

***Rhodium-Catalyzed Endo-Selective Epoxide-Opening Cascades: Formal  
Synthesis of (–)-Brevisin***

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**Supporting Information**

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## I. General Experimental

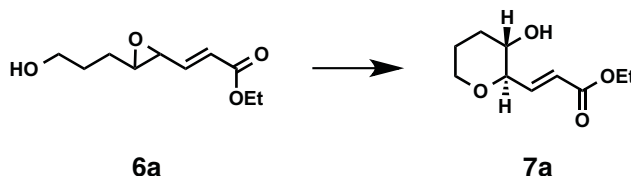
All reactions were performed under an atmosphere of argon under anhydrous conditions, unless otherwise noted. Dichloromethane, tetrahydrofuran (THF), Et<sub>2</sub>O, benzene, dioxane, acetonitrile, dimethylformamide (DMF), pyridine, dimethylsulfoxide (DMSO) and triethylamine were purified via an SG Water USA solvent column system. Solvents used for Rh-promoted epoxide-opening reactions were sparged with argon prior to use. Unless otherwise noted, all reagents were commercially obtained and used without further purification. Analytical thin layer chromatography (TLC) was performed using EM Science silica gel 60 F<sub>254</sub> plates, visualizing with a UV lamp (254 nm), KMnO<sub>4</sub>, *p*-anisaldehyde, or CAM. Liquid chromatography was performed using forced flow (flash chromatography) of the indicated solvent system on Silicycle silica gel (230–400 mesh) or Biotage® Isolera flash purification system on SNAP HP-SIL columns.

<sup>1</sup>H NMR and <sup>13</sup>C Nuclear Magnetic Resonance (NMR) spectra were recorded at ambient temperature at 600 MHz and 150 MHz, respectively, using a Bruker AVANCE-600 spectrometer or 500 MHz and 125 MHz, respectively, using a Varian Inova-500 spectrometer. The <sup>1</sup>H NMR data are reported as follows: chemical shift in parts per million (ppm) from an internal standard of residual CHCl<sub>3</sub> in CDCl<sub>3</sub> (7.27 ppm) on the  $\delta$  scale, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet), coupling constants in hertz (Hz), and integration (H). Chemical shifts of <sup>13</sup>C NMR spectra are reported in ppm from the central peak of CDCl<sub>3</sub> (77.2 ppm).

Infrared (IR) spectra were recorded on a Perkin-Elmer Model 2000 FT-IR or an Agilent Cary 630 FTIR Spectrometer. High resolution mass spectra (HR-MS) were acquired on a Bruker Daltronics APEXIV 4.7 Tesla Fourier Transform Ion Cyclotron Resonance Mass Spectrometer at the Massachusetts Institute of Technology Department of Chemistry Instrumentation Facility. Optical rotations were measured using a Jasco Model 1010 digital polarimeter at 589 nm and calculated using the formula:  $[\alpha]_D = (\alpha_{\text{obs}} * 100) / (l * c)$ , where  $c$  = (g of substrate/100 mL of solvent) and  $l$  = 1 dm.

## II. Procedures for Epoxide-Opening Reactions

### A. Rh-promoted Epoxide-Opening:



**[Rh(CO)<sub>2</sub>Cl]<sub>2</sub> promoted cyclization of epoxy alcohol 6a:** To a 20 ml vial equipped with a magnetic stir bar was added epoxide **6a** (57 mg, 0.28 mmol), THF (1.4 mL), and a solution of [Rh(CO)<sub>2</sub>Cl]<sub>2</sub> in THF (2.8 mg, 7  $\mu$ mol, in 1.4 mL THF) and stirred at room temperature. After consumption of the starting material (1 h, as determined by TLC analysis), 40 mg

of polymer-bound triphenylphosphine resin was added and stirred for 30 min. The cloudy brown solution was filtered through a plug of silica gel (pretreated with Et<sub>3</sub>N/EtOAc 2:98 then flushed with EtOAc), eluted with EtOAc, and concentrated *in vacuo*. <sup>1</sup>H NMR spectroscopic analysis of the unpurified mixture indicated a >95:5 [*endo*(**7a**)/*exo*(**8a**)] ratio of products. The resultant pale yellow film was purified by flash chromatography (EtOAc/hexanes, gradient 20:80 to 40:60) to afford **7a** as a colorless oil (53.2 mg, 94%).

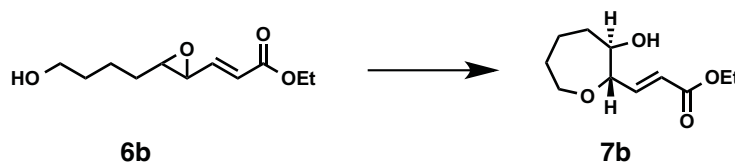
#### Characterization Data for **7a**:

<sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.08 (dd, *J* = 15.8, 4.9 Hz, 1H), 6.09 (dd, *J* = 15.8, 1.5 Hz, 1H), 4.18 (q, *J* = 7.1 Hz, 2H), 3.95 (d, *J* = 12.1 Hz, 1H), 3.67 (ddd, *J* = 9.0, 4.9, 1.4 Hz, 1H), 3.41-3.34 (m, 2H), 2.54-2.50 (br, 1H), 2.16-2.13 (m, 1H), 1.72-1.67 (m, 2H), 1.52-1.44 (m, 1H), 1.27 (t, *J* = 7.1 Hz, 3H)

<sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 166.7, 145.4, 122.2, 81.3, 70.0, 67.5, 60.7, 32.7, 25.4, 14.4

FT-IR (ATR, cm<sup>-1</sup>): 3422, 2940, 2857, 1700, 1658, 1445, 1368, 1303, 1265, 1174, 1077, 1041, 982

HRMS (DART, *m/z*): [M+NH<sub>4</sub>]<sup>+</sup> calculated for C<sub>10</sub>H<sub>16</sub>O<sub>4</sub>: 218.1387, found 218.1385



**[Rh(CO)<sub>2</sub>Cl]<sub>2</sub> promoted cyclization of epoxy alcohol **6b**:** To a 20 ml vial equipped with a magnetic stir bar was added epoxide **6b** (54 mg, 0.25 mmol), THF (1.25 mL), and a solution of [Rh(CO)<sub>2</sub>Cl]<sub>2</sub> in THF (4.9 mg, 13 μmol, in 1.25 mL THF) and stirred at room temperature. After consumption of the starting material (9 h, as determined by TLC analysis), 45 mg of polymer-bound triphenylphosphine resin was added and stirred for 30 min. The cloudy brown solution was filtered through a plug of silica gel (pretreated with Et<sub>3</sub>N/EtOAc 2:98 then flushed with EtOAc), eluted with EtOAc, and concentrated *in vacuo*. <sup>1</sup>H NMR spectroscopic analysis of the unpurified mixture indicated a >95:5 [*endo*(**7b**)/*exo*(**8b**)] ratio of products. The resultant pale yellow film was purified by flash chromatography (EtOAc/hexanes, gradient 20:80 to 40:60) to afford **7b** as a colorless oil (43.6 mg, 81%).

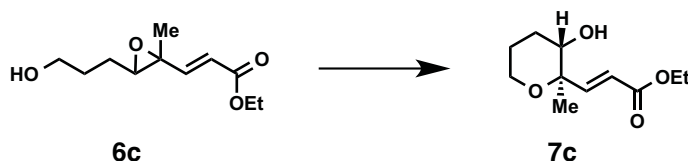
#### Characterization Data for **7b**:

<sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.09 (dd, *J* = 15.7, 4.4 Hz, 1H), 6.10 (dd, *J* = 15.7, 1.8 Hz, 1H), 4.19 (q, *J* = 7.1 Hz, 2H), 3.94 (dt, *J* = 12.2, 5.3 Hz, 1H), 3.88 (ddd, *J* = 8.5, 4.4, 1.8 Hz, 1H), 3.70-3.60 (m, 2H), 2.13 (br, 1H), 2.01-1.97 (m, 1H), 1.80-1.67 (m, 4H), 1.61-1.55 (m, 1H), 1.28 (t, *J* = 7.1 Hz, 3H)

<sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) δ 166.9, 147.2, 121.1, 83.4, 74.7, 70.8, 60.6, 36.1, 30.7, 21.0, 14.4

FT-IR (ATR, cm<sup>-1</sup>): 3425, 2932, 2864, 1700, 1656, 1446, 1368, 1300, 1270, 1172, 1135, 1102, 1038

HRMS (DART, *m/z*): [M+NH<sub>4</sub>]<sup>+</sup> calculated for C<sub>11</sub>H<sub>18</sub>O<sub>4</sub>: 232.1543, found 232.1543



**[Rh(CO)<sub>2</sub>Cl]<sub>2</sub> promoted cyclization of epoxy alcohol 6c:** To a 20 ml vial equipped with a magnetic stir bar was added epoxide **6c** (60 mg, 0.28 mmol), THF (2.3 mL), and a solution of [Rh(CO)<sub>2</sub>Cl]<sub>2</sub> in THF (1.1 mg, 3  $\mu$ mol, in 0.5 mL THF) and stirred at room temperature. After consumption of the starting material (3 h, as determined by TLC analysis), 11 mg of polymer-bound triphenylphosphine resin was added and stirred for 30 min. The cloudy brown solution was filtered through a plug of silica gel (pretreated with Et<sub>3</sub>N/EtOAc 2:98 then flushed with EtOAc), eluted with EtOAc, and concentrated *in vacuo*. <sup>1</sup>H NMR spectroscopic analysis of the unpurified mixture indicated only *endo*-**7c** present and no *exo*-**8c** was observed. The resultant pale yellow film was purified by flash chromatography (EtOAc/hexanes, gradient 15:85 to 35:65) to afford **7c** as a colorless oil (56 mg, 93%).

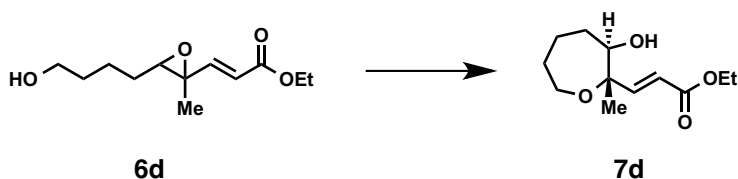
#### Characterization Data for 7c:

<sup>1</sup>H NMR (600 MHz, CDCl<sub>3</sub>)  $\delta$  7.05 (d, *J* = 16.0 Hz, 1H), 6.04 (d, *J* = 16.0 Hz, 1H), 4.21 (q, *J* = 7.1 Hz, 2H), 3.72 (ddd, *J* = 11.5, 6.7, 4.5 Hz, 1H), 3.67 (ddd, *J* = 11.6, 7.4, 3.8 Hz, 1H), 3.62-3.59 (m, 1H), 1.92 (d, *J* = 6.7 Hz, 1H), 1.86-1.71 (m, 3H), 1.56-1.50 (m, 1H), 1.31 (s, 3H) 1.30 (t, *J* = 7.1 Hz, 6H)

<sup>13</sup>C NMR (150 MHz, CDCl<sub>3</sub>)  $\delta$  166.8, 151.4, 120.8, 77.07, 70.9, 61.8, 60.7, 27.7, 22.6, 19.8, 14.4

FT-IR (ATR, cm<sup>-1</sup>): 3452, 2979, 2940, 2870, 1700, 1654, 1445, 1368, 1302, 1268, 1230, 1178, 1117, 1083, 1056

HRMS (DART, *m/z*): [M+H]<sup>+</sup> calculated for C<sub>11</sub>H<sub>18</sub>O<sub>4</sub>: 215.1278, found 215.1278



**[Rh(CO)<sub>2</sub>Cl]<sub>2</sub> promoted cyclization of epoxy alcohol 6d:** To a 20 ml vial equipped with a magnetic stir bar was added epoxide **6d** (60 mg, 0.26 mmol), THF (2.0 mL), and a solution of [Rh(CO)<sub>2</sub>Cl]<sub>2</sub> in THF (2.5 mg, 7  $\mu$ mol, in 0.6 mL THF) and stirred at room temperature. After consumption of the starting material (5 h, as determined by TLC analysis), 25 mg of polymer-bound triphenylphosphine resin was added and stirred for 30 min. The cloudy brown solution was filtered through a plug of silica gel (pretreated with Et<sub>3</sub>N/EtOAc 2:98 then flushed with EtOAc), eluted with EtOAc, and concentrated *in vacuo*. <sup>1</sup>H NMR spectroscopic analysis of the unpurified mixture indicated only *endo*-**7d** present and no

*exo*-**8d** was observed. The resultant pale yellow film was purified by flash chromatography (EtOAc/hexanes, gradient 10:90 to 35:65) to afford **7d** as a colorless oil (53 mg, 88%).

