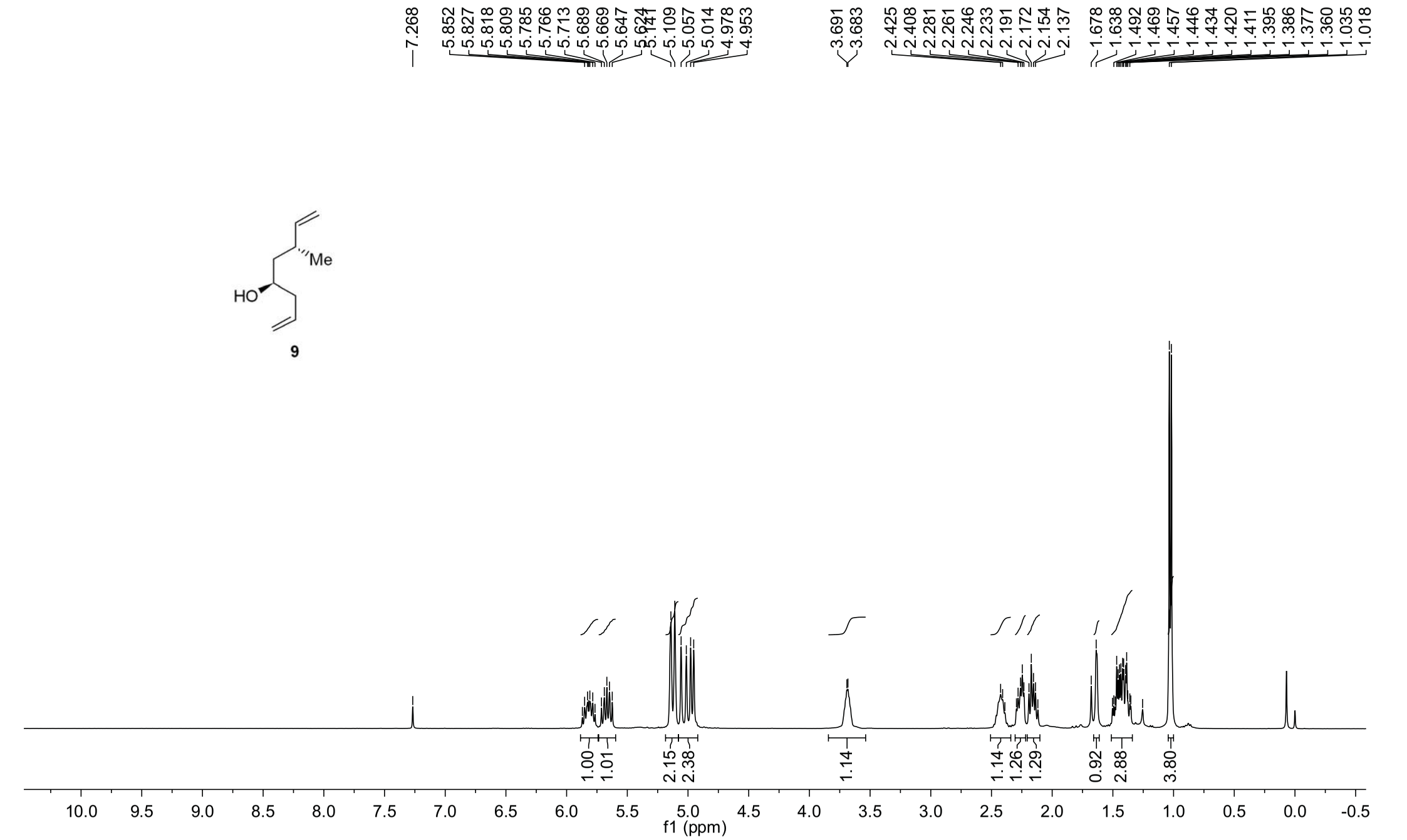
202.240
142.173
113.612
77.319
77.000
76.683
67.900
49.832
32.205
25.544
19.859