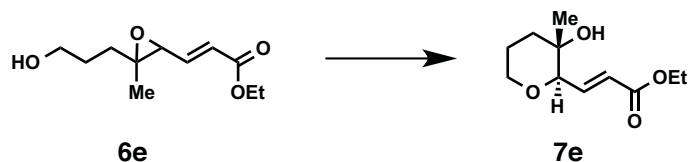
#### Characterization Data for **7d**:

**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>) δ 7.12 (d, *J* = 15.8 Hz, 1H), 6.05 (d, *J* = 15.8 Hz, 1H), 4.20 (q, *J* = 7.1 Hz, 2H), 3.85 (dd, *J* = 9.7, 1.0 Hz, 1H), 3.77 (dtd, *J* = 12.5, 3.9, 0.9 Hz, 1H), 3.44 (ddd, *J* = 12.7, 7.0, 5.5 Hz, 1H), 2.02 (dddd, *J* = 13.6, 11.1, 9.7, 2.5 Hz, 1H), 1.95 (br, 1H), 1.83-1.80 (m, 1H), 1.69-1.59 (m, 3H), 1.45-1.37 (m, 1H), 1.30 (t, *J* = 7.1 Hz, 3H), 1.25 (s, 3H)

**<sup>13</sup>C NMR** (125 MHz, CDCl<sub>3</sub>) δ 167.2, 152.2, 119.4, 80.2, 76.0, 64.7, 60.7, 32.5, 30.8, 24.6, 21.2, 14.4

**FT-IR** (ATR, cm<sup>-1</sup>): 3452, 2981, 2934, 1699, 1653, 1446, 1368, 1299, 1271, 1175, 1118, 1096, 1072, 1045

**HRMS** (DART, *m/z*): [M+NH<sub>4</sub>]<sup>+</sup> calculated for C<sub>12</sub>H<sub>20</sub>O<sub>4</sub>: 246.1700, found 246.1694



**[Rh(CO)<sub>2</sub>Cl]<sub>2</sub> promoted cyclization of epoxy alcohol **6e**:** To a 100 ml round bottom flask equipped with a magnetic stir bar open to air was added epoxide **6e** (47.4 mg, 0.22 mmol) and a solution of [Rh(CO)<sub>2</sub>Cl]<sub>2</sub> in 1,4-dioxane (8.5 mg, 22 μmol, in 4.4 mL 1,4-dioxane) and quickly heated to 80 °C in an oil bath. After consumption of the starting material (30 min, as determined by TLC analysis), the reaction was removed from the oil bath and 150 mg of polymer-bound triphenylphosphine resin was added and stirred for 2 h. The cloudy brown solution was filtered through a plug of silica gel (pretreated with Et<sub>3</sub>N/EtOAc 2:98 then flushed with EtOAc), eluted with EtOAc, and concentrated *in vacuo*. <sup>1</sup>H NMR spectroscopic analysis of the unpurified mixture indicated a 12.5:1 [*endo*(**7e**)/*exo*(**8e**)] ratio of products. The resultant pale yellow film was purified by flash chromatography (EtOAc/hexanes, gradient 20:80 to 40:60) to afford **7e** as a colorless oil (35.5 mg, 76%).

#### Characterization Data for **7e**:

**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>) δ 7.07 (dd, *J* = 15.8, 4.2 Hz, 1H), 6.08 (dd, *J* = 15.8, 1.9 Hz, 1H), 4.19 (q, *J* = 7.1 Hz, 2H), 4.01 (ddt, *J* = 11.4, 3.1, 1.6 Hz, 1H), 3.80 (dd, *J* = 4.2, 1.9 Hz, 1H), 3.43 (td, *J* = 11.7, 2.5 Hz, 1H), 1.90-1.87 (m, 2H), 1.77-1.70 (m, 1H), 1.67-1.61 (m, 2H), 1.28 (t, *J* = 7.1 Hz, 3H), 1.16 (s, 3H)

**<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>) δ 166.6, 144.2, 122.4, 83.3, 70.3, 68.0, 60.5, 39.2, 24.7, 21.4, 14.4

**FT-IR** (ATR, cm<sup>-1</sup>): 3448, 2976, 2939, 2856, 1700, 1658, 1449, 1368, 1304, 1262, 1174, 1116, 1069, 1050, 1033

**HRMS** (DART, *m/z*): [M+H]<sup>+</sup> calculated for C<sub>11</sub>H<sub>18</sub>O<sub>4</sub>: 215.1278, found 215.1292



**[Rh(CO)<sub>2</sub>Cl]<sub>2</sub> promoted cyclization of epoxy alcohol 6f:** To a 200 ml Schlenk tube equipped with a magnetic stir bar was added epoxide **6f** (53 mg, 0.23 mmol) and a solution of [Rh(CO)<sub>2</sub>Cl]<sub>2</sub> in THF (8.9 mg, 23  $\mu$ mol, in 4.6 mL THF), then the tube was sealed and quickly heated to 80 °C in an oil bath. After 18 h, the reaction was removed from the oil bath and 150 mg of polymer-bound triphenylphosphine resin was added and stirred for 1 h. The cloudy brown solution was filtered through a plug of silica gel (pretreated with Et<sub>3</sub>N/EtOAc 2:98 then flushed with EtOAc), eluted with EtOAc, and concentrated *in vacuo*. <sup>1</sup>H NMR spectroscopic analysis of the unpurified mixture indicated a 4:1 [*endo*(**7f**)/*exo*(**8f**)] ratio of products. The resultant pale yellow film was purified by flash chromatography (EtOAc/hexanes, gradient 20:80 to 40:60) to afford **7f** as a colorless oil (11 mg, 21%).

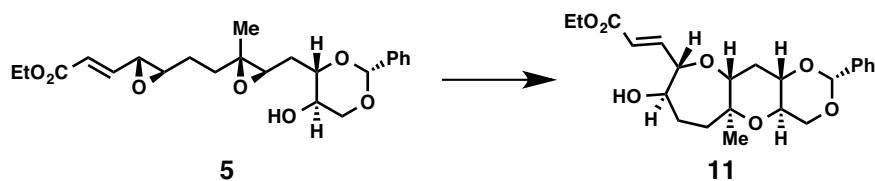
#### Characterization Data for 7f:

**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>)  $\delta$  7.10 (dd, *J* = 15.7, 3.9 Hz, 1H), 6.14 (d, *J* = 15.7 Hz, 1H), 4.20 (q, *J* = 7.1 Hz, 2H), 4.04 (dt, *J* = 11.8, 5.7 Hz, 1H), 3.95 (d, *J* = 1.7 Hz, 1H), 3.61-3.56 (m, 1H), 1.86-1.73 (m, 4H), 1.64-1.59 (m, 2H), 1.30 (t, *J* = 7.1 Hz, 3H), 1.26 (br, 1H), 1.13 (s, 3H)

**<sup>13</sup>C NMR** (125 MHz, CDCl<sub>3</sub>)  $\delta$  166.8, 146.3, 121.8, 84.8, 75.5, 71.8, 60.5, 44.4, 31.1, 24.3, 20.8, 14.4

**FT-IR** (ATR, cm<sup>-1</sup>): 3443, 2929, 2859, 1700, 1654, 1457, 1369, 1300, 1260, 1166, 1105, 1043

**HRMS** (DART, *m/z*): [M+H]<sup>+</sup> calculated for C<sub>12</sub>H<sub>20</sub>O<sub>4</sub>: 229.1434, found 229.1441



**[Rh(CO)<sub>2</sub>Cl]<sub>2</sub> promoted cyclization of 5:** To a solution of diepoxy alcohol **5** (17.1 mg, 40.9  $\mu$ mol) in dioxane (1.0 mL) was added a solution of [Rh(CO)<sub>2</sub>Cl]<sub>2</sub> in dioxane (0.080 mL, 0.025 M, 2.0  $\mu$ mol) and the reaction mixture was heated to 65 °C for 4 h. After cooling to room temperature, 4.0 mg of polymer-bound triphenylphosphine was added and the reaction mixture was stirred for 30 min. The solution was passed through a pad of silica gel, eluted with EtOAc, and then concentrated *in vacuo*. The resultant yellow oil was purified by flash chromatography (EtOAc/hexanes, gradient 40:60 to 60:40) to afford **11** as a colorless film (10.4 mg, 61%).

#### Characterization Data for 11:

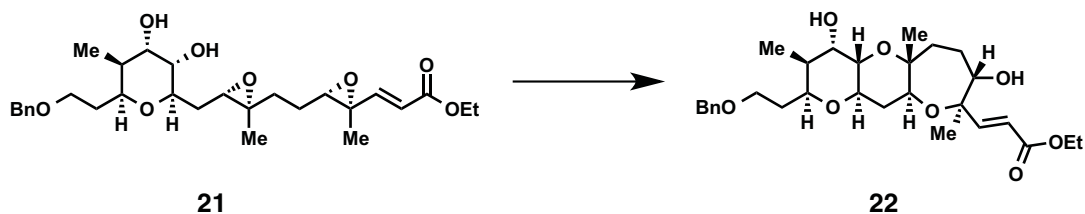
**<sup>1</sup>H NMR** (600 MHz, CDCl<sub>3</sub>) δ 7.50 (m, 2H), 7.38 (m, 3H), 6.85 (dd, *J* = 15.5, 4.3 Hz, 1H), 6.11 (dd, *J* = 15.5, 1.9 Hz, 1H), 5.52 (s, 1H), 4.41 (m, 1H), 4.25 (dd, *J* = 9.7, 4.2 Hz, 1H), 4.21 (q, *J* = 7.1 Hz, 2H), 4.09 (m, 1H), 3.89 (dd, *J* = 11.8, 4.6 Hz, 1H), 3.66 (m, 1H), 3.61 (m, 1H), 3.50 (ddd, *J* = 12.7, 8.8, 4.3 Hz, 1H), 2.19 (dt, *J* = 11.7, 4.4 Hz, 1H), 2.00 (m, 1H), 1.83 (m, 2H), 1.70 (m, 1H), 1.61 (s, 1H), 1.59 (m, 1H), 1.33 (s, 3H), 1.30 (t, *J* = 7.1 Hz, 3H)

**<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>) δ 166.7, 145.9, 137.6, 129.3, 128.6, 126.6, 121.5, 101.9, 83.1, 78.2, 78.0, 76.6, 73.3, 70.3, 66.2, 60.8, 34.2, 32.8, 25.5, 16.4, 14.5

**FT-IR** (ATR, cm<sup>-1</sup>): 3447, 2963, 2925, 2859, 1718, 1654

**HRMS** (ESI, *m/z*): [M+H]<sup>+</sup> calculated for C<sub>23</sub>H<sub>30</sub>O<sub>7</sub>: 419.2064, found 419.2068

[α]<sub>D</sub><sup>24</sup> = +29.4 (*c* = 0.110, CHCl<sub>3</sub>)



**[Rh(CO)<sub>2</sub>Cl]<sub>2</sub> promoted cyclization of 21:** To a 2 dram vial equipped with a magnetic stir bar was added **21** (7.8 mg, 0.015 mmol), THF (0.5 mL), and a solution of [Rh(CO)<sub>2</sub>Cl]<sub>2</sub> in THF (0.6 mg, 1.5 μmol, in 0.25 mL THF) and stirred at room temperature. After consumption of the starting material (3 h, as determined by TLC analysis), 10 mg of polymer-bound triphenylphosphine resin was added and stirred for 30 min. The cloudy brown solution was filtered through a plug of silica gel (pretreated with Et<sub>3</sub>N/EtOAc 2:98 then flushed with EtOAc), eluted with EtOAc, and concentrated *in vacuo*. The resultant pale yellow film was purified by flash chromatography (EtOAc/hexanes, gradient 40:60 to 70:30) to afford **21** as a colorless oil (6.1 mg, 78%).