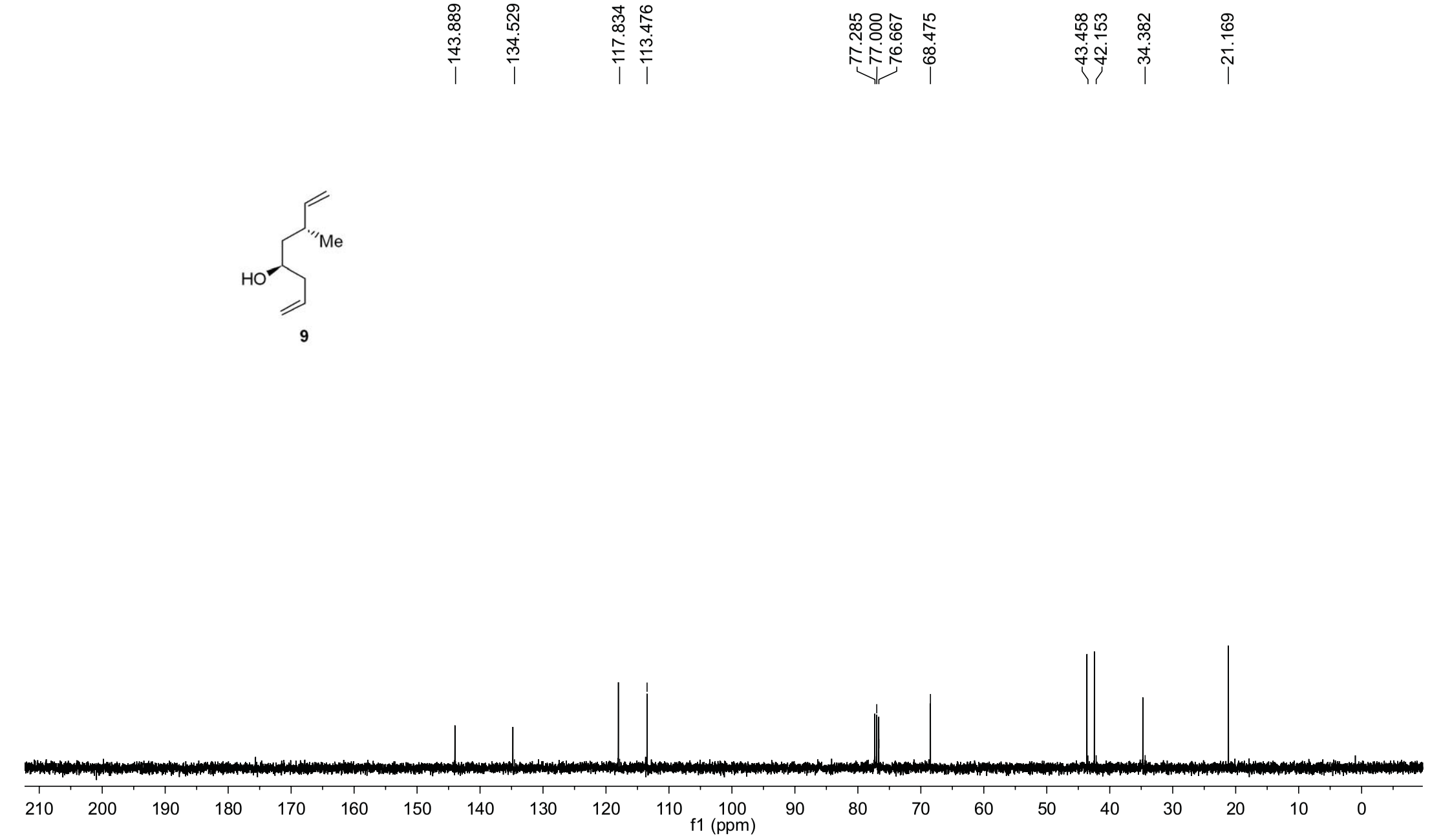
7



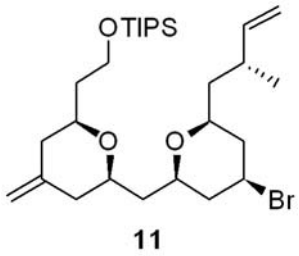
LHZ0463B H1 CDCl3 400 M Hz



LHZ00463B C13 CDCl3 100 M Hz

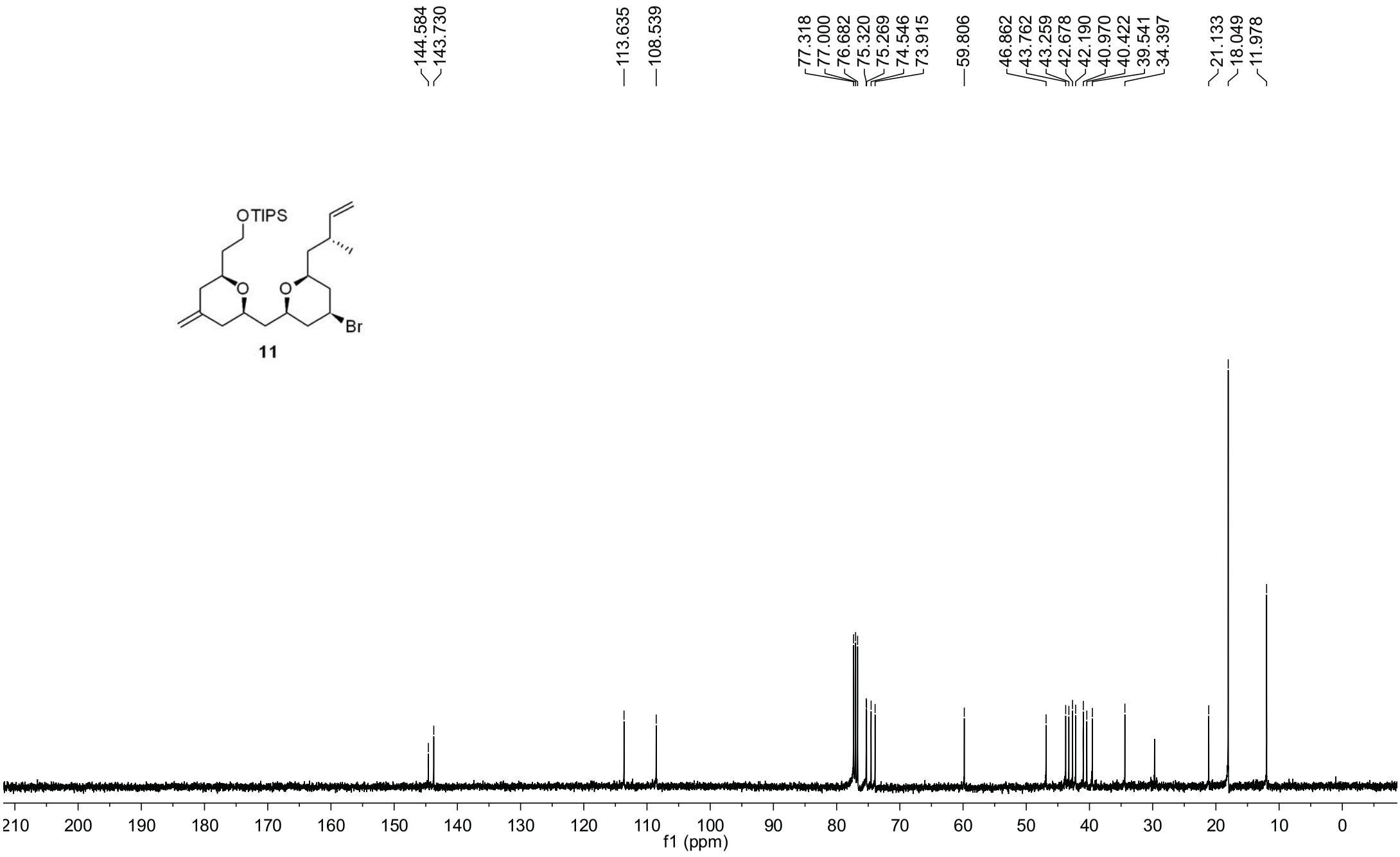


XHM0349 H1 CDCl3 400 M Hz

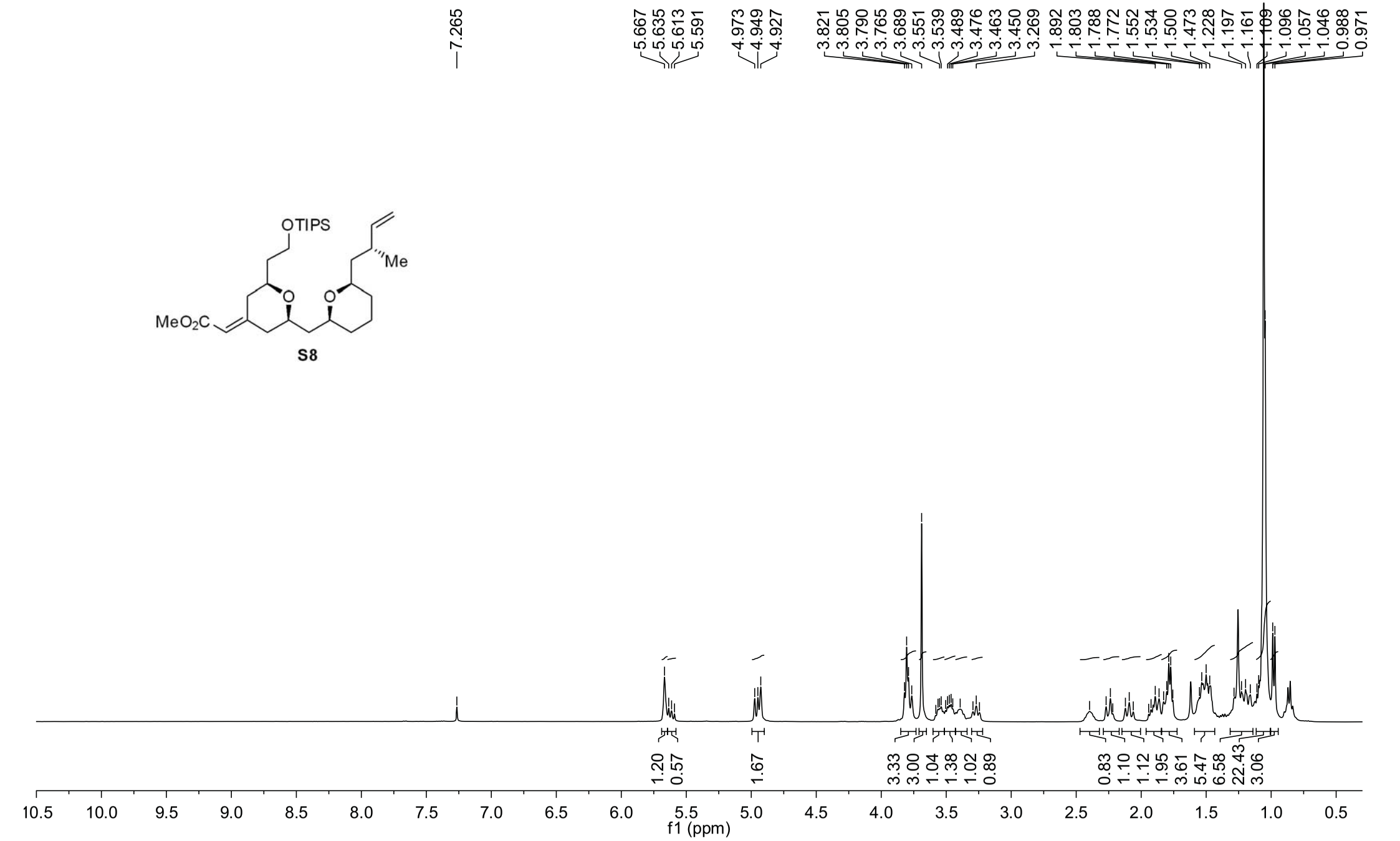


11

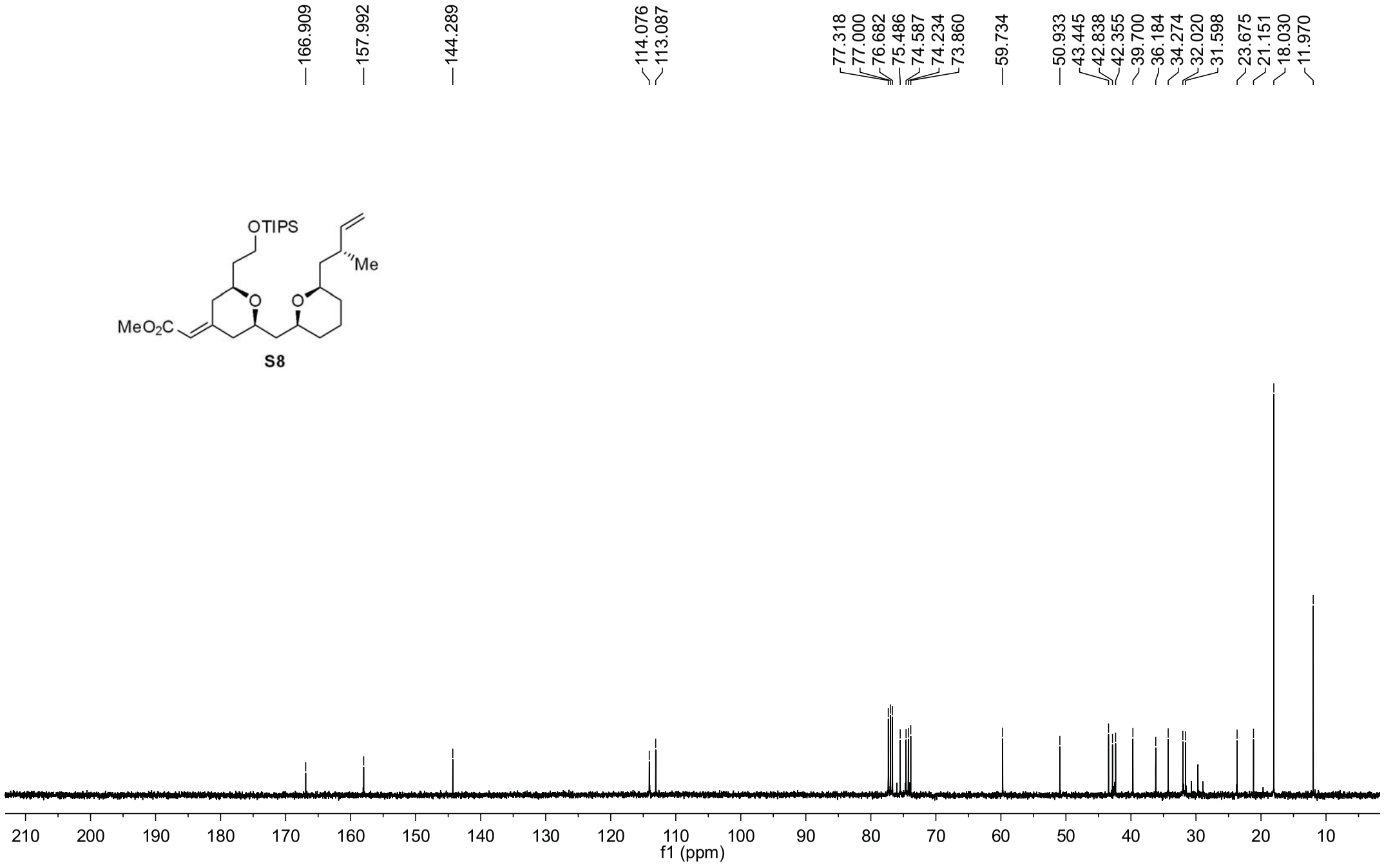
XHM0349 C13 CDCl3 100 M Hz



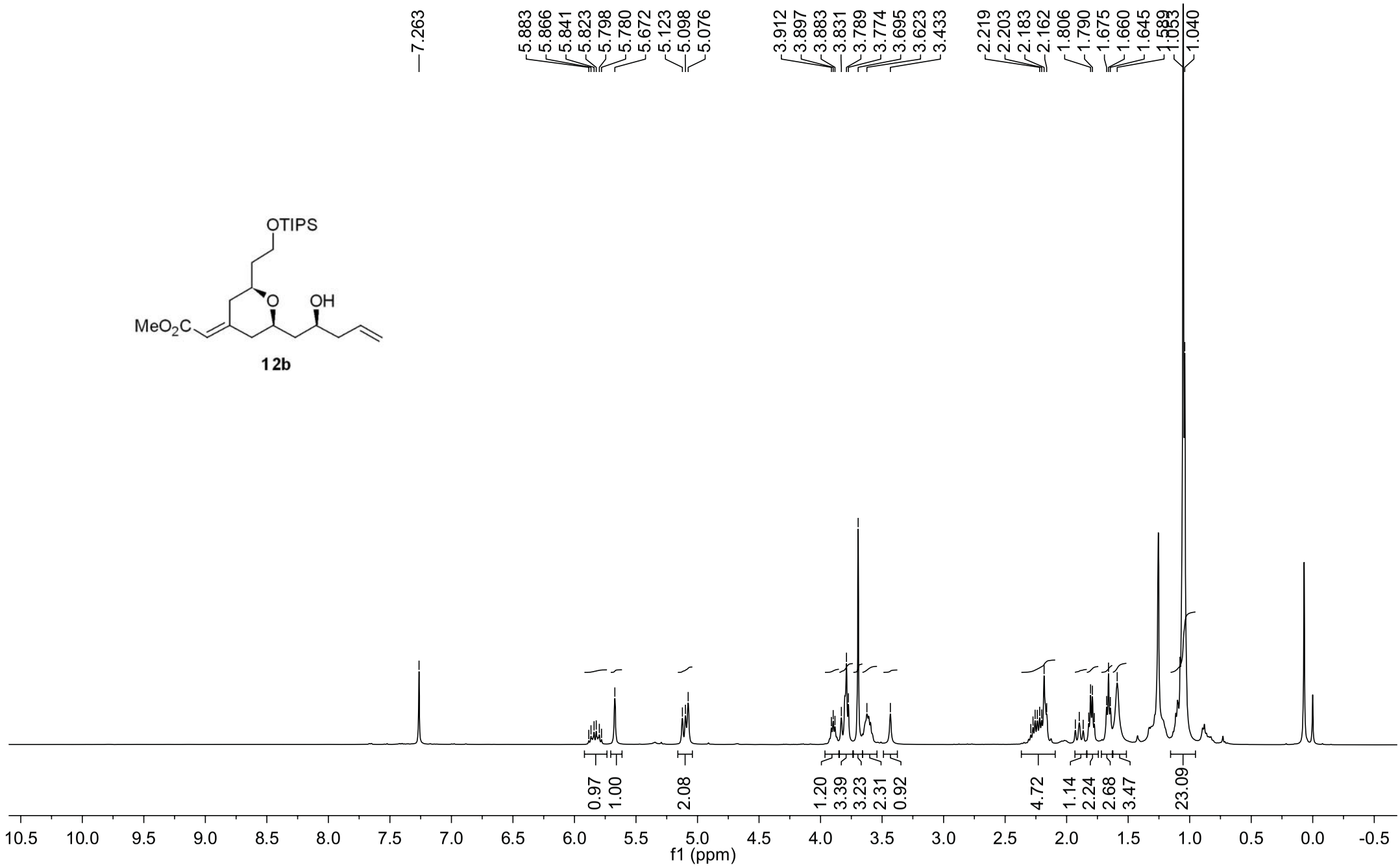
XHM0329 H1 CDCl3 400 M Hz



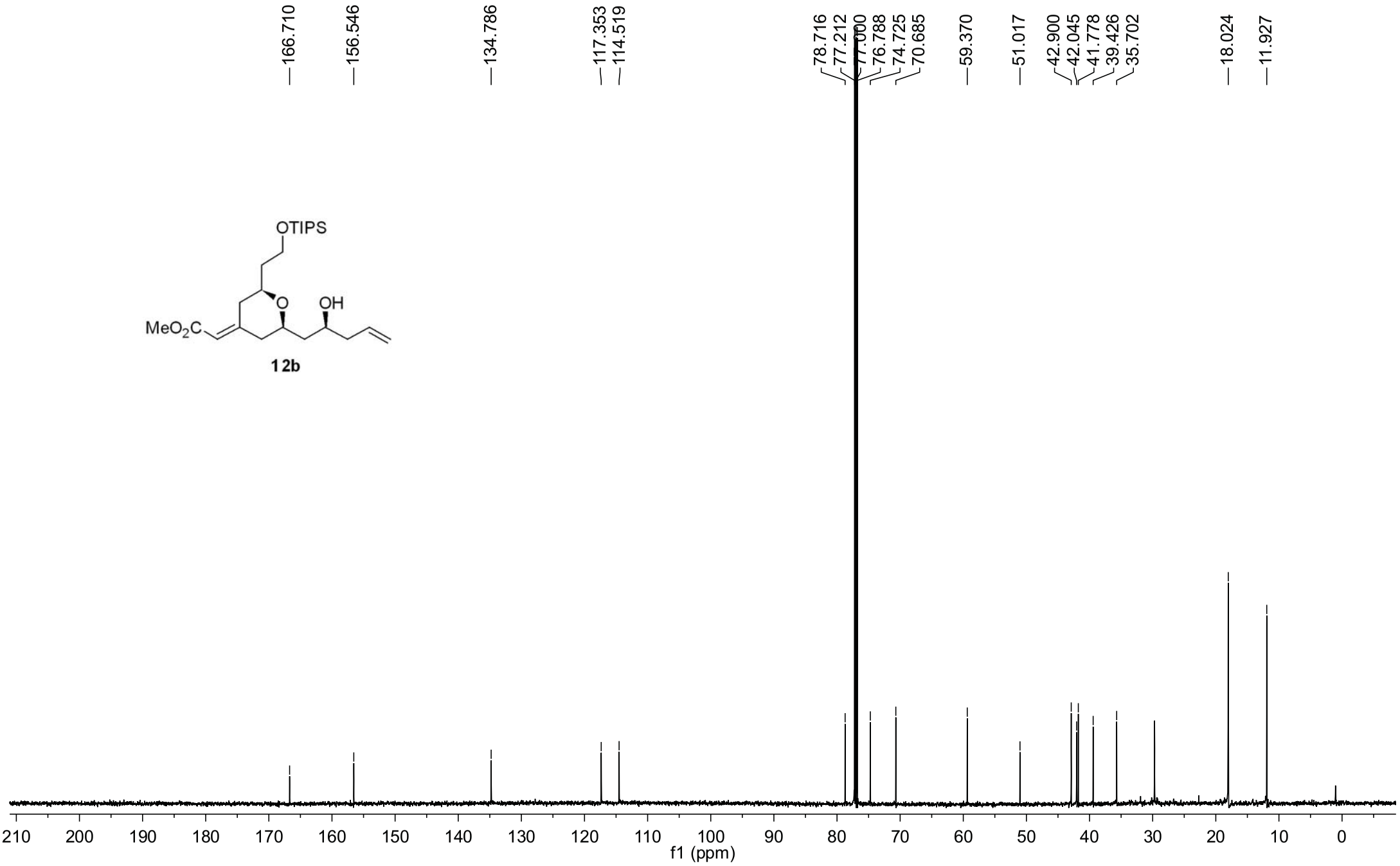
XHM0329 H1 CDCl3 100 M Hz



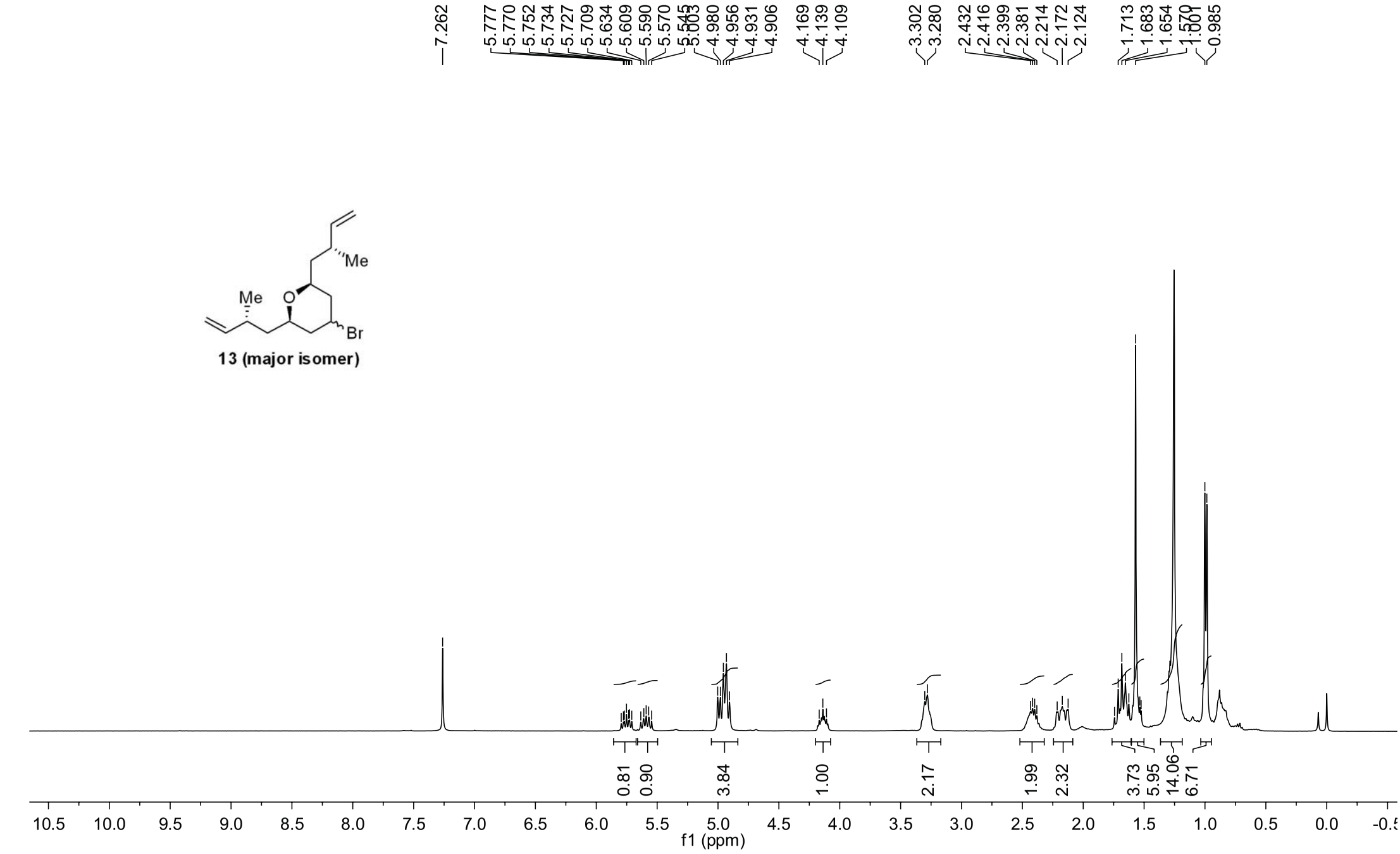
XHM0364 H1 CDCl3 400 M Hz



XHM0364 C13 CDCl3 150 M Hz

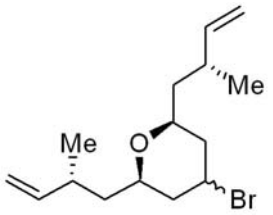


LHZ0566A H1 CDCl3 400 M Hz

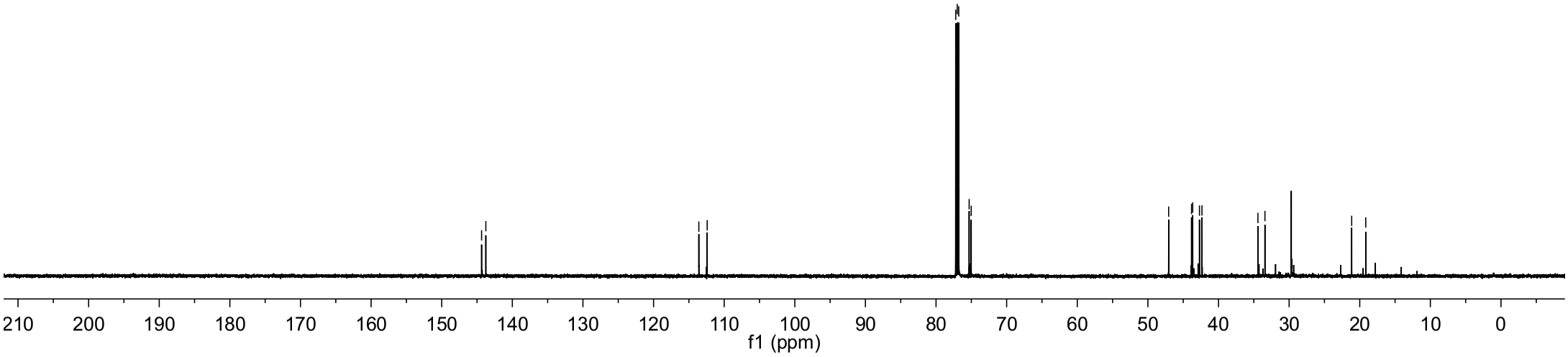


LHZ0566A C13 CDCl3 150 M Hz

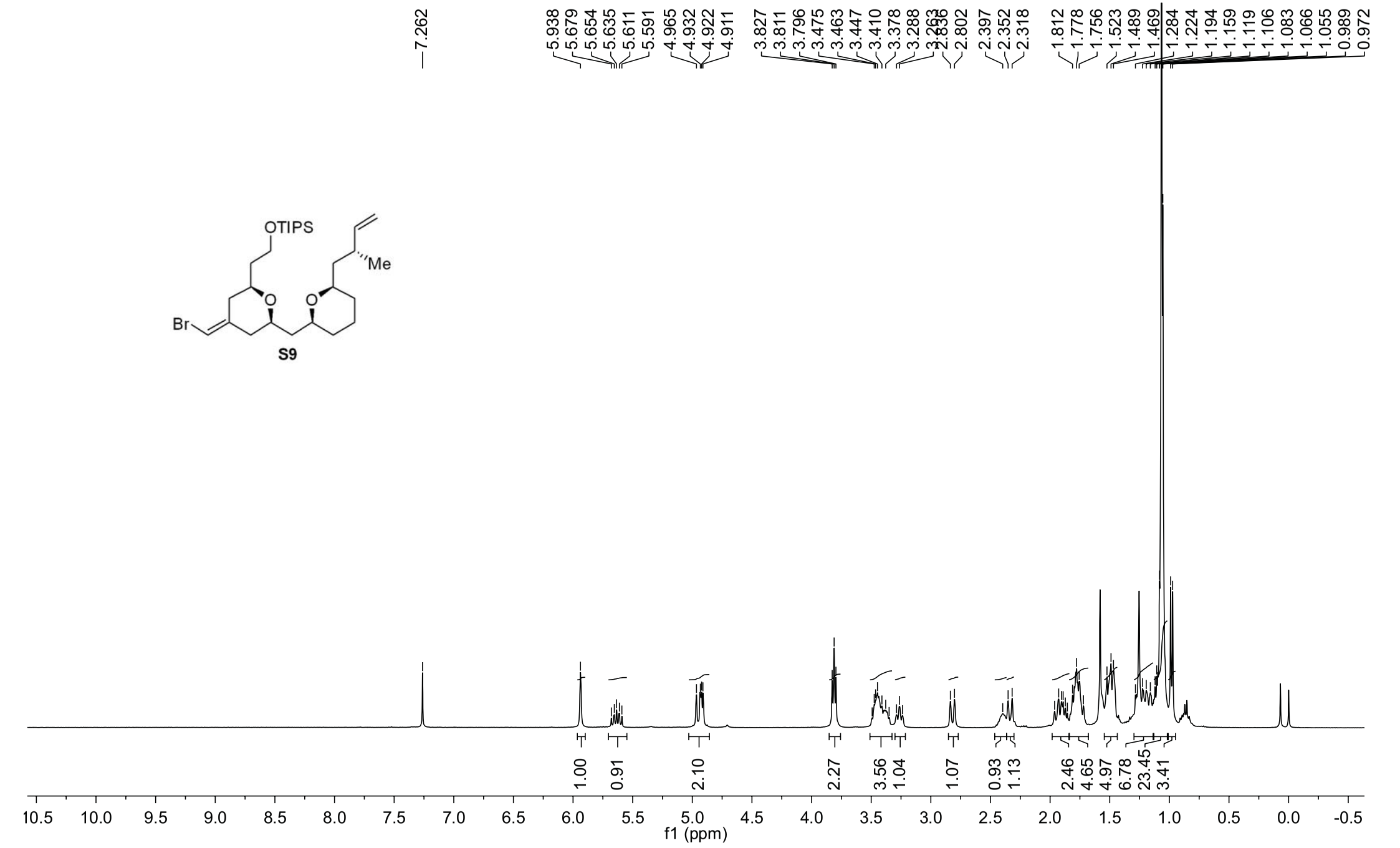
144.352
143.749
113.590
112.409
77.211
77.000
76.788
75.311
75.021
47.059
43.817
43.653
42.696
42.343
34.419
33.424
21.140
19.148



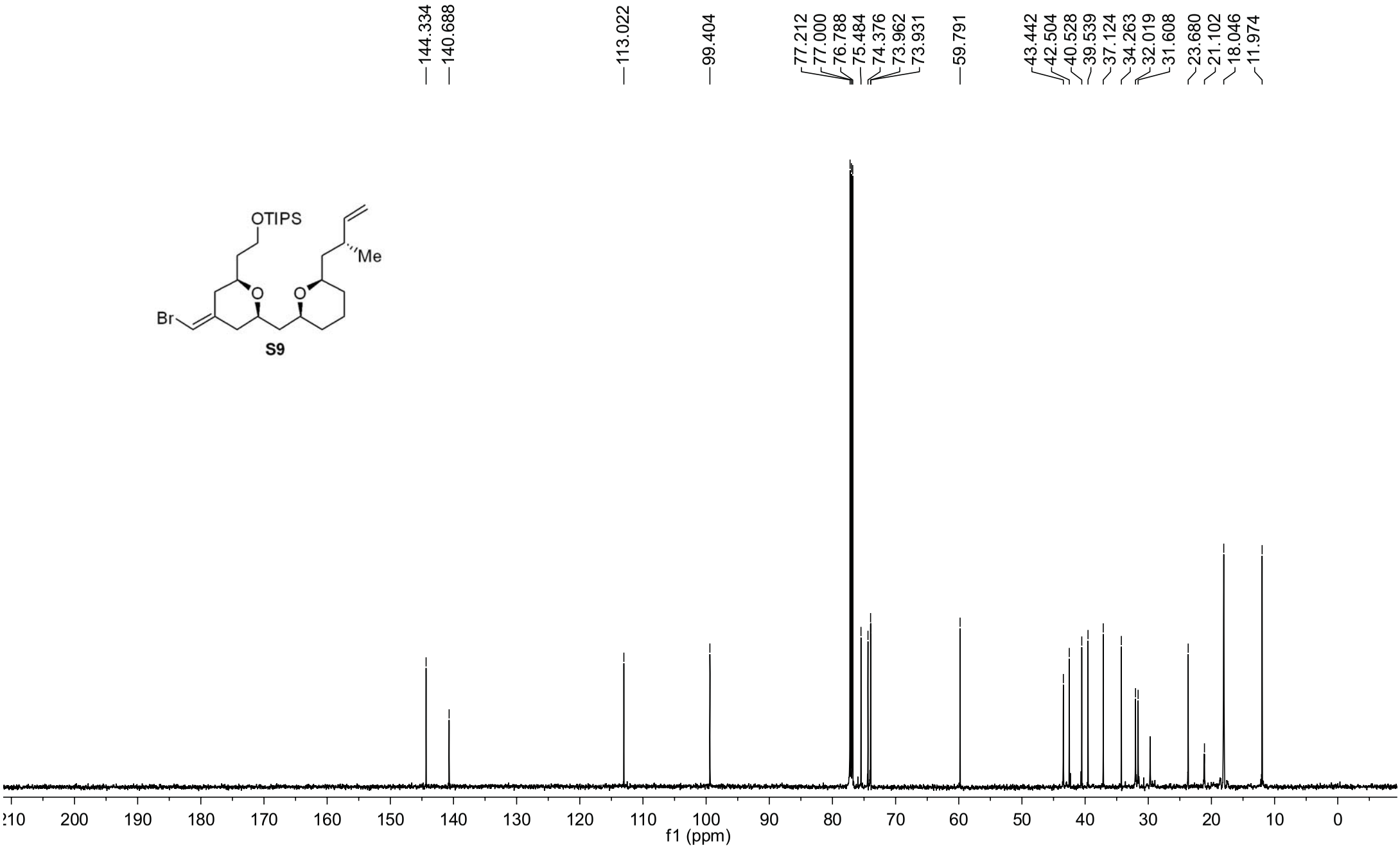
13 (major isomer)



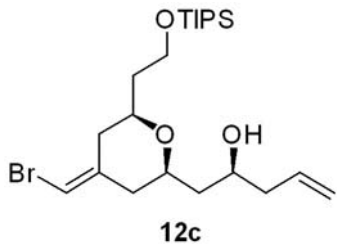
XHM0350 H1 CDCl3 400 M Hz



XHM0350 C13 CDCl3 150 M Hz

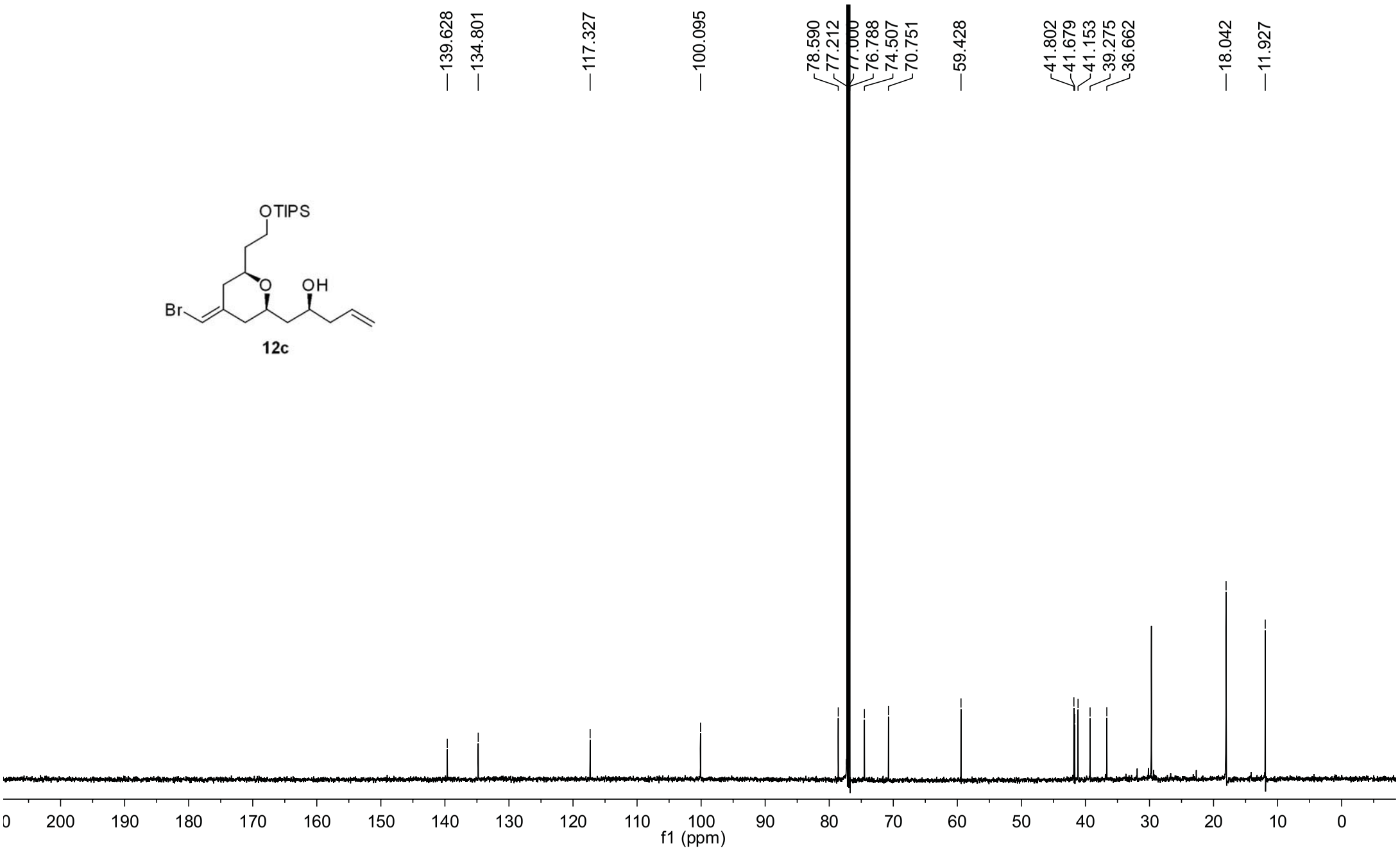


XHM0360 H1 CDCl3 400 M Hz

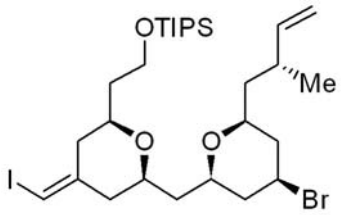


12c

XHM0360 C13 CDCl3 150 M Hz

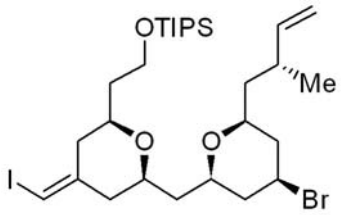


XHM0236 H1 CDCl3 400 M Hz



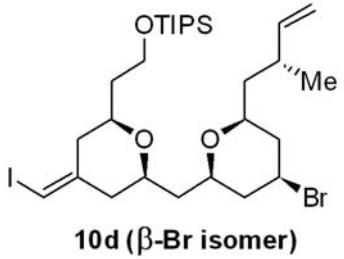
10d (β-Br isomer)

XHM0236 C13 CDCl3 100 M Hz

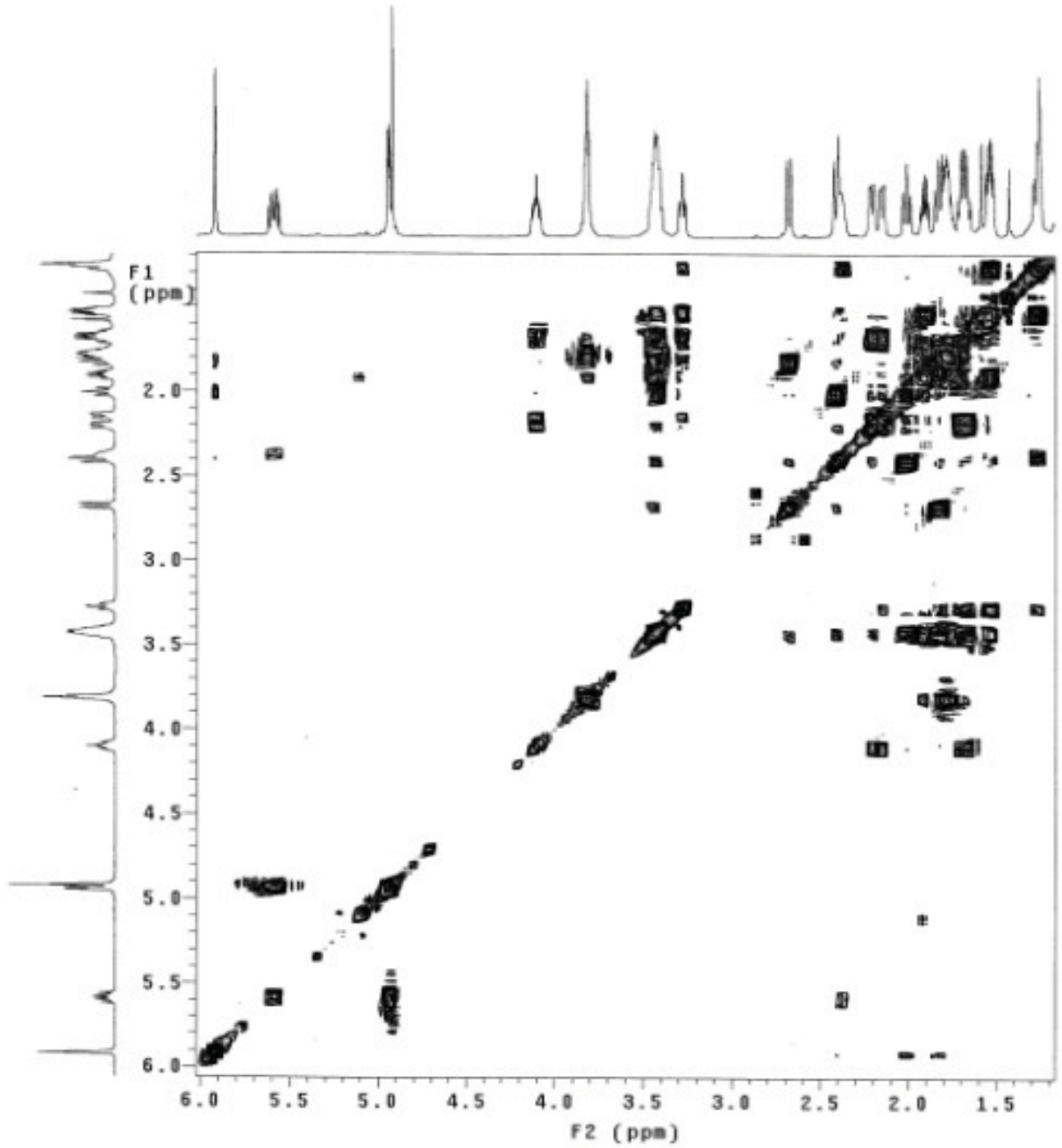


10d (β-Br isomer)