#### Characterization Data for 22:

**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>) δ 7.36-7.28 (m, 5H), 6.72 (d, *J* = 15.4 Hz, 1H), 6.08 (d, *J* = 15.4 Hz, 1H), 4.55-4.47 (m, 2H), 4.25-4.16 (m, 2H), 4.02 (td, *J* = 6.1, 3.3 Hz, 1H), 3.98 (d, *J* = 6.8 Hz, 1H), 3.89 (dd, *J* = 11.9, 4.8 Hz, 1H), 3.80 (t, *J* = 2.6 Hz, 1H), 3.57 (dd, *J* = 7.4, 5.8 Hz, 2H), 3.48 (ddd, *J* = 11.9, 9.9, 4.2 Hz, 1H), 3.36 (dd, *J* = 9.8, 2.8 Hz, 1H), 1.99-1.88 (m, 4H), 1.86-1.74 (m, 3H), 1.68-1.61 (m, 2H), 1.57 (q, *J* = 11.9 Hz, 1H), 1.50 (ddd, *J* = 13.3, 5.0, 2.3 Hz, 1H), 1.36 (s, 3H), 1.31 (t, *J* = 7.1 Hz, 3H), 1.26 (s, 3H), 0.98 (d, *J* = 7.4 Hz, 3H)

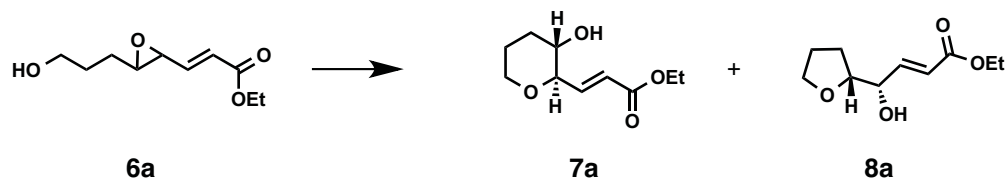
**<sup>13</sup>C NMR** (125 MHz, CDCl<sub>3</sub>) δ 167.0, 151.9, 138.8, 128.5, 127.82, 127.64, 120.3, 80.5, 78.5, 74.0, 73.0, 72.10, 71.99, 71.6, 71.0, 69.3, 67.6, 60.7, 39.0, 34.22, 34.03, 32.6, 24.9, 20.7, 16.4, 14.4, 11.2

**FT-IR** (ATR, cm<sup>-1</sup>): 3427, 2929, 2871, 1715, 1655, 1455, 1367, 1292, 1224, 1179, 1088, 1075, 1029

**HRMS** (DART, *m/z*): [M+H]<sup>+</sup> calculated for C<sub>29</sub>H<sub>42</sub>O<sub>8</sub>: 519.2925, found 519.2953

$[\alpha]_D^{24} = -50.5$  ( $c = 0.30$ ,  $\text{CH}_2\text{Cl}_2$ )

### B. CSA-Promoted Epoxide-Opening:



**(±)-CSA Promoted cyclization of epoxy alcohol 6a:** To a 20 ml vial equipped with a magnetic stir bar was added epoxide **6a** (60 mg, 0.30 mmol) in  $\text{CH}_2\text{Cl}_2$  (15 mL) and (±)-CSA (7.0 mg, 0.03 mmol) and stirred at room temperature. After consumption of the starting material (15 h, as determined by TLC analysis), the clear solution was filtered through a plug of silica gel (pretreated with  $\text{Et}_3\text{N}/\text{EtOAc}$  2:98 then flushed with EtOAc), eluted with EtOAc, and concentrated *in vacuo*.  $^1\text{H}$  NMR spectroscopic analysis of the unpurified mixture indicated a 1:1 [*endo*(**7a**)/*exo*(**8a**)] ratio of products. The resultant clear film was purified by flash chromatography (EtOAc/hexanes, gradient 20:80 to 40:60) to afford **7a** as a colorless oil (25.9 mg, 43%) and **8a** as a colorless oil (30.3 mg, 50%).

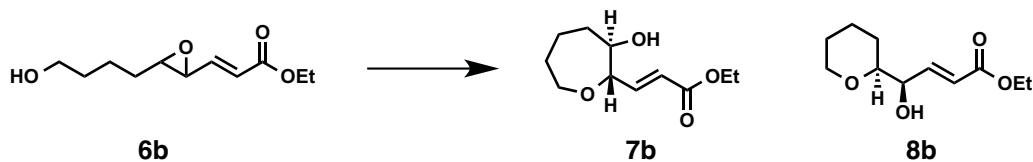
### Characterization Data for 8a:

$^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  6.90 (dd,  $J = 15.7, 4.3$  Hz, 1H), 6.15 (dd,  $J = 15.7, 2.0$  Hz, 1H), 4.53 (td,  $J = 3.9, 1.9$  Hz, 1H), 4.21 (q,  $J = 7.1$  Hz, 2H), 3.98 (td,  $J = 7.3, 3.7$  Hz, 1H), 3.92 (dt,  $J = 8.2, 6.6$  Hz, 1H), 3.80 (dt,  $J = 8.2, 6.8$  Hz, 1H), 2.45-2.38 (br, 1H), 1.92-1.87 (m, 2H), 1.81-1.77 (m, 2H), 1.30 (t,  $J = 7.1$  Hz, 4H)

$^{13}\text{C}$  NMR (125 MHz,  $\text{CDCl}_3$ )  $\delta$  166.5, 145.4, 121.8, 81.0, 71.9, 69.3, 60.6, 26.3, 25.2, 14.4

FT-IR (ATR,  $\text{cm}^{-1}$ ): 3426, 2977, 2932, 2872, 1717, 1659, 1464, 1447, 1368, 1302, 1267, 1175, 1067, 1039

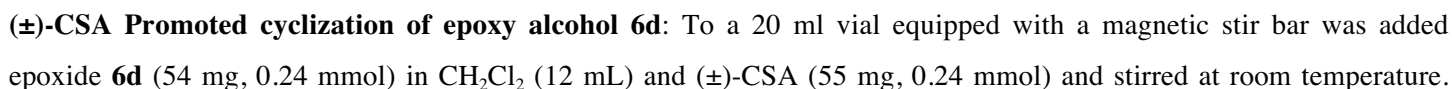
HRMS (DART,  $m/z$ ):  $[\text{M}+\text{NH}_4]^+$  calculated for  $\text{C}_{10}\text{H}_{16}\text{O}_4$ : 218.1387, found 218.1380



**(±)-CSA Promoted cyclization of epoxy alcohol 6b:** To a 20 ml vial equipped with a magnetic stir bar was added epoxide **6b** (54 mg, 0.25 mmol) in  $\text{CH}_2\text{Cl}_2$  (12 mL) and (±)-CSA (58 mg, 0.25 mmol) and stirred at room temperature. After consumption of the starting material (7 h, as determined by TLC analysis), the clear solution was filtered through a plug of silica gel (pretreated with  $\text{Et}_3\text{N}/\text{EtOAc}$  2:98 then flushed with EtOAc), eluted with EtOAc, and concentrated *in vacuo*.  $^1\text{H}$  NMR spectroscopic analysis of the unpurified mixture indicated a 1:3 [*endo*(**7b**)/*exo*(**8b**)] ratio of products. The resultant clear film was purified by flash chromatography (EtOAc/hexanes, gradient 20:80 to 40:60) to afford **8b** as a colorless oil (35.8 mg, 67%) and **7b** as a colorless oil (11.4 mg, 21%).



**HRMS** (DART,  $m/z$ ):  $[M+NH_4]^+$  calculated for  $C_{11}H_{18}O_4$ : 232.1543, found 232.1539



After consumption of the starting material (4 h, as determined by TLC analysis), the clear solution was filtered through a plug of silica gel (pretreated with Et<sub>3</sub>N/EtOAc 2:98 then flushed with EtOAc), eluted with EtOAc, and concentrated *in vacuo*. <sup>1</sup>H NMR spectroscopic analysis of the unpurified mixture indicated a 1:1.8 [*endo*(**7d**)/*exo*(**8d**)] ratio of products. The resultant clear film was purified by flash chromatography (EtOAc/hexanes, gradient 15:85 to 35:65) to afford **8d** as a colorless oil (23.1 mg, 43%) and **7d** as a colorless oil (13.3 mg, 25%).

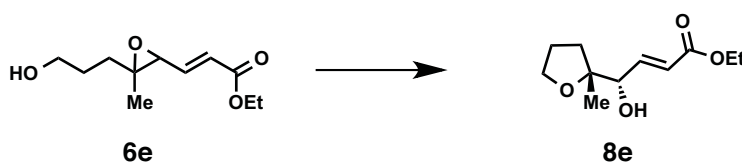
#### Characterization Data for **8d**:

<sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 6.97 (d, *J* = 15.6 Hz, 1H), 6.10 (d, *J* = 15.6 Hz, 1H), 4.19 (q, *J* = 7.1 Hz, 2H), 4.03 (dt, *J* = 11.1, 2.1 Hz, 1H), 3.44 (td, *J* = 11.5, 2.7 Hz, 1H), 3.22 (dd, *J* = 11.3, 1.9 Hz, 1H), 2.87 (br, 1H), 1.89-1.86 (m, 1H), 1.59-1.33 (m, 5H), 1.29 (t, *J* = 7.1 Hz, 3H), 1.28 (s, 3H)

<sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) δ 166.9, 150.6, 120.4, 83.6, 74.5, 69.2, 60.5, 26.2, 25.9, 24.2, 23.4, 14.4

FT-IR (ATR, cm<sup>-1</sup>): 3487, 2936, 2854, 1715, 1655, 1443, 1367, 1302, 1283, 1265, 1174, 1089, 1034

HRMS (DART, *m/z*): [M+NH<sub>4</sub>]<sup>+</sup> calculated for C<sub>12</sub>H<sub>20</sub>O<sub>4</sub>: 246.1700, found 246.1694



(±)-CSA promoted cyclization of epoxy alcohol **6e**: To a 20 ml vial equipped with a magnetic stir bar was added epoxide **6e** (50 mg, 0.23 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (12 mL) and (±)-CSA (5 mg, 0.02 mmol) and stirred at room temperature. After consumption of the starting material (30 min, as determined by TLC analysis), the clear solution was filtered through a plug of silica gel (pretreated with Et<sub>3</sub>N/EtOAc 2:98 then flushed with EtOAc), eluted with EtOAc, and concentrated *in vacuo*. <sup>1</sup>H NMR spectroscopic analysis of the unpurified mixture indicated a 1:>20 [*endo*(**7e**)/*exo*(**8e**)] ratio of products. The resultant clear film was purified by flash chromatography (EtOAc/hexanes, gradient 20:80 to 40:60) to afford **8e** as a colorless oil (48 mg, 96%).