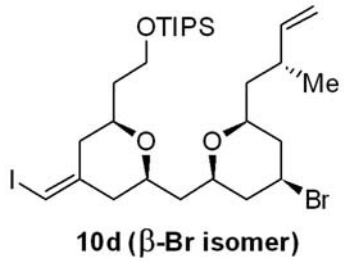
XHM0236 gCOSY CDCl3 600 M Hz



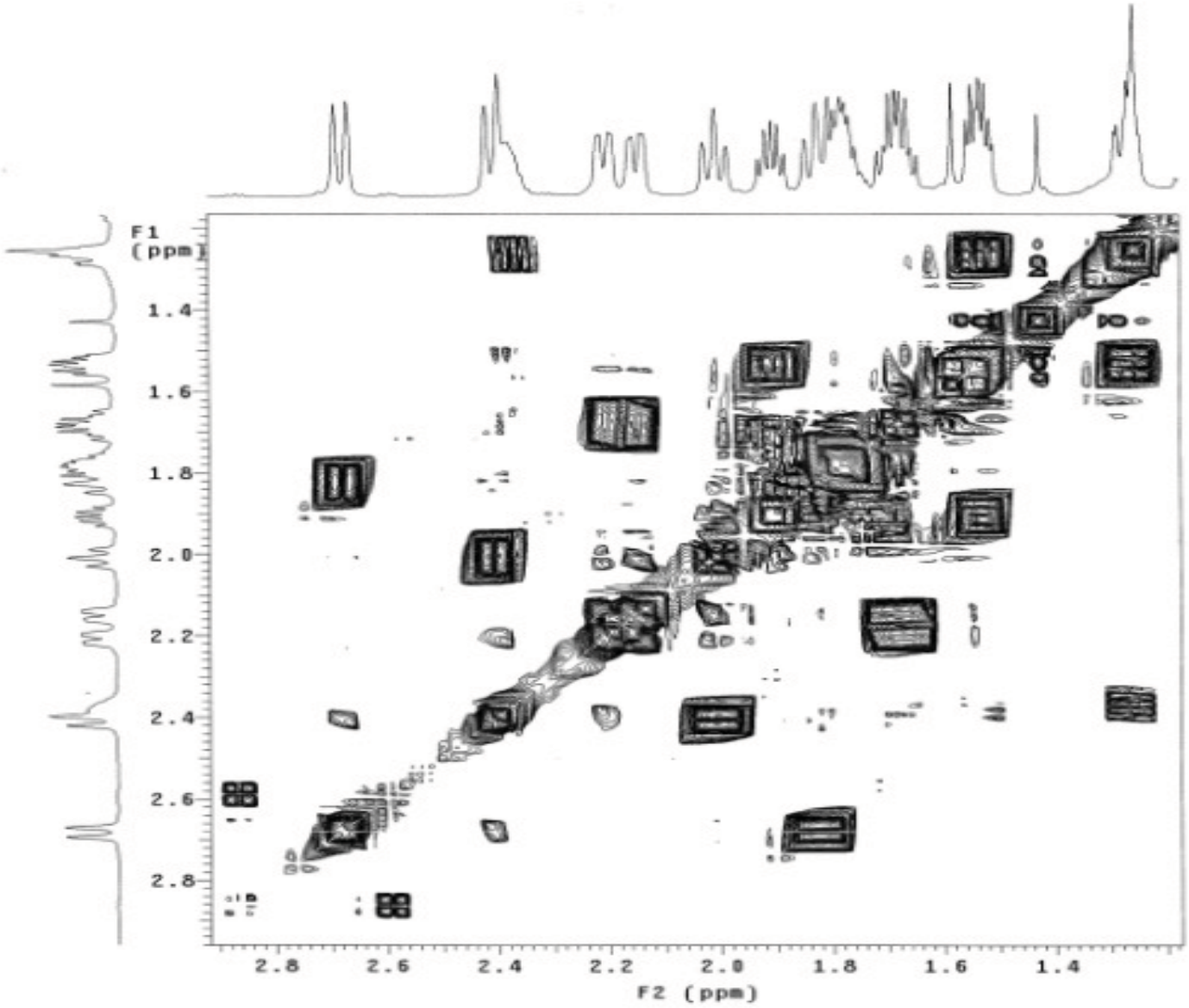
10d (β-Br isomer)



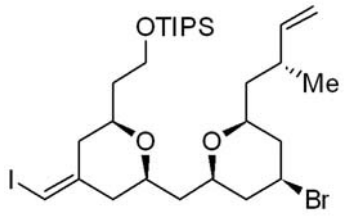
XHM0236 gCOSY CDCl3 600 M Hz



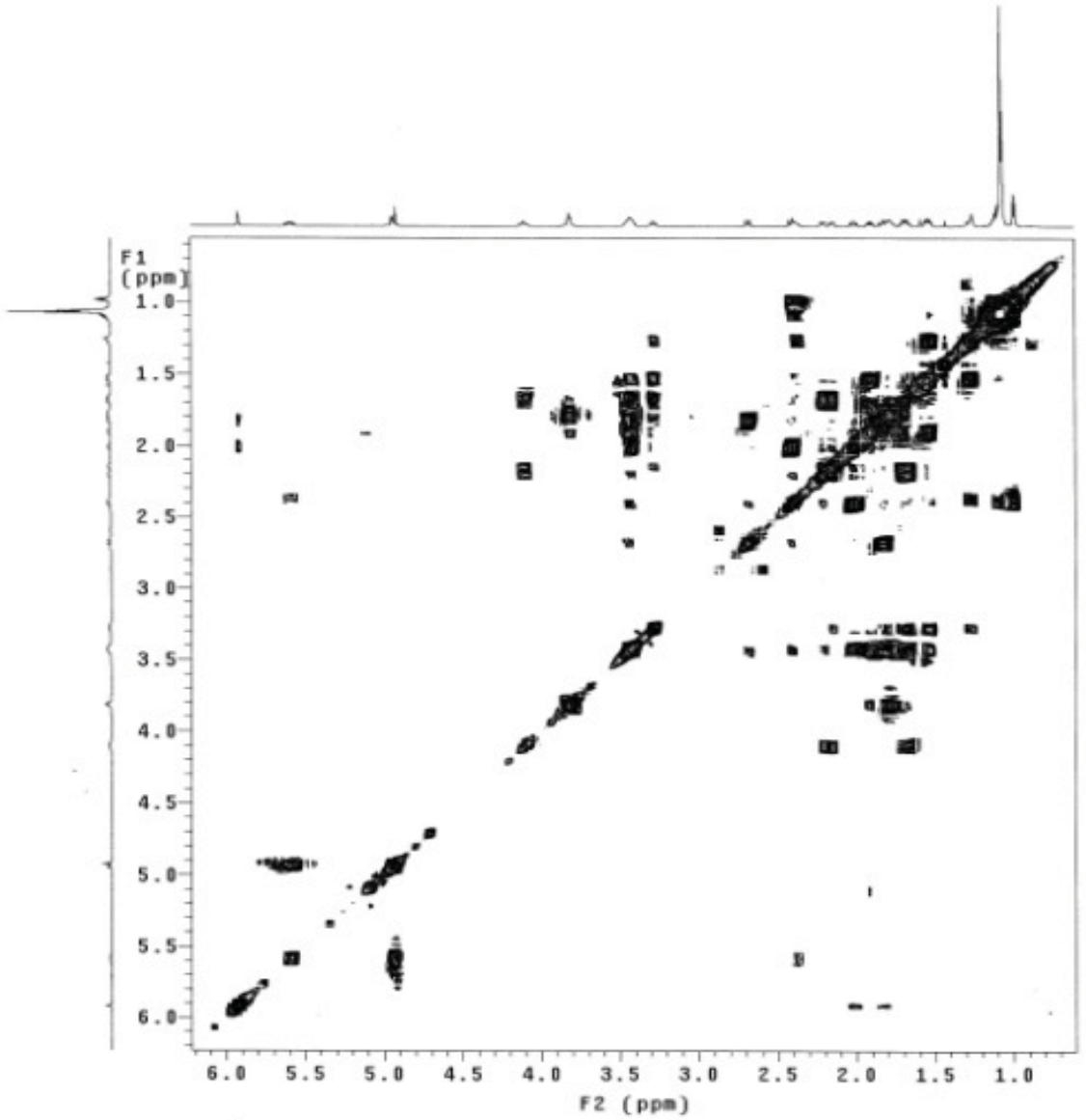
10d (β-Br isomer)



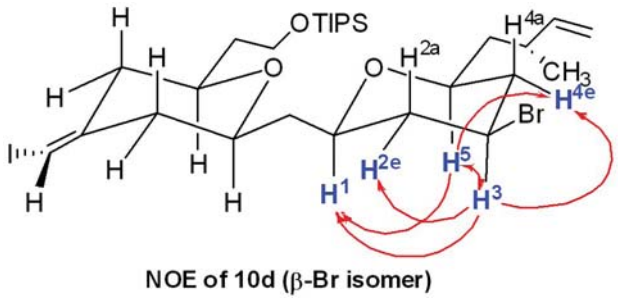
XHM0236 gCOSY CDCl3 600 M Hz



10d (β-Br isomer)

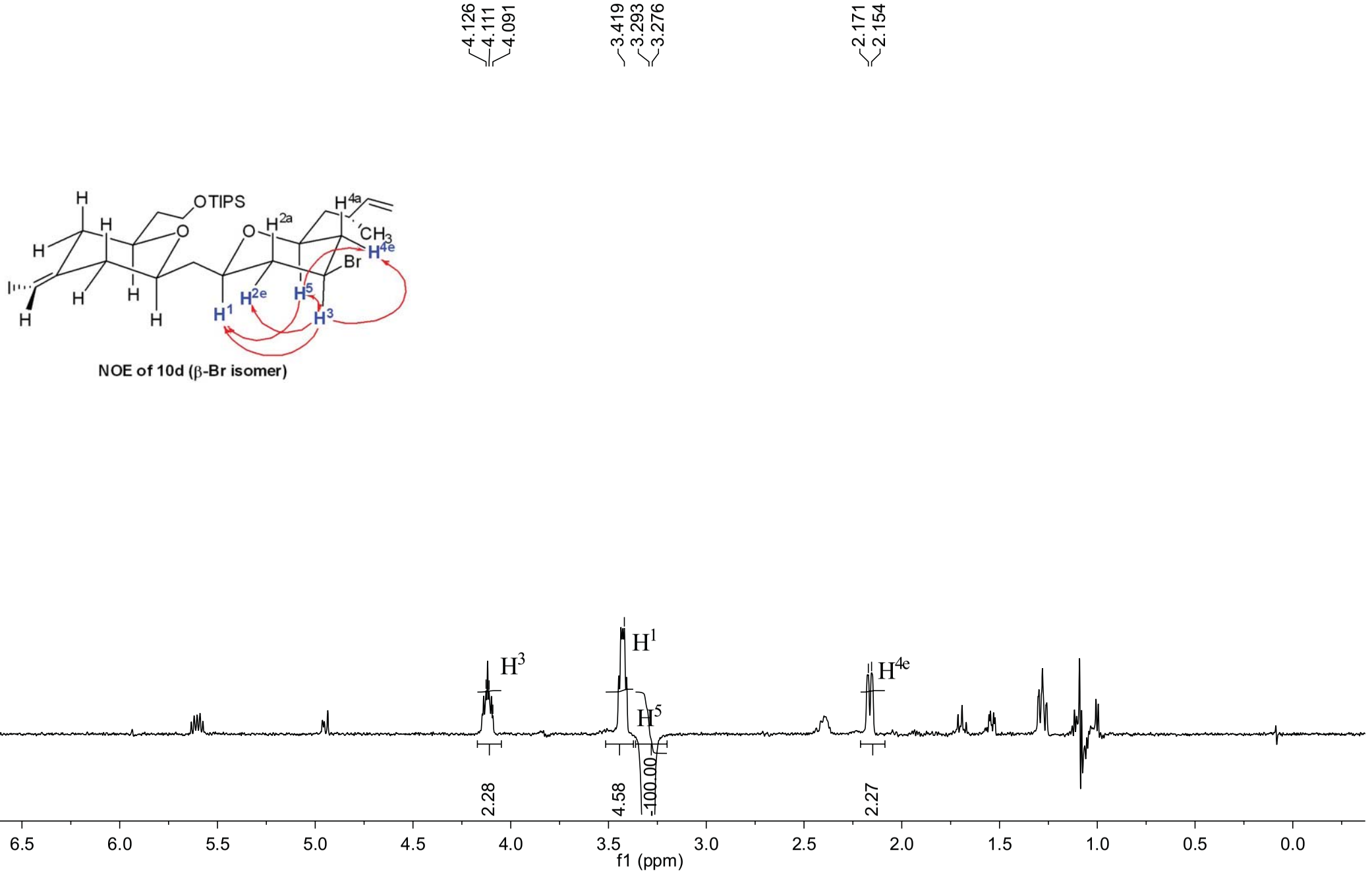


XHM0236 NOEDS CDCl3 4.10 600 M Hz

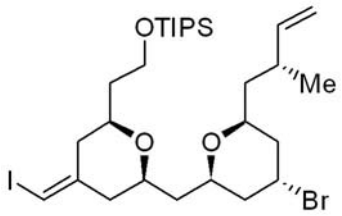


NOE of 10d (β-Br isomer)

XHM0236 NOEDS CDCl3 3.26 600 M Hz

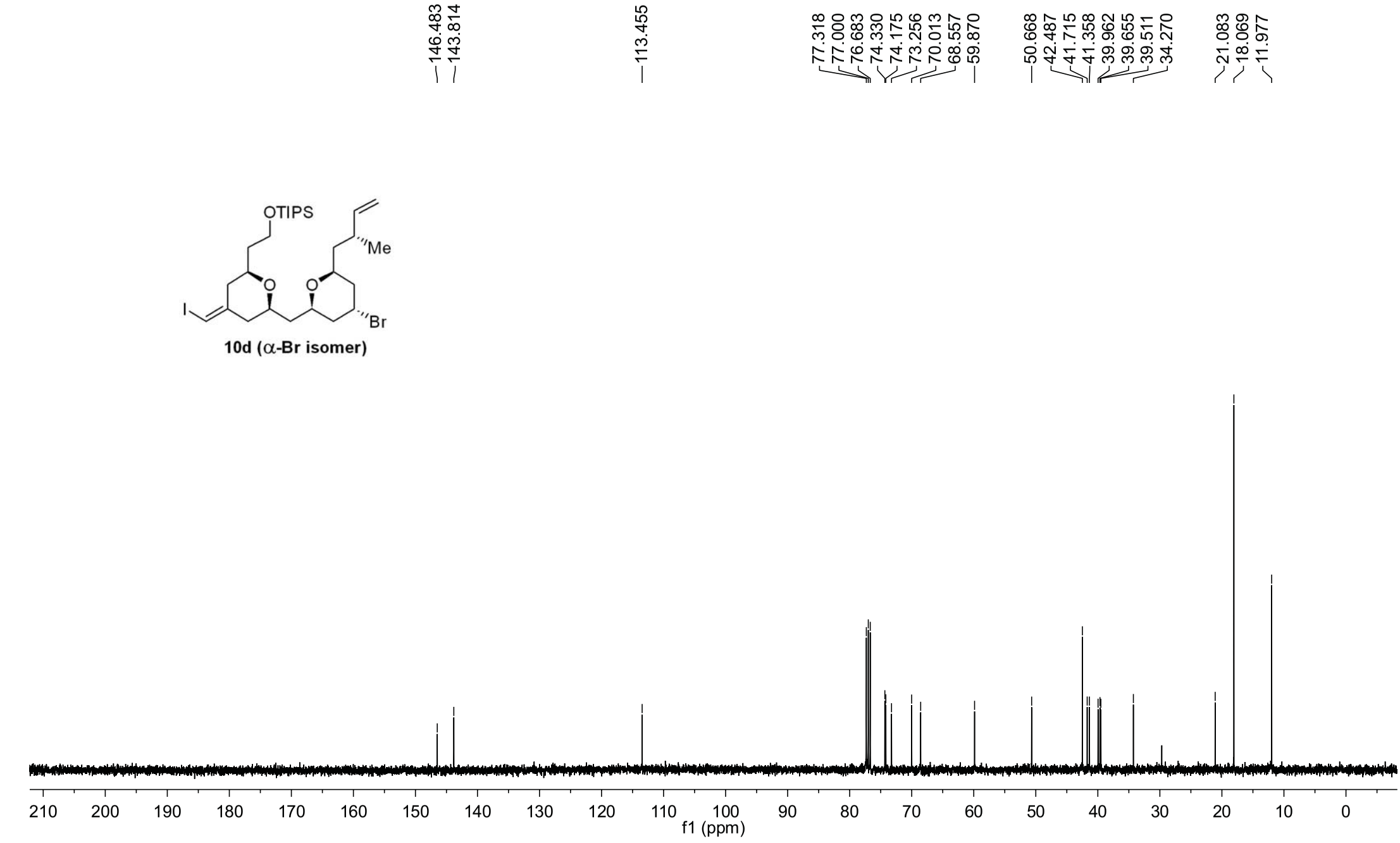


XHM0236B H1 CDCl3 400 M Hz

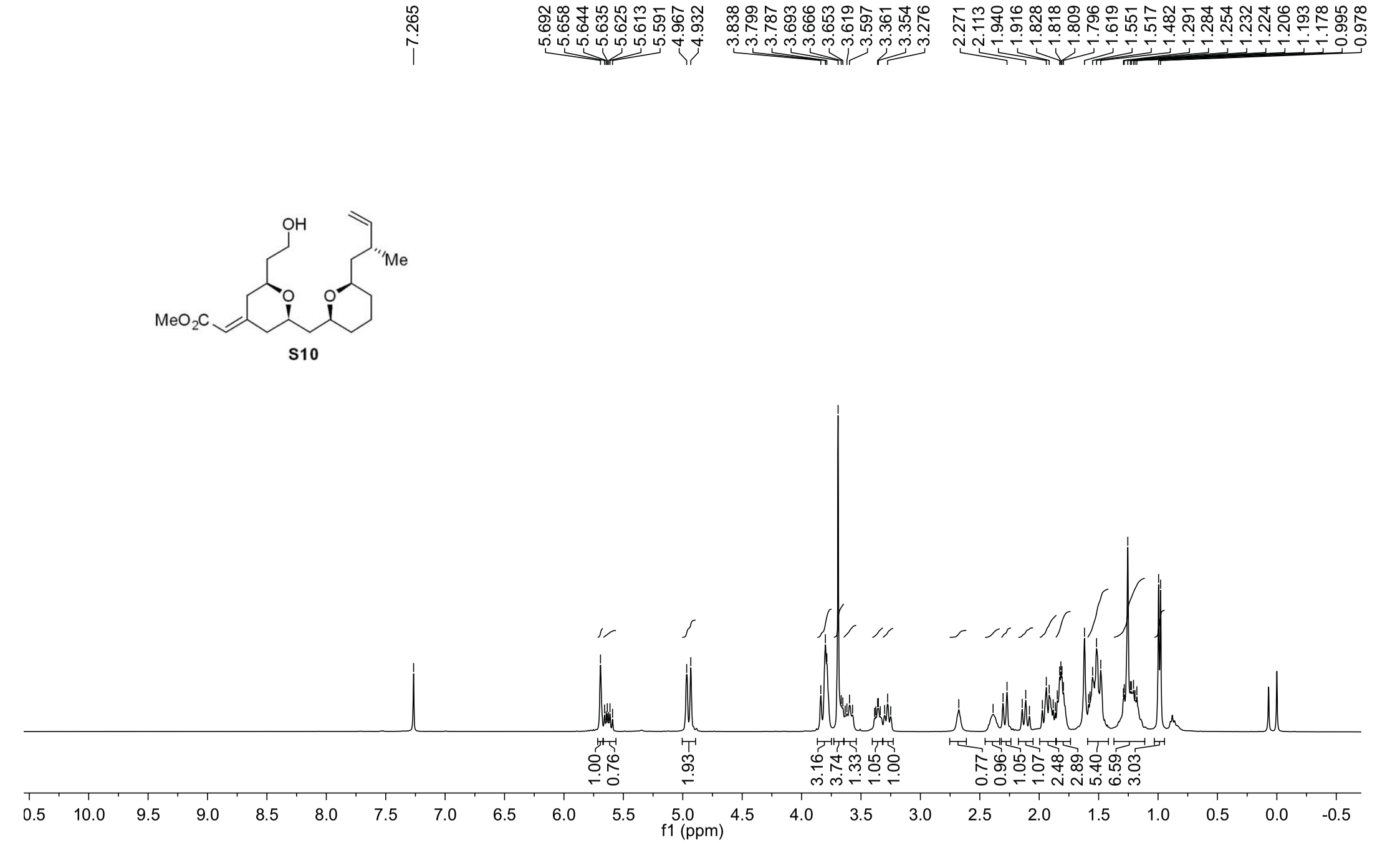


10d (α-Br isomer)

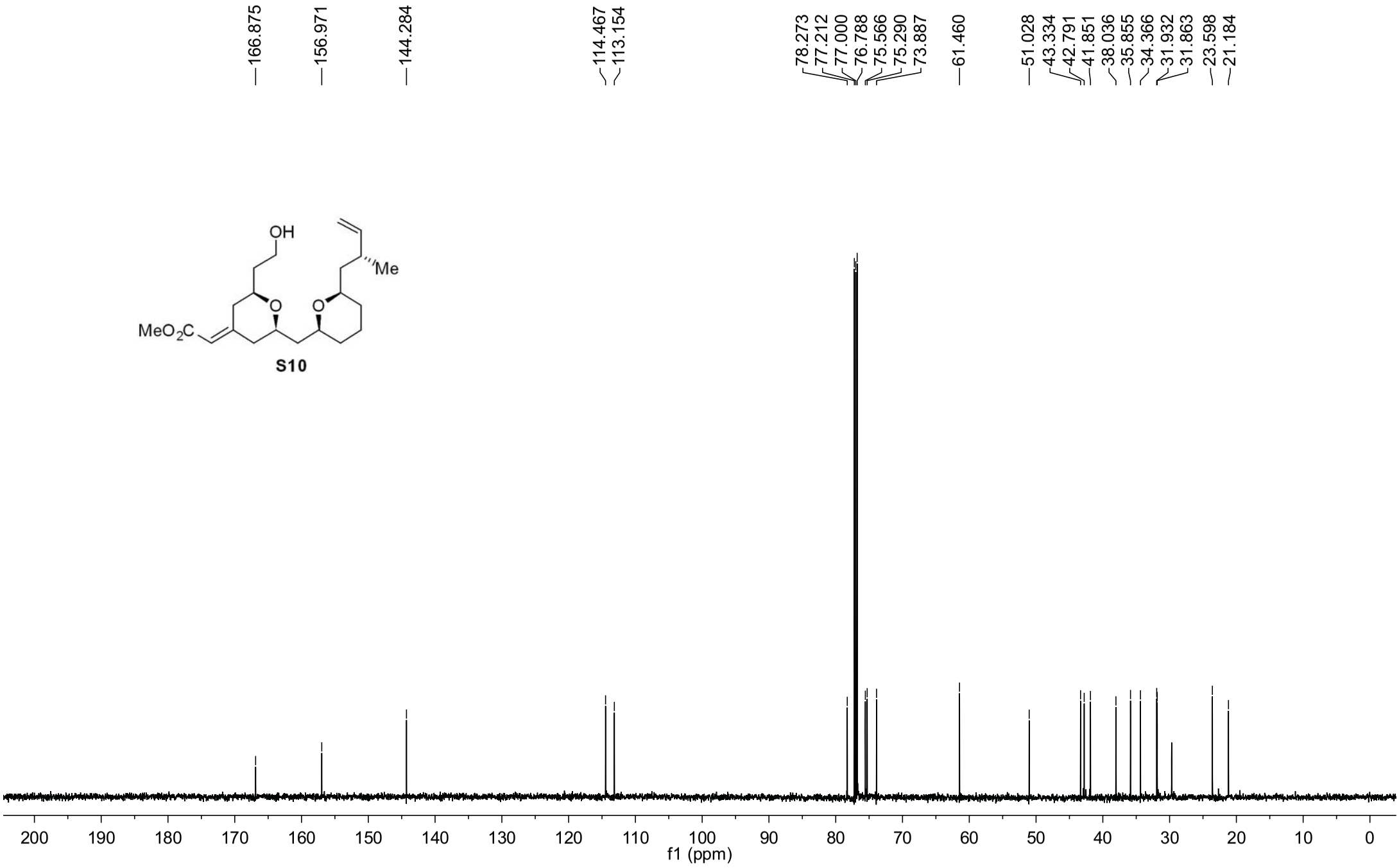
XHM0236B C13 CDCl3 100 M Hz



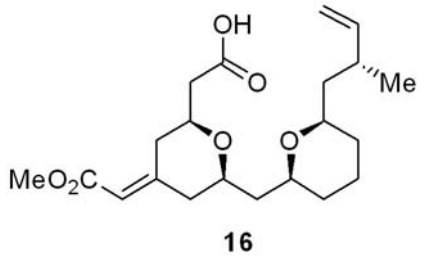
XHM0351 H1 CDCl3 400 M Hz



XHM0351 C13 CDCl3 150 M Hz



LHZ0615 H1 CDCl3 400 M Hz



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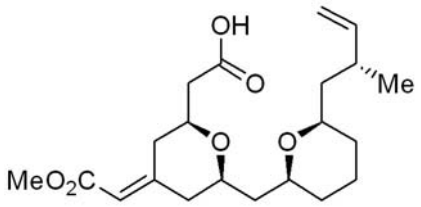
LHZ0615 C13 CDCl3 100 M Hz

175.851
166.736
156.223
144.236
114.873
113.079
77.315
77.000
76.680
75.528
75.053
73.837
73.703
51.051
43.304
42.342
41.597
41.028
35.128
34.227
31.923
31.478
23.541
21.124



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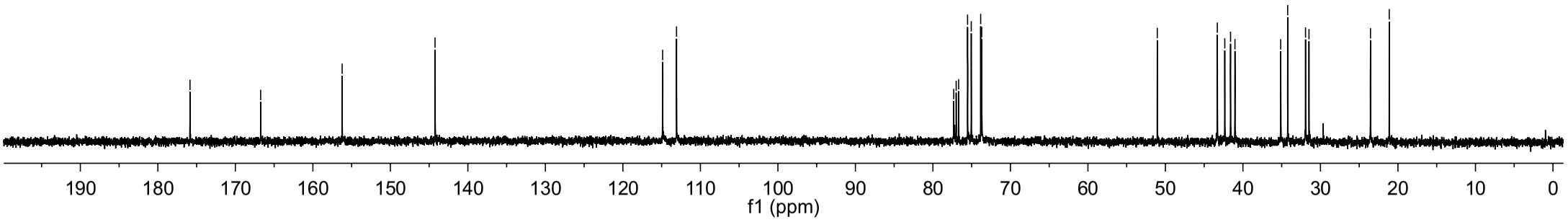
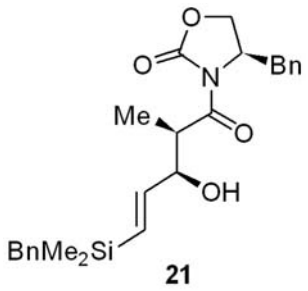


XHM0151-1 H1 CDCl3 400 M Hz



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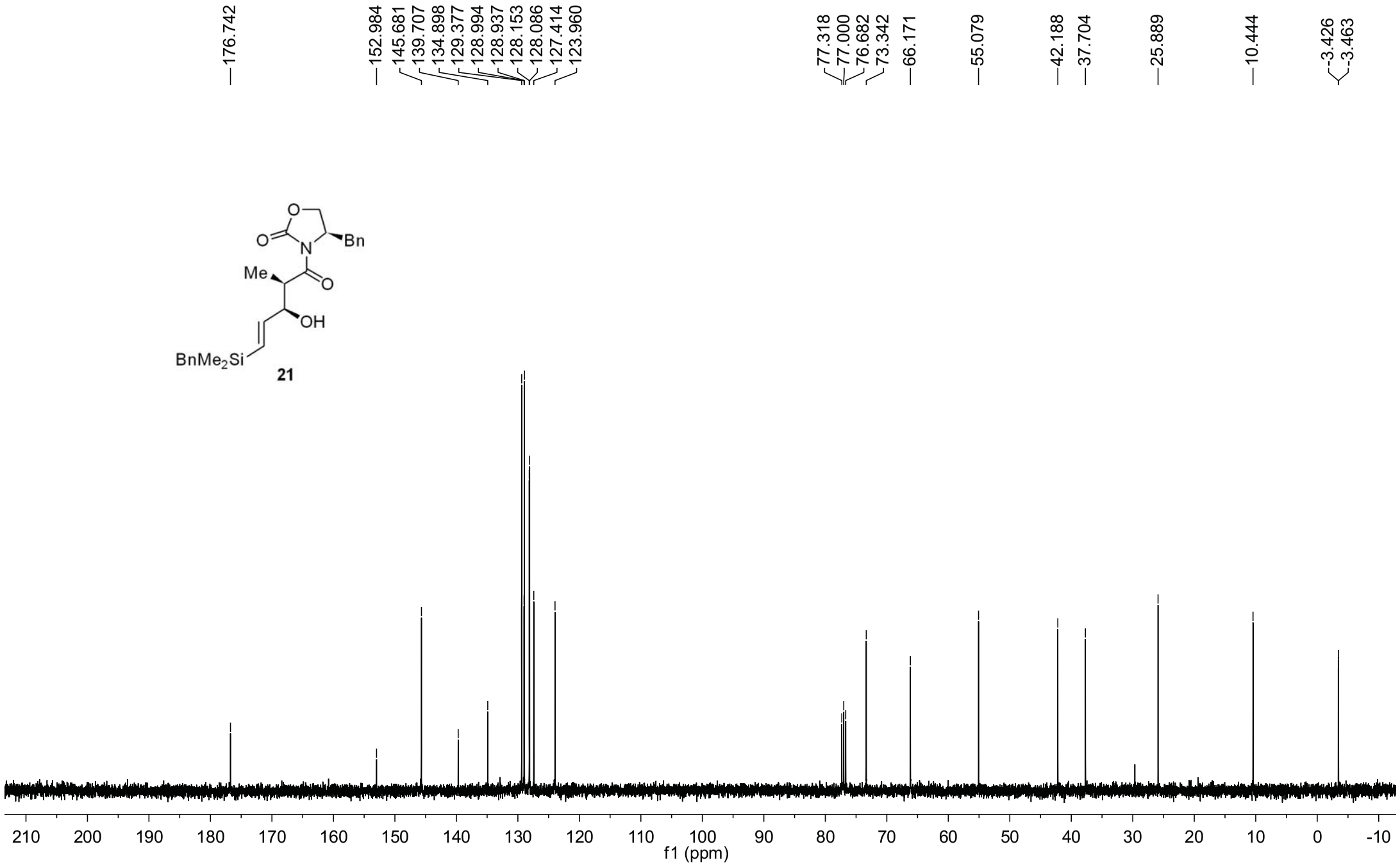
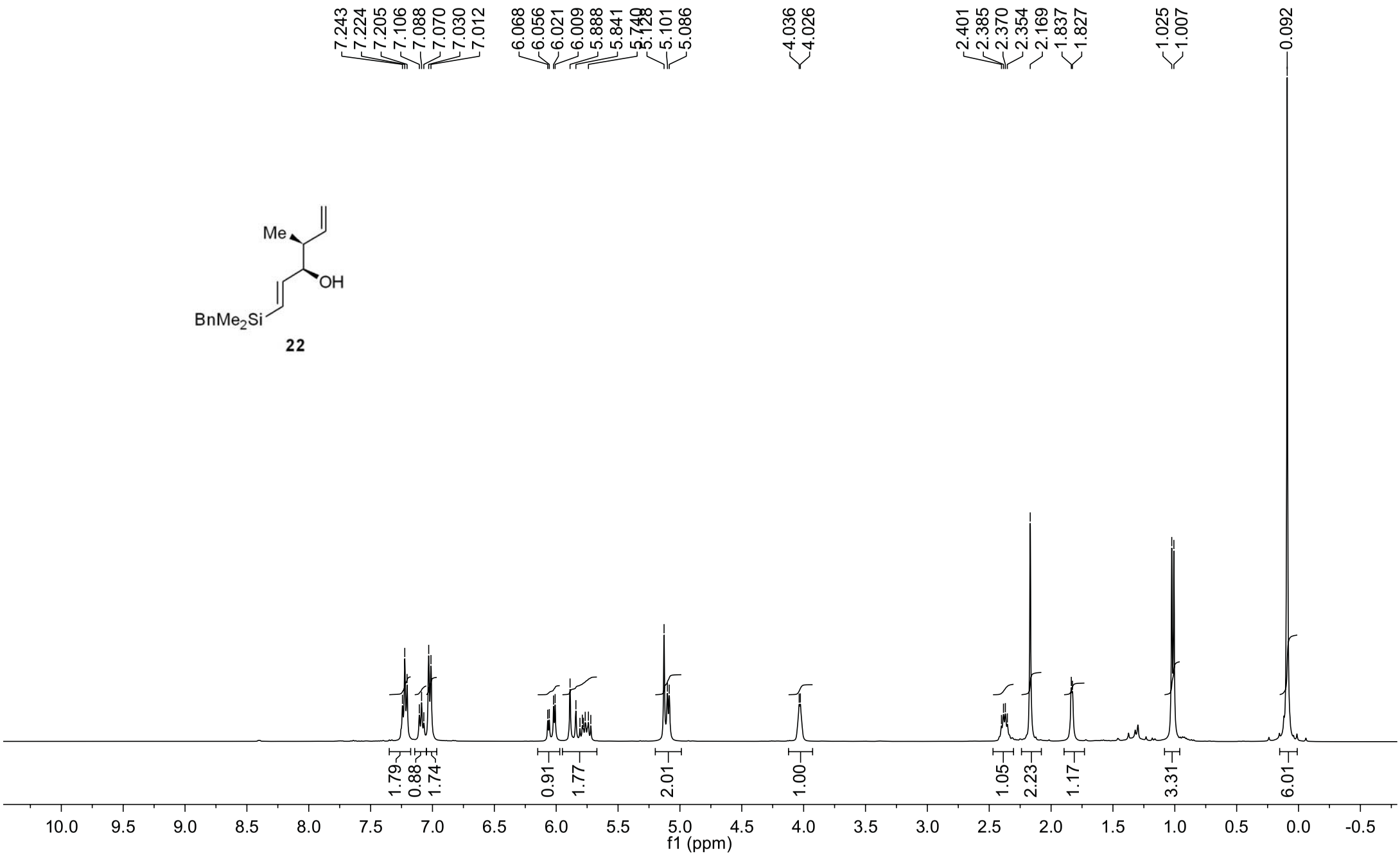
XHM0151-1 C13 CDCl3 100 M Hz