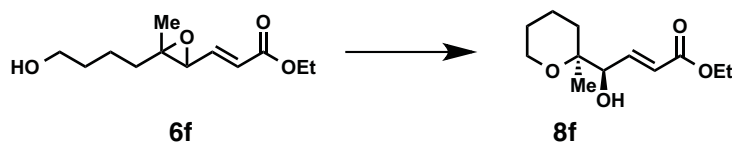
#### Characterization Data for **8e**:

<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 6.93 (dd, *J* = 15.6, 4.6 Hz, 1H), 6.18 (dd, *J* = 15.6, 1.9 Hz, 1H), 4.25 (dd, *J* = 4.6, 1.9 Hz, 1H), 4.20 (q, *J* = 7.1 Hz, 2H), 3.95-3.85 (m, 2H), 2.57 (br, 1H), 2.02-1.87 (m, 3H), 1.50-1.44 (m, 1H), 1.29 (t, *J* = 7.1 Hz, 3H), 1.21 (s, 3H)

<sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 166.6, 145.4, 122.5, 85.1, 76.2, 68.7, 60.6, 31.4, 26.5, 23.8, 14.4

FT-IR (ATR, cm<sup>-1</sup>): 3435, 2976, 2873, 1717, 1656, 1448, 1369, 1305, 1272, 1175, 1094, 1036

HRMS (DART, *m/z*): [M+H]<sup>+</sup> calculated for C<sub>11</sub>H<sub>18</sub>O<sub>4</sub>: 215.1278, found 215.1291



**(±)-CSA promoted cyclization of epoxy alcohol 6f:** To a 20 ml vial equipped with a magnetic stir bar was added epoxide **6f** (44.6 mg, 0.20 mmol) in  $\text{CH}_2\text{Cl}_2$  (10 mL) and (±)-CSA (10 mg, 0.04 mmol) and stirred at room temperature. After consumption of the starting material (5 h, as determined by TLC analysis), the clear solution was filtered through a plug of silica gel (pretreated with  $\text{Et}_3\text{N}/\text{EtOAc}$  2:98 then flushed with  $\text{EtOAc}$ ), eluted with  $\text{EtOAc}$ , and concentrated *in vacuo*.  $^1\text{H}$  NMR spectroscopic analysis of the unpurified mixture indicated a 1:>20 [*endo*(**7f**)/*exo*(**8f**)] ratio of products. The resultant clear film was purified by flash chromatography ( $\text{EtOAc}/\text{hexanes}$ , gradient 20:80 to 40:60) to afford **8f** as a colorless oil (40.4 mg, 90%).

#### Characterization Data for 8f:

**$^1\text{H}$  NMR** (500 MHz,  $\text{CDCl}_3$ )  $\delta$  6.92 (dd,  $J = 15.6, 4.8$  Hz, 1H), 6.16 (dd,  $J = 15.6, 1.9$  Hz, 1H), 4.19 (q,  $J = 7.1$  Hz, 2H), 4.11 (dd,  $J = 4.8, 1.8$  Hz, 1H), 3.77-3.67 (m, 2H), 3.00 (br, 1H), 1.73-1.57 (m, 3H), 1.52-1.48 (m, 2H), 1.28 (t,  $J = 7.1$  Hz, 3H), 1.22 (s, 3H), 1.19 (dt,  $J = 12.9, 3.4$  Hz, 1H)

**$^{13}\text{C}$  NMR** (125 MHz,  $\text{CDCl}_3$ )  $\delta$  166.6, 145.0, 122.7, 77.51, 75.6, 62.1, 60.5, 28.4, 26.0, 19.0, 18.1, 14.4

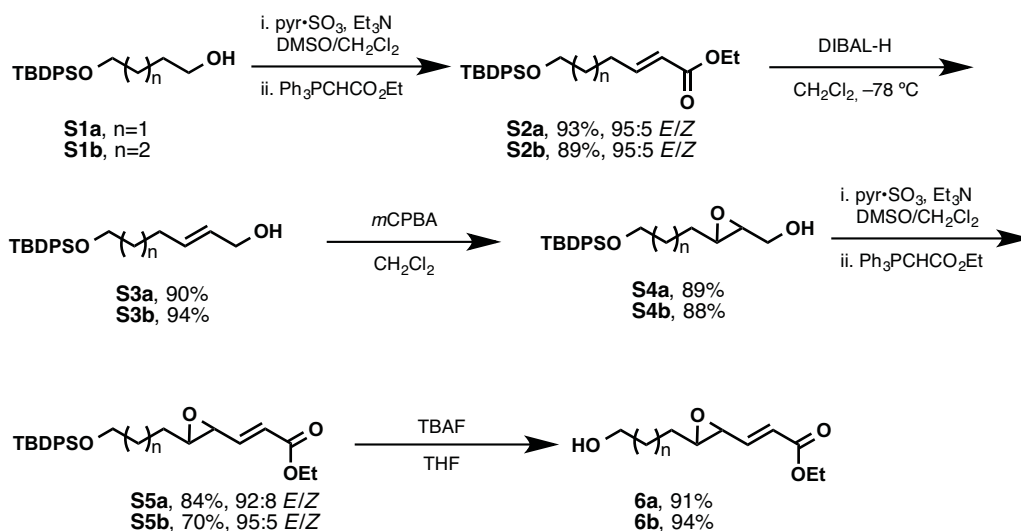
**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3449, 2980, 2937, 2867, 1717, 1656, 1466, 1449, 1369, 1305, 1273, 1212, 1176, 1114, 1081, 1046

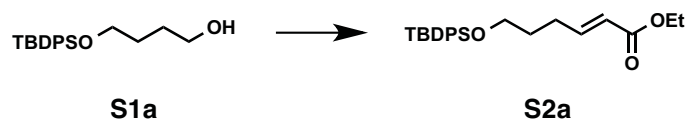
**HRMS** (ESI,  $m/z$ ):  $[\text{M}+\text{Na}]^+$  calculated for  $\text{C}_{12}\text{H}_{20}\text{O}_4$ : 251.1254, found 251.1273

### III. Synthesis of Substrates

#### A. Synthesis of Epoxy Alcohols 6a and 6b:

##### Synthetic Route to Epoxy Alcohols 6a and 6b:





**(E)-Enoate S2a:** To a solution of TBDPS-protected alcohol **S1a**<sup>1</sup> (2.0 g, 6.09 mmol) in  $\text{CH}_2\text{Cl}_2$  (61 mL) was added DMSO (6.1 mL, 85.9 mmol) and  $\text{Et}_3\text{N}$  (4.3 mL, 30.5 mmol), cooled to 0 °C, and  $\text{Pyr}\cdot\text{SO}_3$  (1.94 g, 12.2 mmol) added as a solid. The reaction was allowed to warm to room temperature and stirred for 3 h. At this point, (carbethoxymethylene)triphenylphosphorane (4.25 g, 12.2 mmol) was added as a solid at room temperature and stirred for 30 min. The reaction was quenched by addition of  $\text{H}_2\text{O}$  (35 mL) and diluted with  $\text{CH}_2\text{Cl}_2$  (35 mL). The aqueous layer was separated and extracted twice with  $\text{CH}_2\text{Cl}_2$  (20 mL each). The combined organics were washed with  $\text{H}_2\text{O}$  (20 mL), sat.  $\text{NaCl}_{(\text{aq})}$  (20 mL), dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo* to afford crude enoate **S2a** as a yellow oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 5:95 to 10:90) to afford **S2a** as a colorless oil (2.24 g, 93%, 95:5 *E/Z*). The product could be purified further by flash chromatography (EtOAc/hexanes, gradient 0:100 to 6:94) to afford **S2a** as only the *E* alkene (1.98 g, 82%).

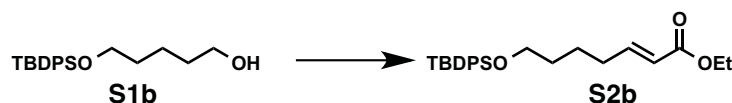
Data were consistent with those reported by Beauchemin and coworkers.<sup>2</sup>

**<sup>1</sup>H NMR** (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.69-7.67 (m, 4H), 7.45-7.39 (m, 6H), 7.00 (dt,  $J$  = 15.6, 6.9 Hz, 1H), 5.84 (dt,  $J$  = 15.6, 1.6 Hz, 1H), 4.21 (q,  $J$  = 7.1 Hz, 2H), 3.70 (t,  $J$  = 6.1 Hz, 2H), 2.39-2.31 (m, 2H), 1.78-1.69 (m, 2H), 1.31 (t,  $J$  = 7.1 Hz, 3H), 1.07 (s, 9H)

**<sup>13</sup>C NMR** (100 MHz,  $\text{CDCl}_3$ )  $\delta$  166.8, 149.1, 135.7, 134.0, 129.8, 127.8, 121.7, 63.1, 60.3, 31.1, 28.8, 27.0, 19.4, 14.5

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3069, 2933, 2858, 1718, 1654, 1472, 1427, 1265, 1203, 1105, 1041

**HRMS** (DART,  $m/z$ ):  $[\text{M}+\text{NH}_4]^+$  calculated for  $\text{C}_{24}\text{H}_{32}\text{O}_3\text{Si}$ : 414.2459, found 414.2460



**(E)-Enoate S2b:** To a solution of TBDPS-protected alcohol **S1b**<sup>1</sup> (2.50 g, 7.30 mmol) in  $\text{CH}_2\text{Cl}_2$  (73 mL) was added DMSO (7.3 mL, 0.10 mol) and  $\text{Et}_3\text{N}$  (5.1 mL, 36.5 mmol), cooled to 0 °C, and  $\text{Pyr}\cdot\text{SO}_3$  (2.32 g, 14.6 mmol) added as a solid. The reaction was allowed to warm to room temperature and stirred for 3h. At this point, (carbethoxymethylene)triphenylphosphorane (5.1 g, 14.6 mmol) was added as a solid at room temperature and stirred for 30 min. The reaction was quenched by addition of  $\text{H}_2\text{O}$  (50 mL) and diluted with  $\text{CH}_2\text{Cl}_2$  (50 mL). The aqueous layer

<sup>1</sup> Zhu, G.; Negishi, E. *Org. Lett.* **2007**, 9, 2771.

<sup>2</sup> Clavette, C.; Rocan, J.-F. V.; Beauchemin, A. M. *Angew. Chem., Int. Ed.* **2013**, 52, 12705.

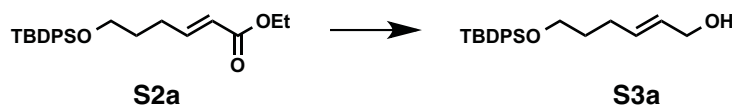
was separated and extracted twice with  $\text{CH}_2\text{Cl}_2$  (30 mL each). The combined organics were washed with  $\text{H}_2\text{O}$  (50 mL), sat.  $\text{NaCl}_{(\text{aq})}$  (50 mL), dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo* to afford crude enoate **S2b** as a yellow oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 5:95 to 10:90) to afford **S2b** as a colorless oil (2.68 g, 89%, 95:5 *E/Z*). The product was purified further by flash chromatography (EtOAc/hexanes, gradient 0:100 to 3:97) to afford **S2b** enriched to 98:2 *E/Z* (1.20 g, 40%).