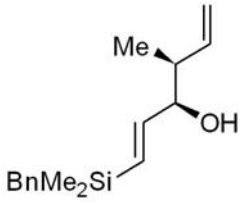


ZZG-5-28 H1 CDCl3 400 M Hz

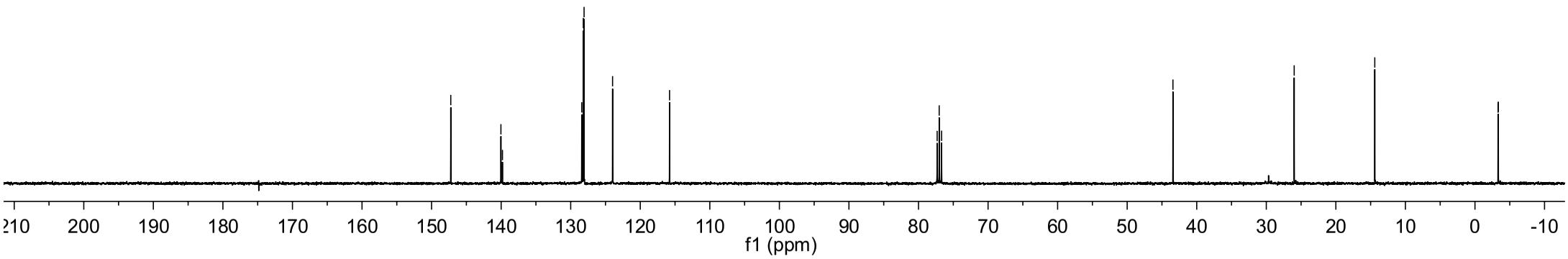


ZZG-5-28 C13 CDCl3 100 M Hz

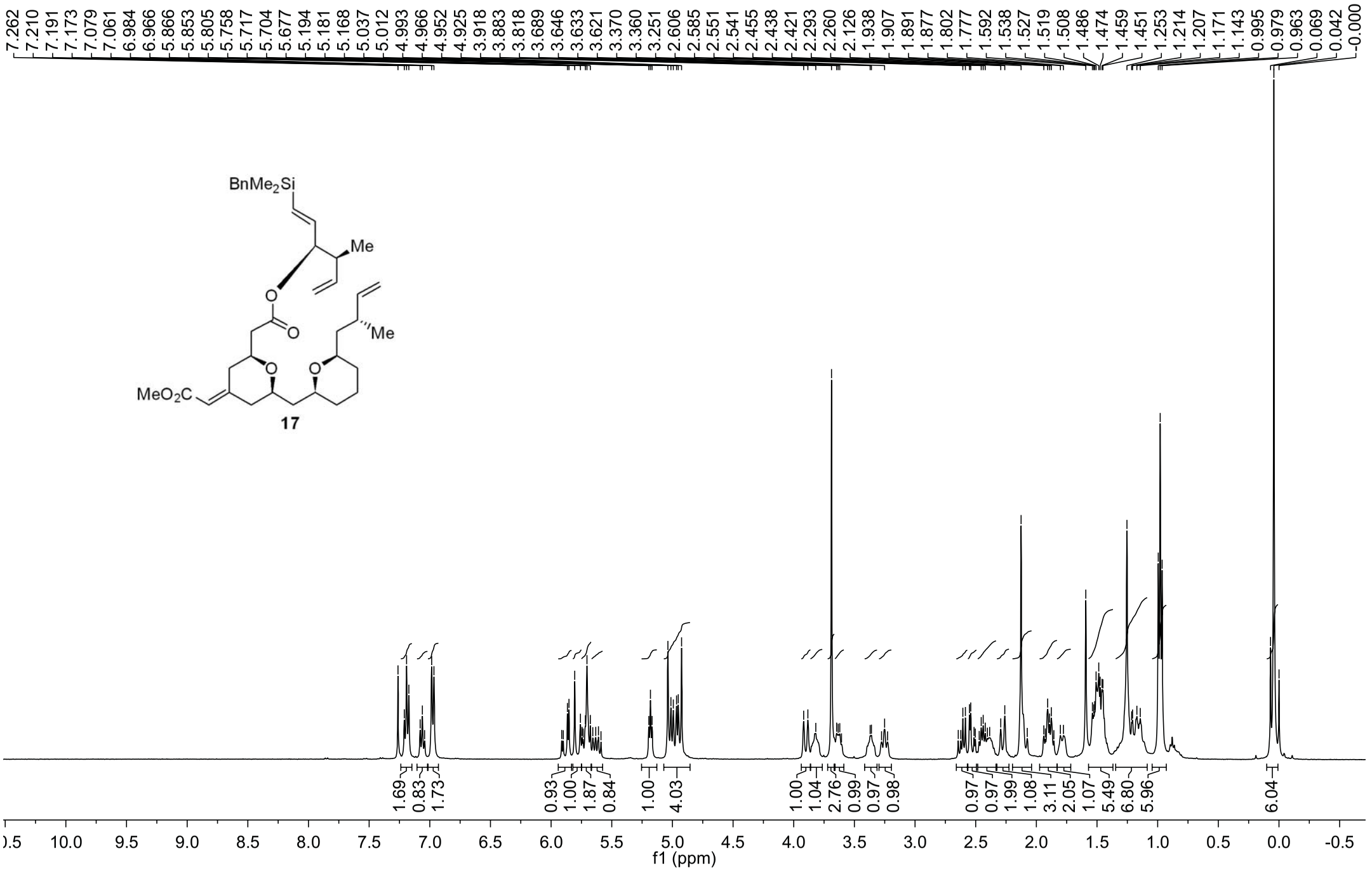
147.241
140.032
139.811
128.412
128.188
128.076
123.980
115.787
77.317
77.025
77.000
76.681
43.421
25.990
14.404
-3.318
-3.355



22



XHM0421 H1 CDCl3 400 M Hz



XHM0421 C13 CDCl3 100 M Hz

169.945
166.753
156.795
144.326
142.685
139.718
139.284
130.386
128.220
128.073
123.975
115.383
114.672
113.073
78.895
77.317
77.000
76.682
75.391
74.939
74.158
73.650
51.023
43.432
42.513
41.667
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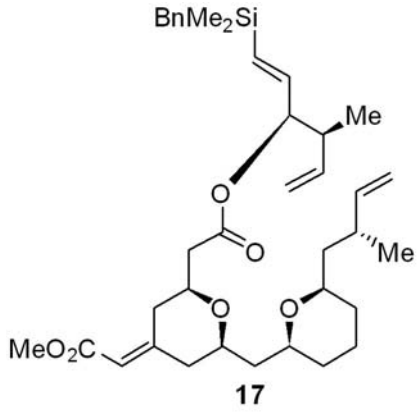
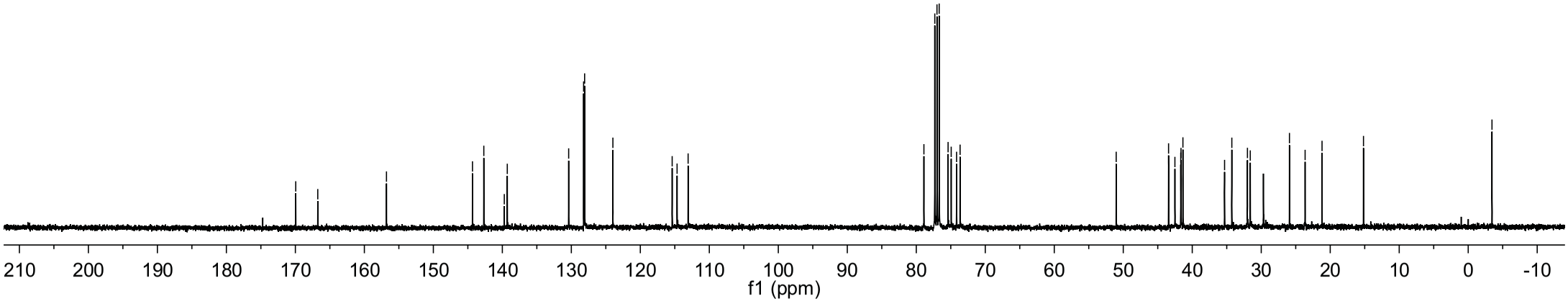
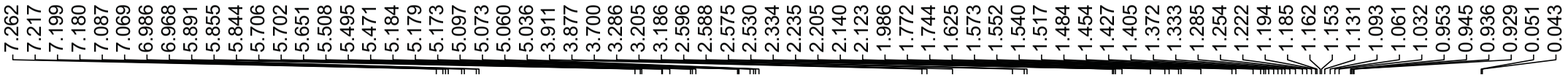
31.590
25.910
23.640
21.188
15.179
-3.446