**$^1\text{H}$  NMR** (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.69-7.67 (m, 4H), 7.45-7.38 (m, 6H), 6.97 (dt,  $J = 15.6, 6.9$  Hz, 1H), 5.81 (dt,  $J = 15.6, 1.5$  Hz, 1H), 4.20 (q,  $J = 7.1$  Hz, 2H), 3.68 (t,  $J = 5.9$  Hz, 2H), 2.20 (qd,  $J = 7.1, 1.3$  Hz, 2H), 1.63-1.55 (m, 4H), 1.31 (t,  $J = 7.1$  Hz, 3H), 1.06 (s, 9H)

**$^{13}\text{C}$  NMR** (125 MHz,  $\text{CDCl}_3$ )  $\delta$  166.9, 149.4, 135.7, 134.1, 129.7, 127.8, 121.5, 63.6, 60.3, 32.11, 32.05, 27.0, 24.5, 19.4, 14.5

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3069, 2932, 2858, 1719, 1653, 1473, 1428, 1265, 1195, 1159, 1108, 1043

**HRMS** (DART,  $m/z$ ):  $[\text{M}+\text{NH}_4]^+$  calculated for  $\text{C}_{25}\text{H}_{34}\text{O}_3\text{Si}$ : 428.2615, found 428.2617



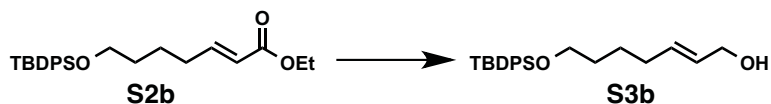
**Alcohol S3a:** To a solution of enoate **S2a** (1.97 g, 4.97 mmol) in  $\text{CH}_2\text{Cl}_2$  (20 mL) at  $-78^\circ\text{C}$  was added DIBAL-H (1.0 M in  $\text{CH}_2\text{Cl}_2$ , 17.4 mL, 17.4 mmol) dropwise over three min. The reaction was stirred for 20 min, and then quenched by slow addition of MeOH (5 mL) at  $-78^\circ\text{C}$ . The reaction mixture was then poured into an Erlenmeyer flask containing sat. aq. Rochelle's salt (150 mL) and stirred vigorously for 2 h at room temperature. The aqueous layer was separated and extracted with  $\text{CH}_2\text{Cl}_2$  (2x20 mL). The combined organics were dried over  $\text{MgSO}_4$ , filtered and concentrated *in vacuo* to afford crude alcohol **S3a** as a colorless oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 10:90 to 35:65) to afford **S3a** as a colorless oil (1.59 g, 90%).

**$^1\text{H}$  NMR** (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.71-7.70 (m, 4H), 7.47-7.39 (m, 6H), 5.72-5.62 (m, 2H), 4.09-4.07 (br, 2H), 3.71 (t,  $J = 6.3$  Hz, 2H), 2.18 (q,  $J = 6.9$  Hz, 2H), 1.69 (quint,  $J = 7.1$  Hz, 2H), 1.48-1.44 (br, 1H), 1.09 (s, 9H)

**$^{13}\text{C}$  NMR** (125 MHz,  $\text{CDCl}_3$ )  $\delta$  135.7, 134.1, 132.9, 129.7, 129.4, 127.8, 63.9, 63.3, 32.1, 28.6, 27.0, 19.4

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3325, 3068, 2932, 2857, 1670, 1589, 1472, 1728, 1389, 1361, 1105, 998, 967

**HRMS** (DART,  $m/z$ ):  $[\text{M}+\text{NH}_4]^+$  calculated for  $\text{C}_{22}\text{H}_{30}\text{O}_2\text{Si}$ : 372.2353, found 372.2346



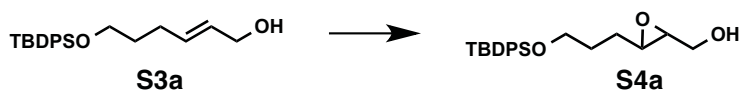
**Alcohol S3b:** To a solution of enoate **S2b** (1.20 g, 2.92 mmol) in  $\text{CH}_2\text{Cl}_2$  (12 mL) at  $-78^\circ\text{C}$  was added DIBAL-H (1.0 M in  $\text{CH}_2\text{Cl}_2$ , 10.5 mL, 10.5 mmol) dropwise over three min. The reaction was stirred for 25 min, and then quenched by slow addition of MeOH (3 mL) at  $-78^\circ\text{C}$ . The reaction mixture was then poured into an Erlenmeyer flask containing sat. aq. Rochelle's salt (100 mL) and stirred vigorously for 2 h at room temperature. The aqueous layer was separated and extracted with  $\text{CH}_2\text{Cl}_2$  (2x20 mL). The combined organics were dried over  $\text{MgSO}_4$ , filtered and concentrated *in vacuo* to afford crude alcohol **S3b** as a colorless oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 10:90 to 35:65) to afford **S3b** as a colorless oil (1.02 g, 94%).

**$^1\text{H}$  NMR** (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.70-7.68 (m, 4H), 7.46-7.38 (m, 6H), 5.72-5.60 (m, 2H), 4.10 (br, 2H), 3.68 (t,  $J = 6.4$  Hz, 2H), 2.06 (q,  $J = 6.9$  Hz, 2H), 1.59 (dq,  $J = 8.7, 6.1$  Hz, 2H), 1.51-1.45 (m, 2H), 1.35 (br, 1H), 1.07 (s, 9H)

**$^{13}\text{C}$  NMR** (125 MHz,  $\text{CDCl}_3$ )  $\delta$  135.7, 134.2, 133.4, 129.7, 129.2, 127.8, 63.98, 63.89, 32.20, 32.08, 27.0, 25.5, 19.4

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3324, 3057, 2931, 2859, 1669, 1590, 1472, 1428, 1389, 1105

**HRMS** (DART,  $m/z$ ):  $[\text{M}+\text{NH}_4]^+$  calculated for  $\text{C}_{23}\text{H}_{32}\text{O}_2\text{Si}$ : 386.2510, found 386.2520



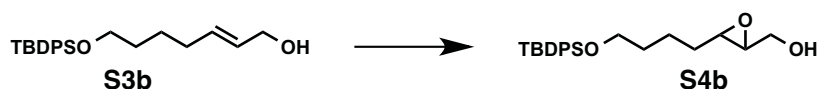
**Epoxide S4a:** To a solution of alcohol **S3a** (1.57 g, 4.43 mmol) in  $\text{CH}_2\text{Cl}_2$  (44 mL) at  $0^\circ\text{C}$  was added *m*CPBA ( $\leq 77$  wt %, 1.49 g, 6.64 mmol) as a solid in one portion. The reaction was allowed to warm to room temperature and stirred for 2 h, and then quenched by addition of 10%  $\text{Na}_2\text{CO}_{3(\text{aq})}$  (60 mL). The aqueous layer was separated and extracted twice with  $\text{CH}_2\text{Cl}_2$  (30 mL each). The combined organic layer was washed with sat.  $\text{NaHSO}_{3(\text{aq})}$  (30 mL), and 10%  $\text{Na}_2\text{CO}_{3(\text{aq})}$  (30 mL). The combined organics were dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo* to afford crude alcohol **S3a** as a colorless oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 15:85 to 45:55) to afford **S3a** as a colorless oil (1.47 g, 89%).

**$^1\text{H}$  NMR** (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.69-7.66 (m, 4H), 7.44-7.38 (m, 6H), 3.88 (dd,  $J = 12.6, 2.5$  Hz, 1H), 3.73-3.71 (m, 2H), 3.59 (dd,  $J = 12.6, 4.4$  Hz, 1H), 2.98-2.96 (m, 1H), 2.91 (ddd,  $J = 4.5, 2.3, 2.3$  Hz, 1H), 1.90-1.80 (br, 1H), 1.75-1.66 (m, 4H), 1.07 (s, 9H)

**$^{13}\text{C}$  NMR** (125 MHz,  $\text{CDCl}_3$ )  $\delta$  135.7, 133.98, 133.97, 129.8, 127.8, 63.4, 61.8, 58.6, 55.9, 29.0, 28.2, 27.0, 19.4

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3407, 2932, 2858, 1472, 1428, 1389, 1361, 1307, 1105

**HRMS** (DART,  $m/z$ ):  $[\text{M}+\text{NH}_4]^+$  calculated for  $\text{C}_{22}\text{H}_{30}\text{O}_3\text{Si}$ : 388.2302, found 388.2292



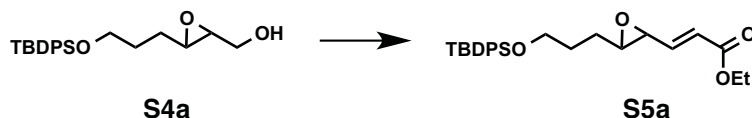
**Epoxide S4b:** To a solution of alcohol **S3b** (0.97 g, 2.63 mmol) in  $\text{CH}_2\text{Cl}_2$  (26 mL) at 0 °C was added *m*CPBA ( $\leq 77$  wt %, 0.88 g, 3.95 mmol) as a solid in one portion. The reaction was allowed to warm to room temperature and stirred for 2 h, and then quenched by addition of 10%  $\text{Na}_2\text{CO}_{3(\text{aq})}$  (30 mL). The aqueous layer was separated and extracted twice with  $\text{CH}_2\text{Cl}_2$  (20 mL each). The combined organic layer was washed with sat.  $\text{NaHSO}_{3(\text{aq})}$  (20 mL), and 10%  $\text{Na}_2\text{CO}_{3(\text{aq})}$  (20 mL). The combined organics were dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo* to afford crude alcohol **S4b** as a colorless oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 10:90 to 40:60) to afford **S4b** as a colorless oil (0.89 g, 88%).

**$^1\text{H}$  NMR** (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.68-7.67 (m, 4H), 7.45-7.38 (m, 6H), 3.93-3.90 (m, 1H), 3.68 (t,  $J = 6.1$  Hz, 2H), 3.65-3.61 (m, 1H), 2.96-2.94 (m, 1H), 2.91 (dt,  $J = 4.4, 2.3$  Hz, 1H), 1.74 (t,  $J = 5.8$  Hz, 1H), 1.65-1.50 (m, 6H), 1.06 (s, 9H)

**$^{13}\text{C}$  NMR** (125 MHz,  $\text{CDCl}_3$ )  $\delta$  135.7, 134.1, 129.7, 127.8, 63.7, 61.8, 58.5, 56.0, 32.4, 31.4, 27.0, 22.5, 19.4

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3420, 3069, 2931, 2858, 1589, 1472, 1428, 1389, 1361, 1188, 1105

**HRMS** (DART,  $m/z$ ):  $[\text{M}+\text{NH}_4]^+$  calculated for  $\text{C}_{23}\text{H}_{32}\text{O}_3\text{Si}$ : 402.2459, found 402.2443



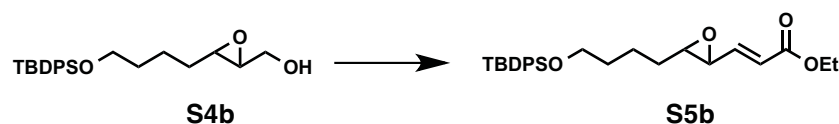
**(E)-Epoxy Enolate S5a:** To a solution of epoxy alcohol **S4a** (1.40 g, 3.78 mmol) in  $\text{CH}_2\text{Cl}_2$  (38 mL) was added DMSO (3.8 mL, 53.5 mmol) and  $\text{Et}_3\text{N}$  (2.6 mL, 19 mmol), cooled to 0 °C, and  $\text{Pyr}\cdot\text{SO}_3$  (1.20 g, 7.56 mmol) added as a solid. The reaction was allowed to warm to room temperature and stirred for 3 h. At this point, (carbethoxymethylene)triphenylphosphorane (2.63 g, 7.56 mmol) was added as a solid at room temperature and stirred for 30 min. The reaction was quenched by addition of  $\text{H}_2\text{O}$  (25 mL) and diluted with  $\text{CH}_2\text{Cl}_2$  (25 mL). The aqueous layer was separated and extracted twice with  $\text{CH}_2\text{Cl}_2$  (20 mL each). The combined organics were washed with  $\text{H}_2\text{O}$  (20 mL), sat.  $\text{NaCl}_{(\text{aq})}$  (20 mL), dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo* to afford crude enoate **S5a** as a yellow oil. The crude product was purified by flash chromatography (EtOAc/hexanes, isocratic 10:90) to afford **S5a** as a colorless oil (1.39 g, 84%, 92:8 *E/Z*). The product was purified further by flash chromatography (EtOAc/hexanes, gradient 0:100 to 8:92) to afford **S5a** as only the (*E*)-alkene (1.07 g, 65%).

**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>) δ 7.68-7.66 (m, 4H), 7.46-7.38 (m, 6H), 6.65 (dd, *J* = 15.7, 7.2 Hz, 1H), 6.11 (dd, *J* = 15.7, 0.7 Hz, 1H), 4.22 (q, *J* = 7.1 Hz, 2H), 3.71 (t, *J* = 5.4 Hz, 2H), 3.20 (ddd, *J* = 7.2, 1.9, 0.5 Hz, 1H), 2.89 (td, *J* = 5.1, 2.0 Hz, 1H), 1.76-1.69 (m, 4H), 1.31 (t, *J* = 7.1 Hz, 3H), 1.06 (s, 9H)

**<sup>13</sup>C NMR** (125 MHz, CDCl<sub>3</sub>) δ 165.8, 144.9, 135.7, 133.92, 133.89, 129.8, 127.84, 127.83, 123.8, 63.2, 61.3, 60.7, 56.5, 28.8, 28.6, 27.0, 19.4, 14.4

**FT-IR** (ATR, cm<sup>-1</sup>): 3067, 2933, 2858, 1719, 1655, 1589, 1472, 1428, 1390, 1368, 1302, 1258, 1182, 1106

**HRMS** (DART, *m/z*): [M+NH<sub>4</sub>]<sup>+</sup> calculated for C<sub>26</sub>H<sub>34</sub>O<sub>4</sub>Si: 456.2565, found 456.2557



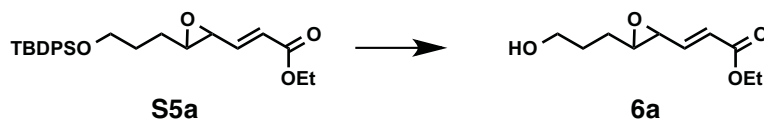
**(E)-Epoxy Enolate S5b:** To a solution of epoxy alcohol **S4b** (0.83 g, 2.16 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (21 mL) was added DMSO (2.2 mL, 31 mmol) and Et<sub>3</sub>N (1.5 mL, 10.8 mmol), cooled to 0 °C, and Pyr•SO<sub>3</sub> (0.69 g, 4.3 mmol) added as a solid. The reaction was allowed to warm to room temperature and stirred for 3 h. At this point, (carbethoxymethylene)triphenylphosphorane (1.5 g, 4.3 mmol) was added as a solid at room temperature and stirred for 30 min. The reaction was quenched by addition of H<sub>2</sub>O (25 mL) and diluted with CH<sub>2</sub>Cl<sub>2</sub> (25 mL). The aqueous layer was separated and extracted twice with CH<sub>2</sub>Cl<sub>2</sub> (20 mL each). The combined organics were washed with H<sub>2</sub>O (20 mL), sat. NaCl<sub>(aq)</sub> (20 mL), dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated *in vacuo* to afford crude enoate **S5b** as a yellow oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 5:95 to 10:90) to afford **S5b** as a colorless oil (0.69 g, 70%, 95:5 *E/Z*). The product was purified further by flash chromatography (EtOAc/hexanes, gradient 0:100 to 6:94) to afford **S5b** as only the (*E*)-alkene (0.38 g, 38%).

**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>) δ 7.68-7.66 (m, 4H), 7.45-7.37 (m, 6H), 6.68 (dd, *J* = 15.7, 7.1 Hz, 1H), 6.12 (dd, *J* = 15.7, 0.6 Hz, 1H), 4.22 (q, *J* = 7.1 Hz, 2H), 3.68 (t, *J* = 5.9 Hz, 2H), 3.19 (ddd, *J* = 7.1, 2.0, 0.6 Hz, 1H), 2.89-2.86 (m, 1H), 1.62-1.52 (m, 6H), 1.30 (t, *J* = 7.1 Hz, 3H), 1.06 (s, 9H)

**<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>) δ 165.9, 144.9, 135.7, 134.1, 129.7, 127.8, 123.7, 63.7, 61.5, 60.7, 56.4, 32.3, 31.8, 27.0, 22.4, 19.4, 14.4

**FT-IR** (ATR, cm<sup>-1</sup>): 3067, 2933, 2858, 1719, 1655, 1589, 1473, 1428, 1390, 1368, 1302, 1256, 1180, 1093, 1041

**HRMS** (DART, *m/z*): [M+NH<sub>4</sub>]<sup>+</sup> calculated for C<sub>27</sub>H<sub>36</sub>O<sub>4</sub>Si: 470.2721, found 470.2703





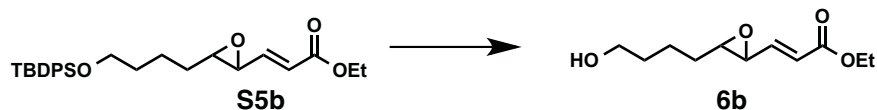
**(E)-Epoxy Alcohol 6a:** To a solution of enoate **S5a** (0.60 g, 1.37 mmol) in THF (2.7 mL) at 0 °C was added TBAF (1.0 M in THF, 2.7 mL, 2.7 mmol) dropwise over 1 min. The reaction was stirred and allowed to warm to room temperature over 2 h. The crude reaction mixture was purified without concentration by flash chromatography (pretreated with Et<sub>3</sub>N/EtOAc/Hexanes 1:49:50 then gradient EtOAc/Hex, 50:50 to 60:40) to afford **6a** as a colorless oil (0.25 g, 91%).

**<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>) δ 6.67 (dd, *J* = 15.7, 7.1 Hz, 1H), 6.12 (d, *J* = 15.7 Hz, 1H), 4.19 (q, *J* = 7.1 Hz, 2H), 3.69 (t, *J* = 5.9 Hz, 2H), 3.25 (dd, *J* = 7.1, 1.5 Hz, 1H), 2.94 (td, *J* = 5.4, 1.8 Hz, 1H), 1.84-1.61 (m, 5H), 1.28 (t, *J* = 7.1 Hz, 3H)

**<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>) δ 165.8, 144.6, 123.9, 62.3, 61.3, 60.8, 56.6, 29.0, 28.6, 14.4

**FT-IR** (ATR, cm<sup>-1</sup>): 3414, 2983, 2934, 2875, 1715, 1654, 1446, 1369, 1303, 1259, 1182, 1142, 1033

**HRMS** (DART, *m/z*): [M+NH<sub>4</sub>]<sup>+</sup> calculated for C<sub>10</sub>H<sub>16</sub>O<sub>4</sub>: 218.1387, found 218.1391



**(E)-Epoxy Alcohol 6b:** To a solution of enoate **S5b** (0.38 g, 0.84 mmol) in THF (1.7 mL) at 0 °C was added TBAF (1.0 M in THF, 1.7 mL, 1.7 mmol) dropwise over 1 min. The reaction was stirred and allowed to warm to room temperature over 2 h. The crude reaction mixture was purified without concentration by flash chromatography (pretreated with Et<sub>3</sub>N/EtOAc/Hexanes 1:49:50 then gradient EtOAc/Hex, 50:50 to 60:40) to afford **92b** as a colorless oil (0.17 g, 94%).

**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>) δ 6.64 (dd, *J* = 15.7, 7.1 Hz, 1H), 6.10 (d, *J* = 15.7 Hz, 1H), 4.17 (q, *J* = 7.1 Hz, 2H), 3.62 (t, *J* = 6.2 Hz, 2H), 3.21 (dd, *J* = 7.1, 1.7 Hz, 1H), 2.90-2.87 (m, 1H), 1.91 (br, 1H), 1.65-1.50 (m, 6H), 1.26 (t, *J* = 7.1 Hz, 3H)

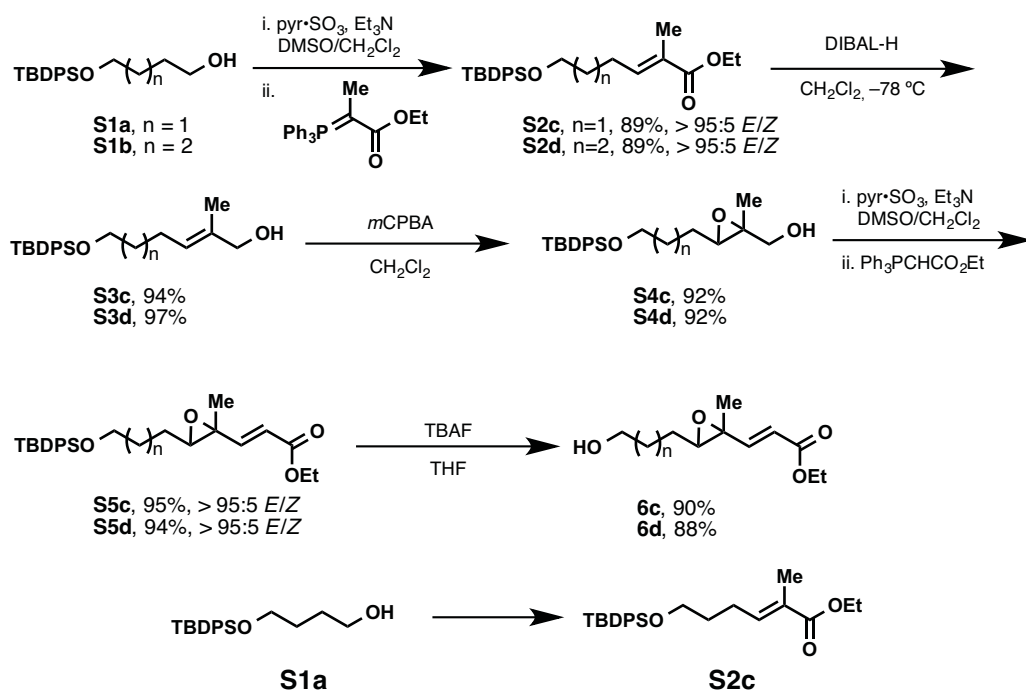
**<sup>13</sup>C NMR** (125 MHz, CDCl<sub>3</sub>) δ 165.8, 144.8, 123.8, 62.5, 61.4, 60.7, 56.4, 32.3, 31.7, 22.3, 14.3

**FT-IR** (ATR, cm<sup>-1</sup>): 3423, 2978, 2936, 2865, 1716, 1655, 1446, 1369, 1303, 1258, 1180, 1141, 1033

**HRMS** (DART, *m/z*): [M+NH<sub>4</sub>]<sup>+</sup> calculated for C<sub>11</sub>H<sub>18</sub>O<sub>4</sub>: 232.1543, found 232.1541

**B. Synthesis of Epoxy Alcohols 6c and 6d:**

Scheme S1: Synthetic Route to epoxy alcohols 6c and 6d.



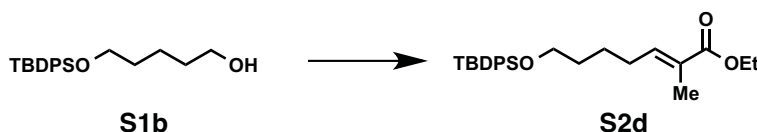
**(E)-Enoate S2c:** To a solution of TBDPS-protected alcohol **S1a**<sup>1</sup> (3.33 g, 10.1 mmol) in  $\text{CH}_2\text{Cl}_2$  (100 mL) was added DMSO (10 mL, 0.14 mol) and  $\text{Et}_3\text{N}$  (7.0 mL, 50 mmol), cooled to  $0^\circ\text{C}$ , and  $\text{Pyr}\cdot\text{SO}_3$  (3.22 g, 20.2 mmol) added as a solid. The reaction was allowed to warm to room temperature and stirred for 3 h. At this point, (Carbethoxyethylidene)triphenylphosphorane (7.32 g, 20.2 mmol) was added as a solid at room temperature and stirred for 12 h. The reaction was quenched by addition of  $\text{H}_2\text{O}$  (75 mL) and diluted with  $\text{CH}_2\text{Cl}_2$  (25 mL). The aqueous layer was separated and extracted twice with  $\text{CH}_2\text{Cl}_2$  (30 mL each). The combined organics were washed with  $\text{H}_2\text{O}$  (50 mL), sat.  $\text{NaCl}_{(\text{aq})}$  (50 mL), dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo* to afford crude enoate **S2c** as a yellow oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 5:95 to 10:90) to afford **S2c** as a colorless oil (2.92 g, 89%, 96:4 E/Z). The product was purified further by flash chromatography with a gradient of solvents (EtOAc/hexanes, gradient 2:98 to 4:96) to afford **S2c** enriched to >99:1 E/Z (1.27 g, 39%).