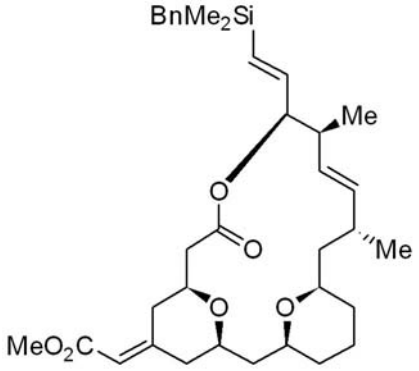


17

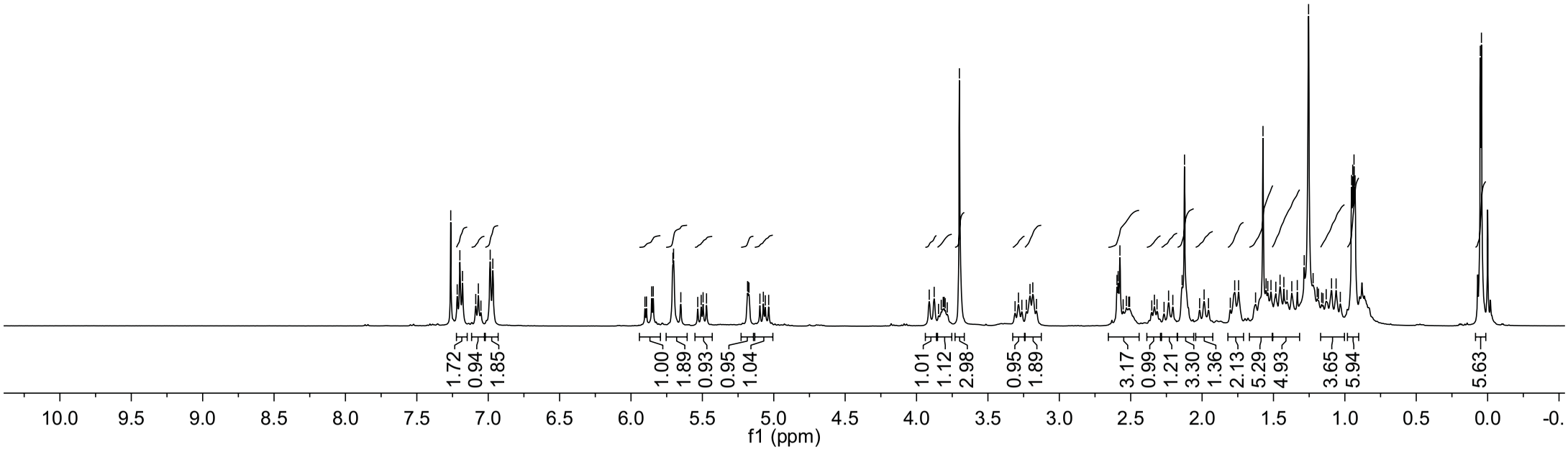


LHZRCM1 H1 CDCl3 400 M Hz

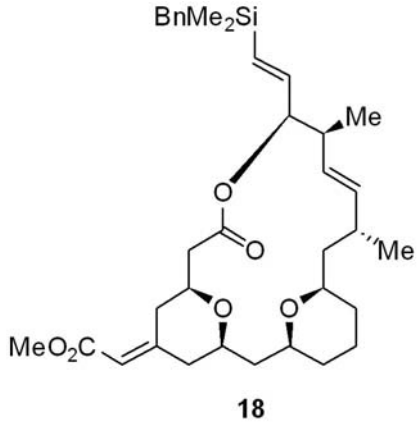




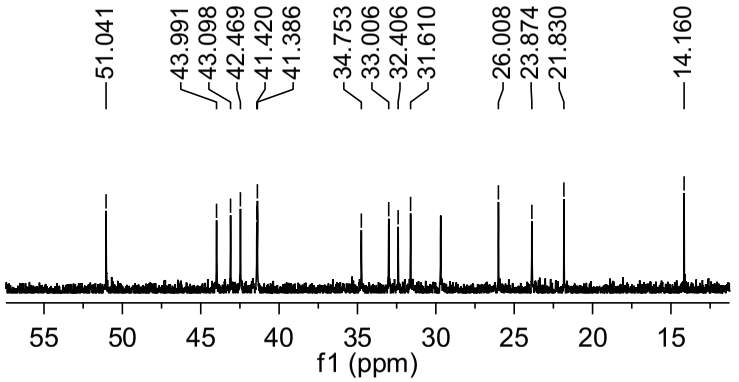
18



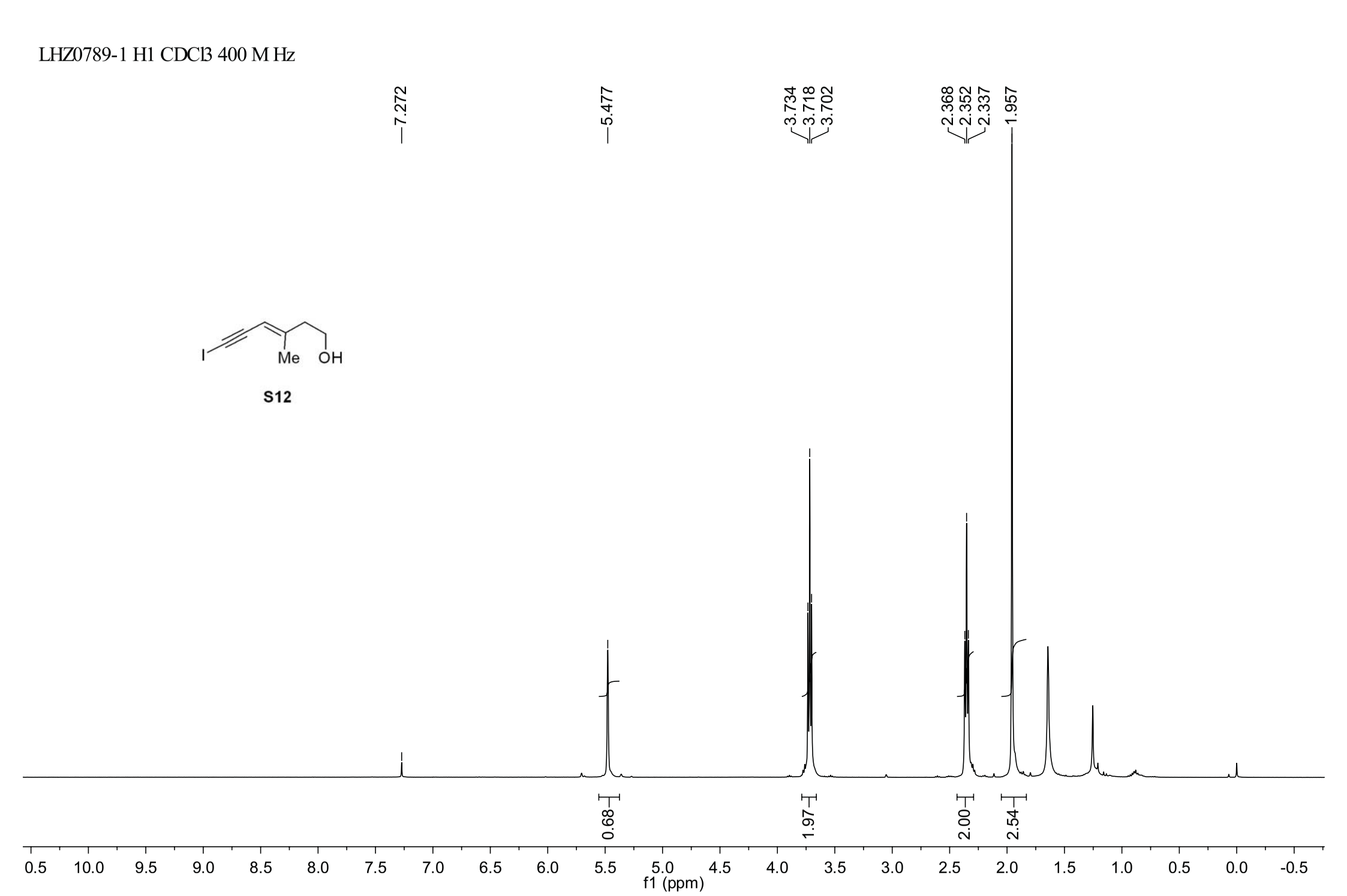
LHZRCM C13 CDCl3 100 M Hz



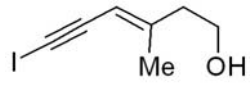
18



LHZ0789-1 H1 CDCl3 400 M Hz

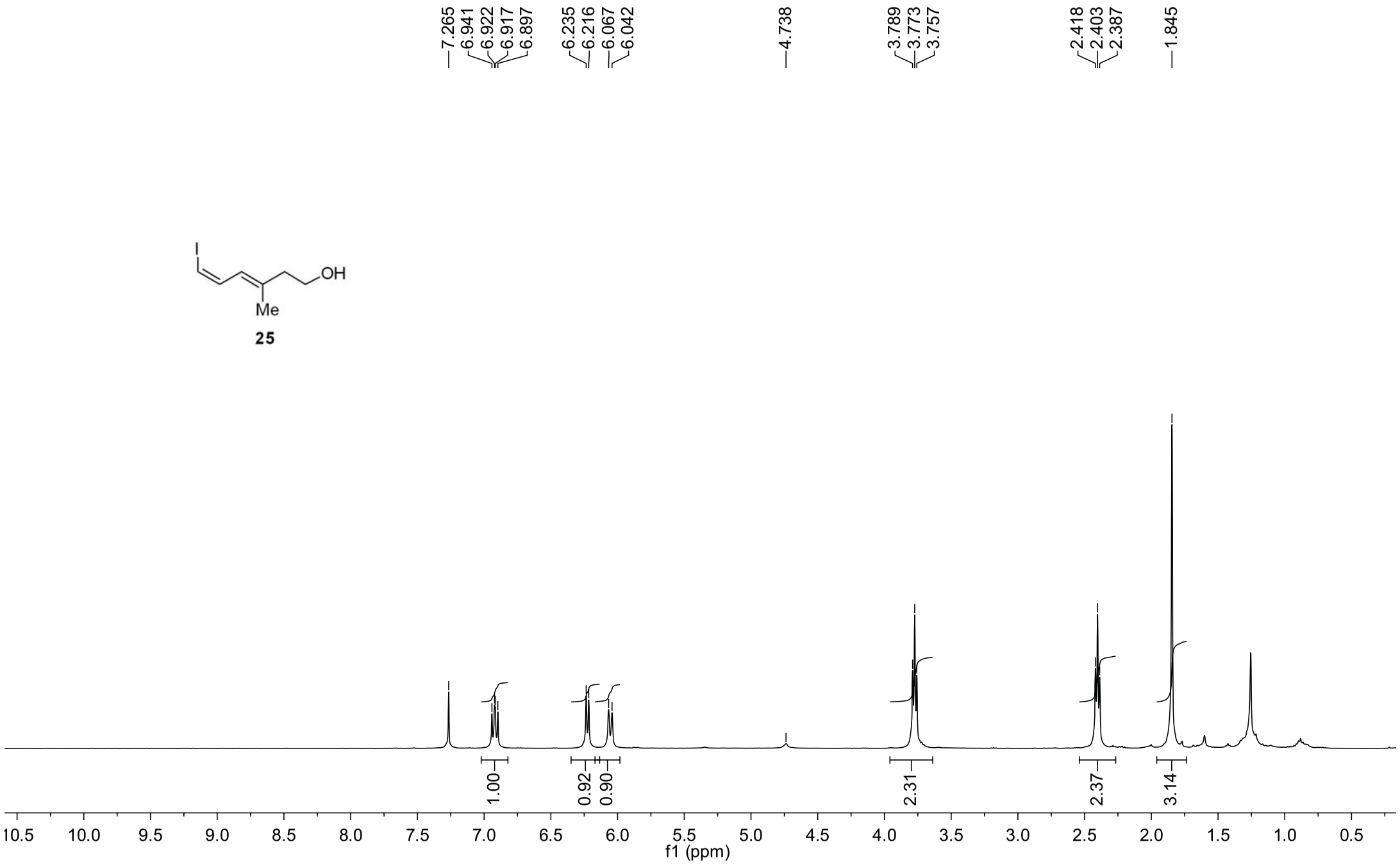


LHZ0789-1 C13 CDCl3 100 M Hz

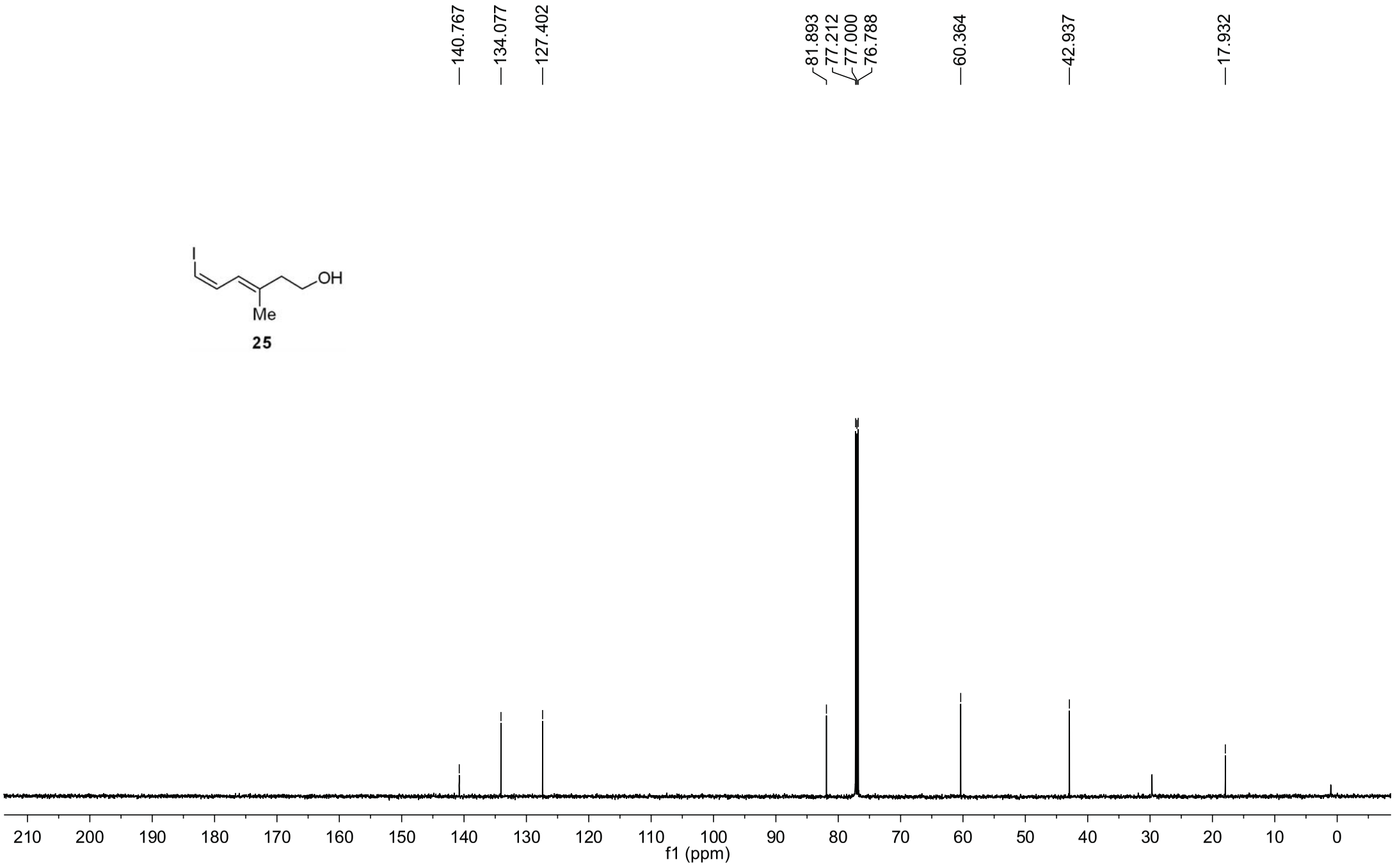


S12

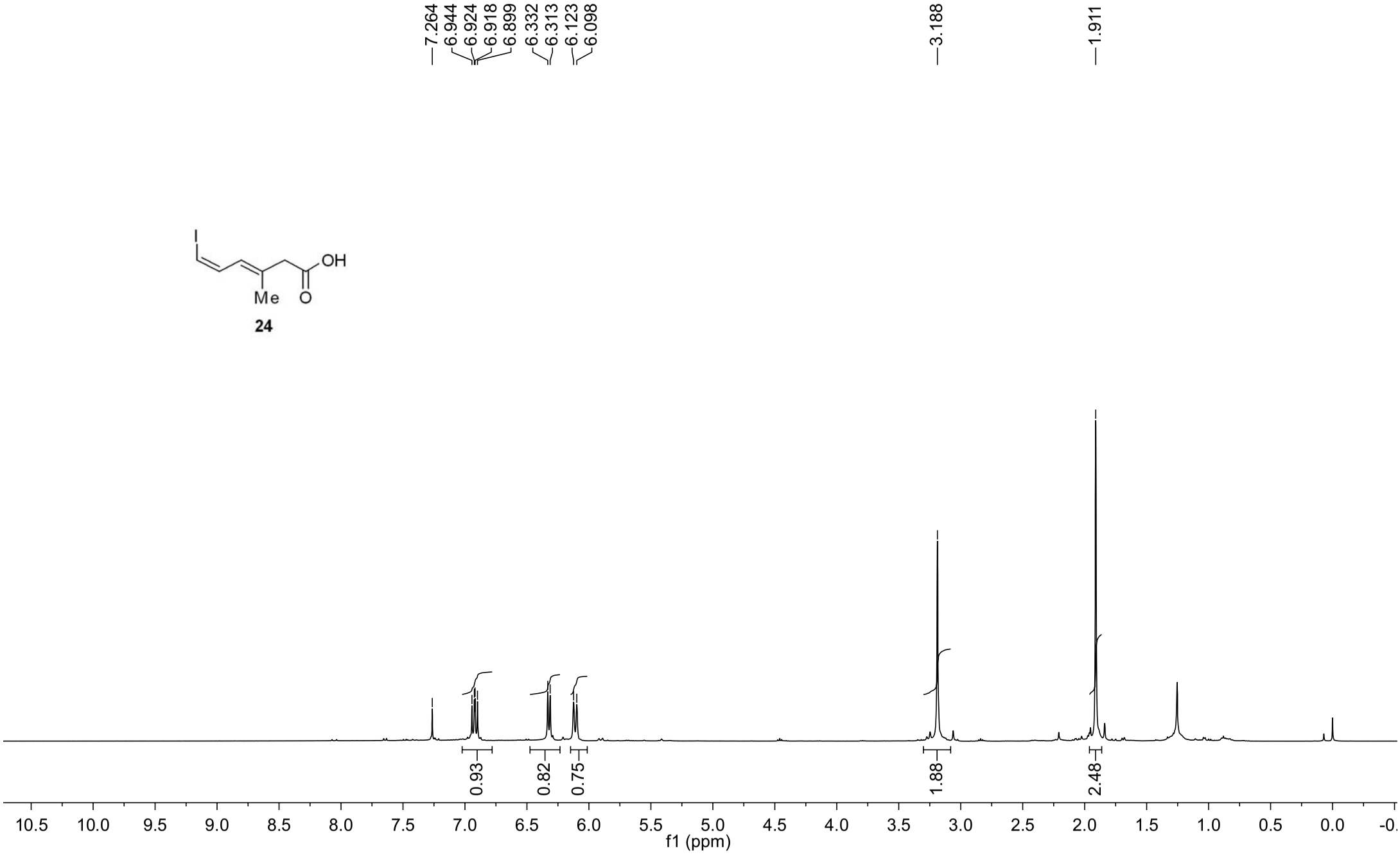
LHZ0789-2C H1 CDCl3+D2O 400 M Hz



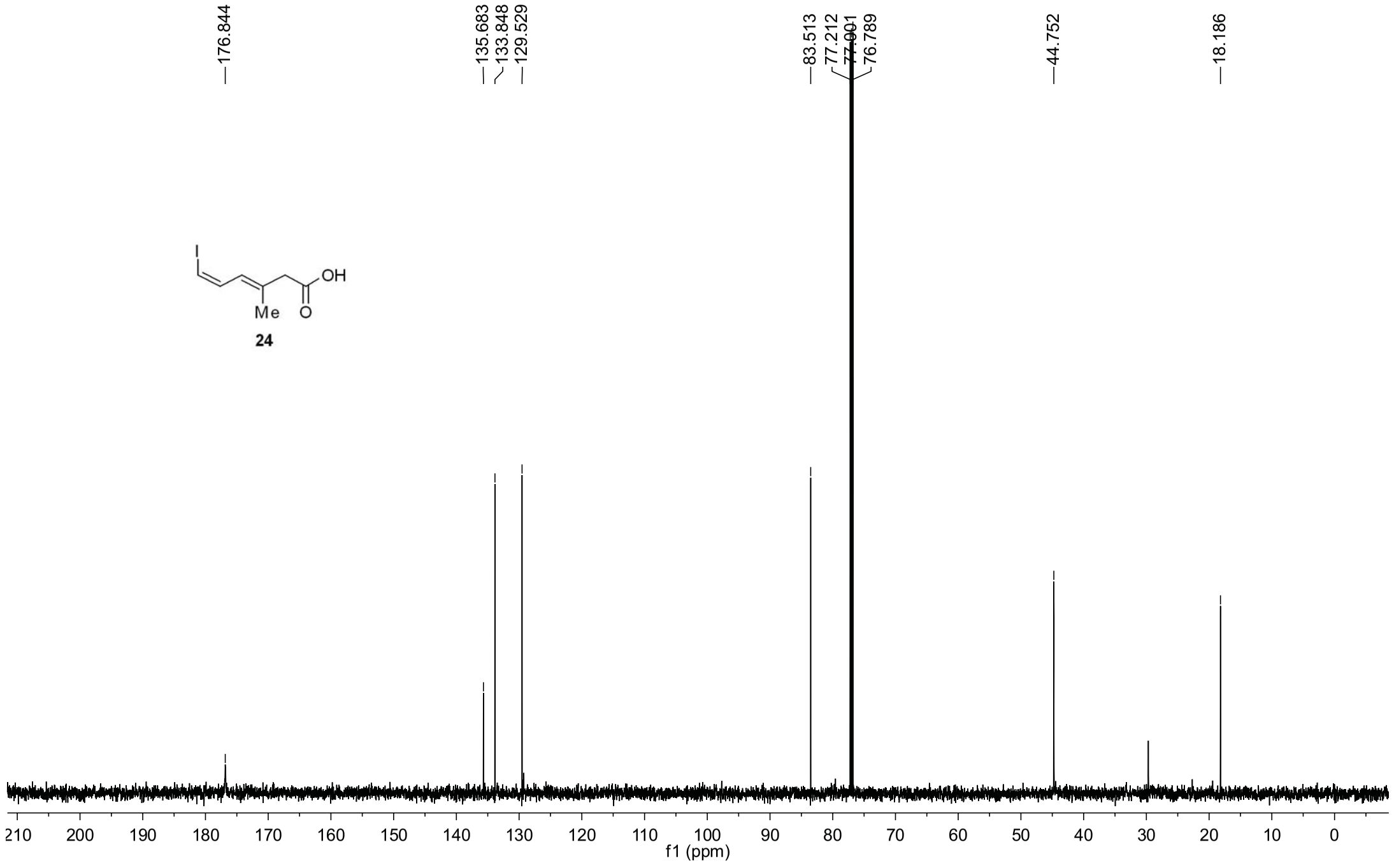
LHZ0789-2C C13 CDCl3 150 M Hz



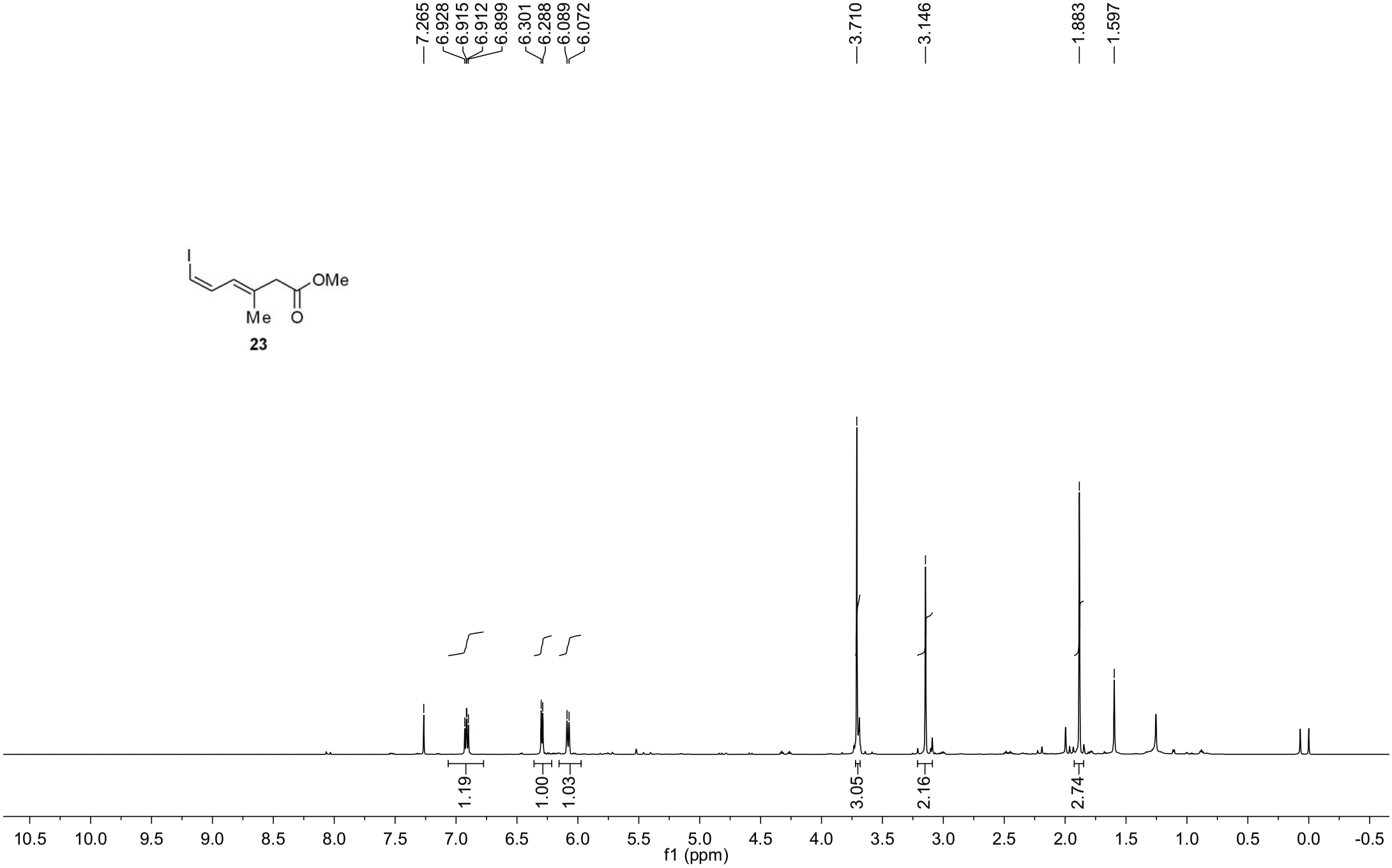
LHZ0789-3 H1 CDCl3 400 M Hz



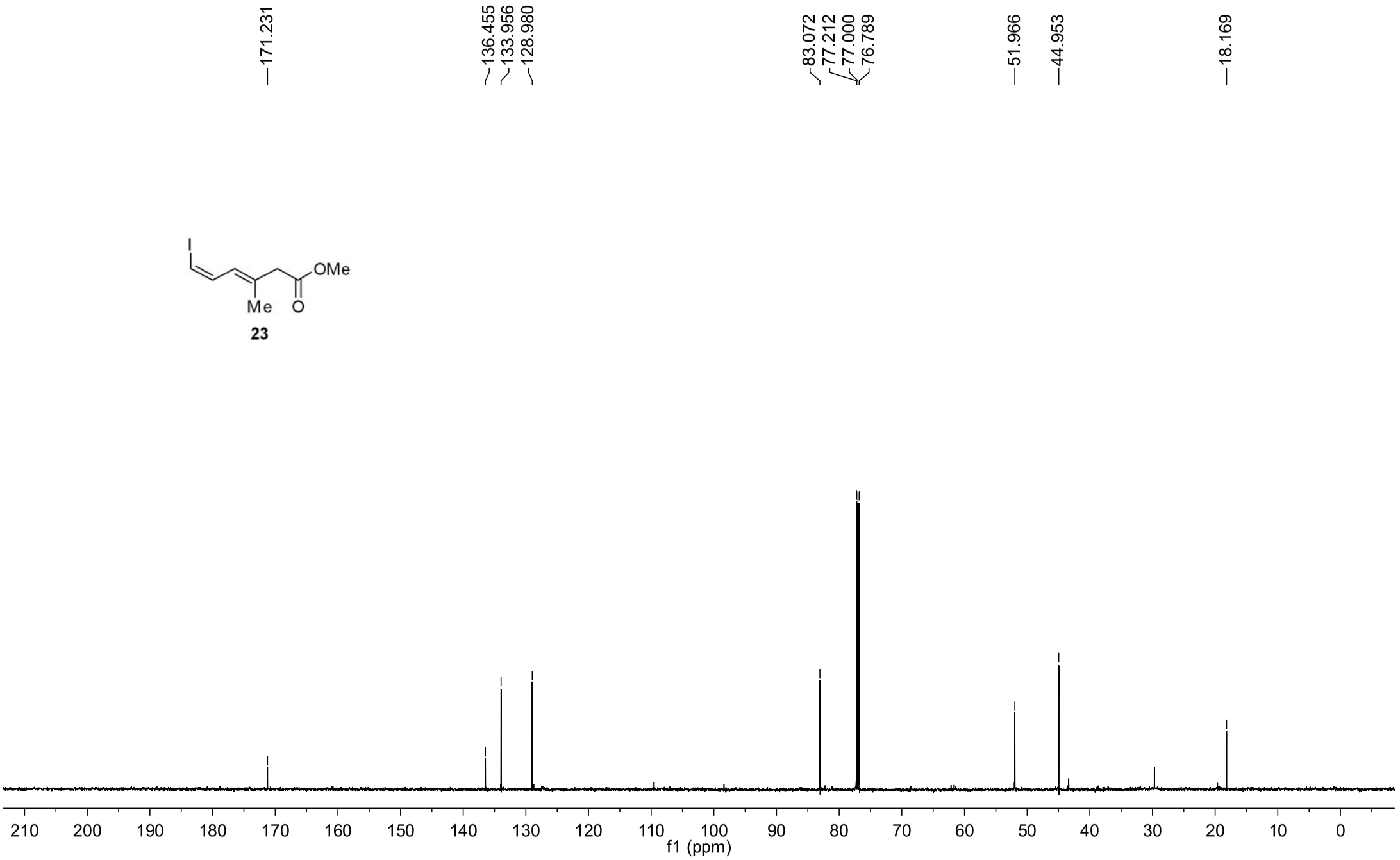
LHZ0789-3 C13 CDCl3 150 MHz



LHZ0789-4 H1 CDCl3 600 M Hz