**<sup>1</sup>H NMR** (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.69-7.66 (m, 4H), 7.46-7.38 (m, 6H), 6.77 (tq,  $J = 7.5, 1.4$  Hz, 1H), 4.20 (q,  $J = 7.1$  Hz, 2H), 3.69 (t,  $J = 6.1$  Hz, 2H), 2.30 (q,  $J = 7.4$  Hz, 2H), 1.85 (d,  $J = 1.3$  Hz, 3H), 1.73-1.67 (m, 2H), 1.31 (t,  $J = 7.1$  Hz, 3H), 1.07 (s, 9H)

**<sup>13</sup>C NMR** (125 MHz,  $\text{CDCl}_3$ )  $\delta$  168.4, 142.0, 135.7, 134.0, 129.8, 128.2, 127.8, 63.4, 60.6, 31.6, 27.0, 25.3, 19.4, 14.5, 12.5

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3073, 2933, 2858, 1708, 1651, 1590, 1473, 1428, 1389, 1366, 1261, 1234, 1190, 1106, 1030

**HRMS** (DART,  $m/z$ ):  $[\text{M}+\text{NH}_4]^+$  calculated for  $\text{C}_{25}\text{H}_{34}\text{O}_3\text{Si}$ : 428.2615, found 428.2635



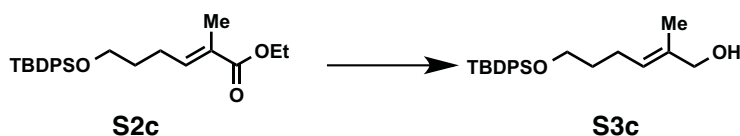
**(E) Enoate S2d:** To a solution of TBDPS-protected alcohol **S1b**<sup>1</sup> (2.64 g, 7.7 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (77 mL) was added DMSO (7.7 mL, 0.11 mol) and Et<sub>3</sub>N (5.4 mL, 39 mmol), cooled to 0 °C, and Pyr•SO<sub>3</sub> (2.45 g, 15.4 mmol) added as a solid. The reaction was allowed to warm to room temperature and stirred for 3h. At this point, (Carbethoxyethylidene)triphenylphosphorane (5.60 g, 15.4 mmol) was added as a solid at room temperature and stirred for 12 h. The reaction was quenched by addition of H<sub>2</sub>O (75 mL) and diluted with CH<sub>2</sub>Cl<sub>2</sub> (25 mL). The aqueous layer was separated and extracted twice with CH<sub>2</sub>Cl<sub>2</sub> (30 mL each). The combined organics were washed with H<sub>2</sub>O (50 mL), sat. NaCl<sub>(aq)</sub> (50 mL), dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated *in vacuo* to afford crude enoate **S2d** as a yellow oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 5:95 to 10:90) to afford **S2d** as a colorless oil (2.92 g, 89%, 96:4 *E/Z*). The product was purified further by flash chromatography with a gradient of solvents (EtOAc/hexanes, gradient 2:98 to 4:96) to afford **S2d** enriched to >99:1 *E/Z* (1.27 g, 39%).

**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>) δ 7.69-7.68 (m, 4H), 7.46-7.38 (m, 6H), 6.77 (d, *J* = 7.4 Hz, 1H), 4.21 (q, *J* = 7.1 Hz, 2H), 3.69 (t, *J* = 5.9 Hz, 2H), 2.18 (q, *J* = 7.2 Hz, 2H), 1.83 (s, 3H), 1.63-1.53 (m, 4H), 1.32 (t, *J* = 7.1 Hz, 3H), 1.07 (s, 9H)

**<sup>13</sup>C NMR** (125 MHz, CDCl<sub>3</sub>) δ 168.4, 142.3, 135.7, 134.1, 129.7, 128.0, 127.8, 63.7, 60.6, 32.4, 28.5, 27.0, 25.1, 19.4, 14.5, 12.5

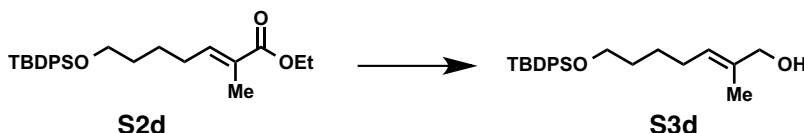
**FT-IR** (ATR, cm<sup>-1</sup>): 3055, 2932, 2858, 1708, 1651, 1590, 1472, 1428, 1389, 1365, 1254, 1223, 1185, 1104

**HRMS** (DART, *m/z*): [M+NH<sub>4</sub>]<sup>+</sup> calculated for C<sub>26</sub>H<sub>36</sub>O<sub>3</sub>Si: 442.2772, found 442.2772

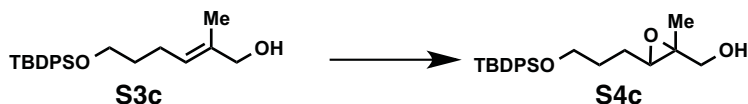


**Alcohol S3c:** To a solution of enoate **S2c** (2.37 g, 5.77 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (25 mL) at -78 °C was added DIBAL-H (1.0 M in CH<sub>2</sub>Cl<sub>2</sub>, 20 mL, 20 mmol) dropwise over three min. The reaction was stirred for 2.5 h, and then quenched by slow addition of MeOH (6 mL) at -78 °C. The reaction mixture was then poured into an Erlenmeyer flask containing sat. aq. Rochelle's salt (150 mL) and stirred vigorously for 2 h at room temperature. The aqueous layer was separated and extracted with CH<sub>2</sub>Cl<sub>2</sub> (2x30 mL). The combined organics were dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo* to afford crude alcohol **S3c** as a colorless oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 15:85 to 20:80) to afford **S3c** as a colorless oil (1.98 g, 94%).

**HRMS** (DART,  $m/z$ ):  $[M+NH_4]^+$  calculated for  $C_{73}H_{37}O_7Si$ : 386.2510, found 386.2492



**HRMS** (DART,  $m/z$ ):  $[M+NH_4]^+$  calculated for  $C_{74}H_{34}O_7Si$ : 400.2666, found 400.2669



**Epoxide S4c:** To a solution of alcohol **S3c** (1.94 g, 5.32 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (53 mL) at 0 °C was added *m*CPBA (≤ 77 wt %, 1.78 g, 8.00 mmol) as a solid in one portion. The reaction was allowed to warm to room temperature and stirred for 2 h, and then quenched by addition of 10% Na<sub>2</sub>CO<sub>3(aq)</sub> (60 mL). The aqueous layer was separated and extracted twice with CH<sub>2</sub>Cl<sub>2</sub> (30 mL each). The combined organic layer was washed with sat. NaHSO<sub>3(aq)</sub> (30 mL), and 10% Na<sub>2</sub>CO<sub>3(aq)</sub> (30 mL). The combined organics were dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated *in vacuo* to afford crude alcohol **S4c** as a

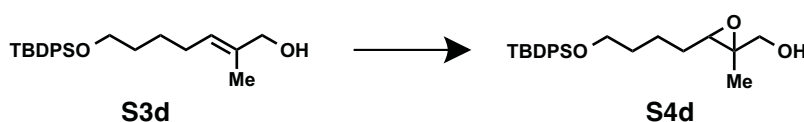
colorless oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 10:90 to 40:60) to afford **S4c** as a colorless oil (1.87 g, 92%).

**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>) δ 7.68-7.66 (m, 4H), 7.44-7.37 (m, 6H), 3.75-3.70 (m, 2H), 3.67 (dd, *J* = 12.1, 4.4 Hz, 1H), 3.56 (dd, *J* = 12.2, 8.7 Hz, 1H), 3.04 (t, *J* = 6.0 Hz, 1H), 1.78-1.67 (m, 4H), 1.60 (dd, *J* = 8.7, 4.4 Hz, 1H), 1.27 (s, 3H), 1.06 (s, 9H)

**<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>) δ 135.73, 135.72, 134.0, 129.8, 127.8, 65.4, 63.5, 61.0, 60.0, 29.5, 27.0, 24.9, 19.4, 14.3

**FT-IR** (ATR, cm<sup>-1</sup>): 3400, 2931, 2858, 1472, 1428, 1387, 1258, 1191, 1106, 1039

**HRMS** (DART, *m/z*): [M+NH<sub>4</sub>]<sup>+</sup> calculated for C<sub>23</sub>H<sub>32</sub>O<sub>3</sub>Si: 402.2459, found 402.2450



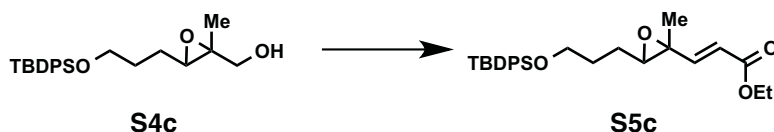
**Epoxide S4d**: To a solution of alcohol **S3d** (1.02 g, 2.67 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (27 mL) at 0 °C was added *m*CPBA (≤ 77 wt %, 0.90 g, 4.0 mmol) as a solid in one portion. The reaction was allowed to warm to room temperature and stirred for 2 h, and then quenched by addition of 10% Na<sub>2</sub>CO<sub>3(aq)</sub> (30 mL). The aqueous layer was separated and extracted twice with CH<sub>2</sub>Cl<sub>2</sub> (20 mL each). The combined organic layer was washed with sat. NaHSO<sub>3(aq)</sub> (20 mL), and 10% Na<sub>2</sub>CO<sub>3(aq)</sub> (20 mL). The combined organics were dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated *in vacuo* to afford crude alcohol **S4d** as a colorless oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 20:80 to 40:60) to afford **S4d** as a colorless oil (0.98 g, 92%).

**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>) δ 7.70-7.67 (m, 4H), 7.45-7.38 (m, 6H), 3.71-3.68 (m, 3H), 3.58 (dd, *J* = 12.1, 8.1 Hz, 1H), 3.04 (t, *J* = 5.8 Hz, 1H), 1.87 (dd, *J* = 8.0, 4.3 Hz, 1H), 1.66-1.52 (m, 6H), 1.28 (s, 3H), 1.07 (s, 9H)

**<sup>13</sup>C NMR** (125 MHz, CDCl<sub>3</sub>) δ 135.7, 134.1, 129.7, 127.8, 65.5, 63.7, 61.0, 60.3, 32.5, 28.1, 27.0, 23.0, 19.4, 14.4

**FT-IR** (ATR, cm<sup>-1</sup>): 3424, 3069, 2931, 2859, 1589, 1472, 1428, 1388, 1260, 1188, 1105, 1039

**HRMS** (DART, *m/z*): [M+NH<sub>4</sub>]<sup>+</sup> calculated for C<sub>24</sub>H<sub>34</sub>O<sub>3</sub>Si: 416.2615, found 416.2593



**(E)-Epoxy Enolate S5c**: To a solution of epoxy alcohol **S4c** (1.82 g, 4.78 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (48 mL) was added DMSO (4.8 mL, 67.6 mmol) and Et<sub>3</sub>N (3.4 mL, 24 mmol), cooled to 0 °C, and Pyr•SO<sub>3</sub> (1.53 g, 9.6 mmol) added as a solid. The reaction was allowed to warm to room temperature and stirred for 3 h. At this point,

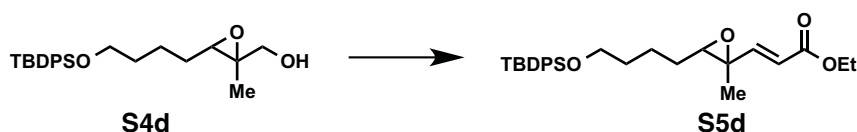
(carbethoxymethylene)triphenylphosphorane (3.34 g, 9.6 mmol) was added as a solid at room temperature and stirred for 30 min. The reaction was quenched by addition of H<sub>2</sub>O (50 mL) and diluted with CH<sub>2</sub>Cl<sub>2</sub> (25 mL). The aqueous layer was separated and extracted twice with CH<sub>2</sub>Cl<sub>2</sub> (25 mL each). The combined organics were washed with H<sub>2</sub>O (30 mL), sat. NaCl<sub>(aq)</sub> (30 mL), dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated *in vacuo* to afford crude enoate **S5c** as a yellow oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 7:93 to 10:90) to afford **S5c** as a colorless oil (2.06 g, 95%, 95:5 *E/Z*).