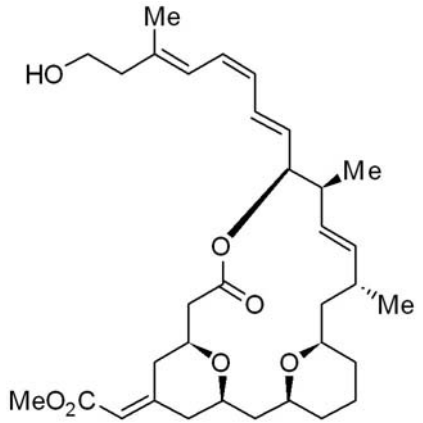


LHZ0789-4 C13 CDCl3 150 M Hz



LHZ0687 H1 CDCl3 400 M Hz

7.264 6.354 6.207 5.932 5.703 5.684 5.666 5.521 5.497 5.268 5.251 5.112 5.088 5.075 3.892 3.857 3.788 3.771 3.757 3.743 3.728 3.696 3.302 3.219 3.202 2.574 2.558 2.551 2.523 2.514 2.412 2.396 2.381 2.371 2.346 2.230 2.202 2.139 2.106 2.039 2.009 1.977 1.809 1.788 1.753 1.677 1.666 1.635 1.579 1.541 1.530 1.520 1.497 1.490 1.461 1.433 1.427 1.410 1.373 1.333 1.313 1.285 1.254 1.205 1.107 1.081 1.066 1.049 0.949 0.932



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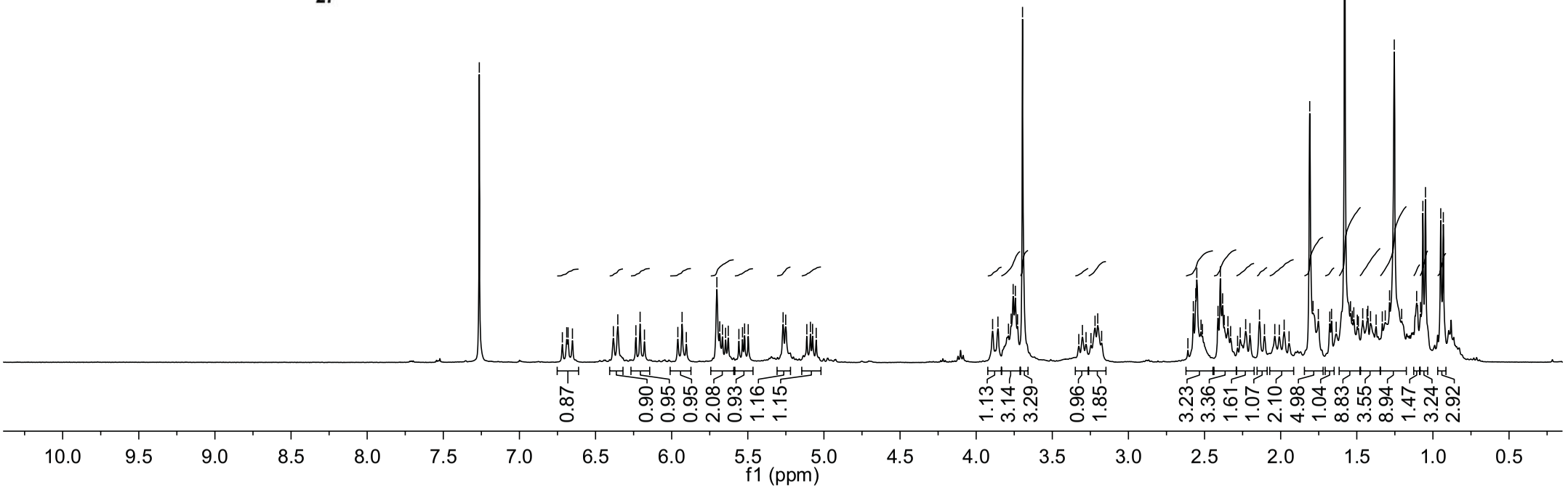
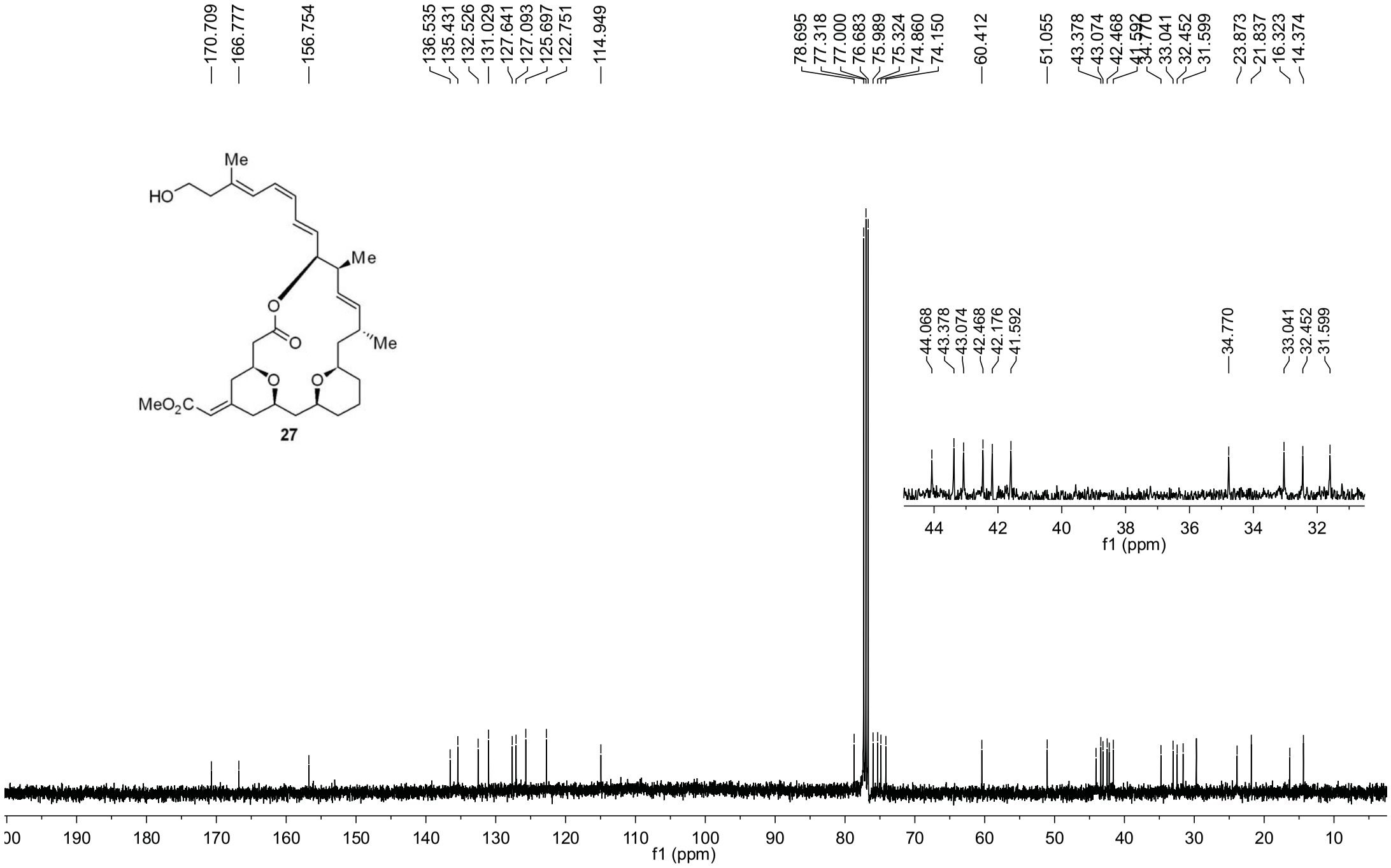
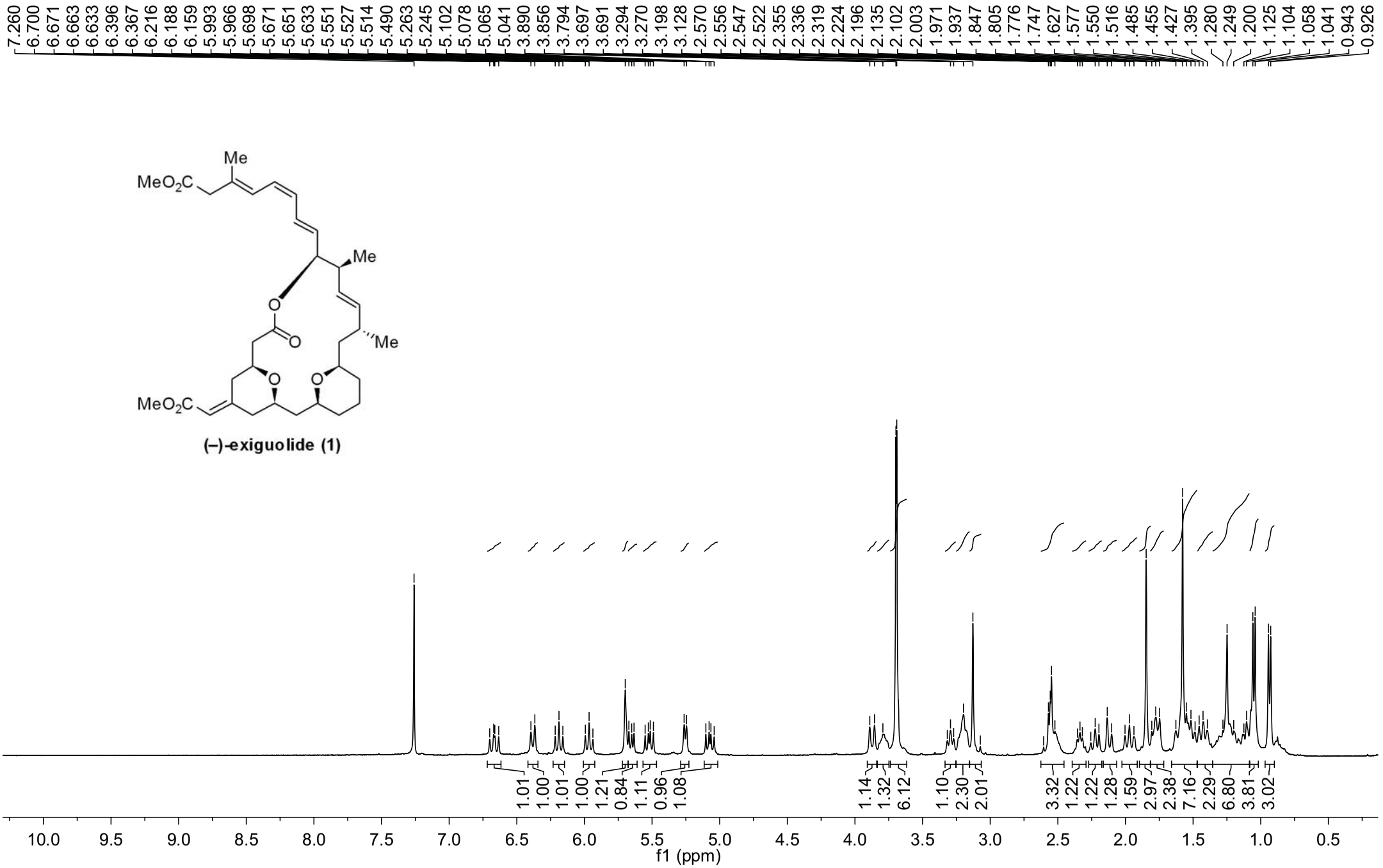


LHZ0687 C13 CDCl3 100 M Hz



LHZ06376 H1 CDCl3 400 M Hz



LHZ06376 C13 CDCl3 100 M Hz