**<sup>1</sup>H NMR** (600 MHz, CDCl<sub>3</sub>) δ 7.66 (m, 4H), 7.45-7.38 (m, 6H), 6.73 (d, *J* = 15.7 Hz, 1H), 6.00 (d, *J* = 15.7 Hz, 1H), 4.21 (q, *J* = 7.1 Hz, 2H), 3.73-3.67 (m, 2H), 2.85 (t, *J* = 5.7 Hz, 1H), 1.76-1.65 (m, 4H), 1.42 (s, 3H), 1.30 (t, *J* = 7.1 Hz, 3H), 1.05 (s, 9H)

**<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>) δ 166.3, 150.1, 135.7, 133.89, 133.87, 129.8, 127.8, 121.7, 65.8, 63.3, 60.7, 58.7, 29.3, 27.0, 25.3, 19.4, 15.2, 14.4

**FT-IR** (ATR, cm<sup>-1</sup>): 2932, 2858, 1719, 1654, 1473, 1428, 1389, 1366, 1304, 1270, 1175, 1111, 1035

**HRMS** (DART, *m/z*): [M+NH<sub>4</sub>]<sup>+</sup> calculated for C<sub>27</sub>H<sub>36</sub>O<sub>4</sub>Si: 470.2721, found 470.2717



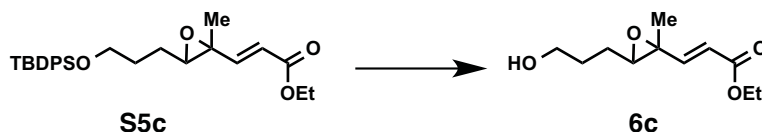
**(E)-Epoxy Enolate S5d**: To a solution of epoxy alcohol **S4d** (0.94 g, 2.36 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (24 mL) was added DMSO (2.4 mL, 34 mmol) and Et<sub>3</sub>N (1.6 mL, 12 mmol), cooled to 0 °C, and Pyr•SO<sub>3</sub> (0.94 g, 5.9 mmol) added as a solid. The reaction was allowed to warm to room temperature and stirred for 3 h. At this point, (carbethoxymethylene)triphenylphosphorane (1.64 g, 4.7 mmol) was added as a solid at room temperature and stirred for 30 min. The reaction was quenched by addition of H<sub>2</sub>O (30 mL) and diluted with CH<sub>2</sub>Cl<sub>2</sub> (15 mL). The aqueous layer was separated and extracted twice with CH<sub>2</sub>Cl<sub>2</sub> (15 mL each). The combined organics were washed with H<sub>2</sub>O (20 mL), sat. NaCl<sub>(aq)</sub> (20 mL), dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated *in vacuo* to afford crude enoate **S5d** as a yellow oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 5:95 to 10:90) to afford **S5d** as a colorless oil (1.04 g, 94%, 95:5 *E/Z*). The product was purified further by flash chromatography (EtOAc/hexanes, gradient 2:98 to 10:90) to afford **S5d** as only the (*E*)-alkene (0.50 g, 45%).

**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>) δ 7.69-7.67 (m, 4H), 7.45-7.38 (m, 6H), 6.77 (d, *J* = 15.8 Hz, 1H), 6.03 (d, *J* = 15.8 Hz, 1H), 4.22 (q, *J* = 7.1, 2H), 3.69 (t, *J* = 6.0 Hz, 2H), 2.84 (t, *J* = 5.7 Hz, 1H), 1.66-1.53 (m, 6H), 1.42 (s, 3H), 1.31 (t, *J* = 7.1 Hz, 3H), 1.07 (s, 9H)

**<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>) δ 166.3, 150.1, 135.7, 134.1, 129.7, 127.8, 121.6, 66.0, 63.6, 60.7, 58.5, 32.4, 28.4, 27.0, 22.9, 19.4, 15.3, 14.4

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 2933, 2858, 1718, 1654, 1472, 1428, 1388, 1366, 1303, 1262, 1210, 1166, 1105, 1033

**HRMS** (DART,  $m/z$ ):  $[\text{M}+\text{NH}_4]^+$  calculated for  $\text{C}_{28}\text{H}_{38}\text{O}_4\text{Si}$ : 484.2878, found 484.2858



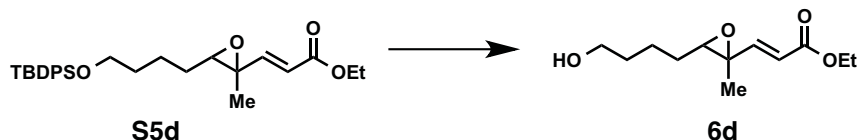
**(E)-Epoxy Alcohol 6c**: To a solution of enoate **S5c** (0.42 g, 0.93 mmol) in THF (1.9 mL) at 0 °C was added TBAF (1.0 M in THF, 1.9 mL, 1.9 mmol) dropwise over 1 min. The reaction was stirred and allowed to warm to room temperature over 1.5 h. The crude reaction mixture was purified without concentration by flash chromatography (pretreated with  $\text{Et}_3\text{N}$ /EtOAc/Hexanes 1:49:50 then gradient EtOAc/Hex, 50:50 to 60:40) to afford **6c** as a colorless oil (0.18 g, 90%).

**$^1\text{H}$  NMR** (600 MHz,  $\text{CDCl}_3$ )  $\delta$  6.73 (d,  $J$  = 15.7 Hz, 1H), 6.00 (d,  $J$  = 15.7 Hz, 1H), 4.19-4.16 (m, 2H), 3.69 (br, 2H), 2.89-2.87 (m, 1H), 2.01 (br, 1H), 1.77-1.63 (m, 4H), 1.43 (s, 3H), 1.27 (t,  $J$  = 7.1 Hz, 3H)

**$^{13}\text{C}$  NMR** (150 MHz,  $\text{CDCl}_3$ )  $\delta$  166.3, 149.8, 121.7, 65.8, 62.2, 60.7, 58.9, 29.4, 25.2, 15.3, 14.3

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3453, 2938, 2885, 1716, 1654, 1456, 1368, 1304, 1264, 1174, 1032

**HRMS** (DART,  $m/z$ ):  $[\text{M}+\text{H}]^+$  calculated for  $\text{C}_{11}\text{H}_{18}\text{O}_4$ : 215.1278, found 215.1290



**(E)-Epoxy Alcohol 6d**: To a solution of enoate **S5d** (0.53 g, 1.14 mmol) in THF (2.3 mL) at 0 °C was added TBAF (1.0 M in THF, 2.3 mL, 2.3 mmol) dropwise over 1 min. The reaction was stirred and allowed to warm to room temperature over 1.5 h. The crude reaction mixture was purified without concentration by flash chromatography (pretreated with  $\text{Et}_3\text{N}$ /EtOAc/Hexanes 1:49:50 then gradient EtOAc/Hex, 50:50 to 60:40) to afford **6d** as a colorless oil (0.21 g, 88%).

**$^1\text{H}$  NMR** (400 MHz,  $\text{CDCl}_3$ )  $\delta$  6.72 (d,  $J$  = 15.8 Hz, 1H), 5.98 (d,  $J$  = 15.8 Hz, 1H), 4.17 (q,  $J$  = 7.1 Hz, 2H), 3.63 (t,  $J$  = 6.1 Hz, 2H), 2.83 (t,  $J$  = 5.9 Hz, 1H), 1.92 (br, 1H), 1.65-1.49 (m, 6H), 1.41 (s, 3H), 1.26 (t,  $J$  = 7.1 Hz, 3H)

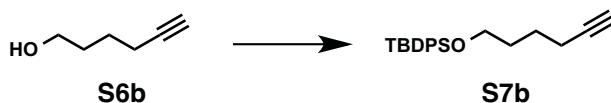
**$^{13}\text{C}$  NMR** (100 MHz,  $\text{CDCl}_3$ )  $\delta$  166.3, 150.0, 121.6, 65.9, 62.6, 60.7, 58.6, 32.4, 28.4, 22.8, 15.3, 14.3

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3400, 2933, 2870, 1716, 1654, 1457, 1388, 1368, 1305, 1264, 1175, 1031

**HRMS** (DART,  $m/z$ ):  $[\text{M}+\text{NH}_4]^+$  calculated for  $\text{C}_{12}\text{H}_{20}\text{O}_4$ : 246.1700, found 246.1699

**HRMS** (DART,  $m/z$ ):  $[M+H]^+$  calculated for  $C_{21}H_{26}OSi$ : 323.1826, found 323.1816





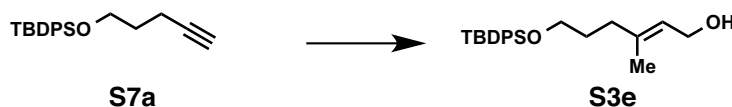
**Alkyne S7b:** To a solution of 5-pentyn-1-ol (**S6b**, 3.93 g, 40.0 mmol) and imidazole (3.81 g, 56.0 mmol) in DMF (40 mL) cooled to 0 °C was added TBDPSCl (12.5 mL, 48.0 mmol). After 5 h, the reaction was quenched with the addition of H<sub>2</sub>O (40 mL) and diluted with Et<sub>2</sub>O (40 mL). The aqueous layer was separated and extracted twice with Et<sub>2</sub>O (20 mL each). The combined organics were washed with H<sub>2</sub>O (2 x 40 mL), sat. NaCl<sub>(aq)</sub> (40 mL), dried over Na<sub>2</sub>SO<sub>4</sub>, filtered, and concentrated *in vacuo* to afford crude alkyne **S7b** as a pale yellow oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 0:100 to 5:95) to afford **S7b** as a colorless oil (12.8 g, 95%).

**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>) δ 7.69-7.67 (m, 4H), 7.45-7.38 (m, 6H), 3.69 (t, *J* = 5.9 Hz, 2H), 2.21 (td, *J* = 6.8, 2.6 Hz, 2H), 1.95 (t, *J* = 2.6 Hz, 1H), 1.72-1.62 (m, 4H), 1.06 (s, 9H)

**<sup>13</sup>C NMR** (125 MHz, CDCl<sub>3</sub>) δ 135.7, 134.1, 129.7, 127.8, 84.7, 68.4, 63.5, 31.7, 27.0, 25.1, 19.4, 18.4

**FT-IR** (ATR, cm<sup>-1</sup>): 3306, 3069, 2932, 2858, 1888, 1824, 1589, 1472, 1427, 1389, 1361, 1261, 1188, 1106, 1008

**HRMS** (DART, *m/z*): [M+H]<sup>+</sup> calculated for C<sub>22</sub>H<sub>28</sub>OSi: 337.1982, found 337.1969



**Alcohol S3e:**<sup>3</sup> To (±)-(ebi)ZrCl<sub>2</sub> (0.20 g, 0.48 mmol) was added AlMe<sub>3</sub> in toluene (7.2 mL, 2.0 M, 14.4 mmol), MAO in toluene (0.32 mL, 10 wt%, 0.48 mmol), and finally alkyne **S7a** (3.10 g, 9.6 mmol). The reaction, which became very viscous, was stirred at room temperature. After 20 h, the reaction mixture was concentrated *in vacuo* (25 °C, 1 torr) and refilled with Ar. The viscous oil was diluted with THF (10 mL), and *n*-BuLi in hexanes (5.2 mL, 1.94 M, 10.1 mmol) was added dropwise over 2 min. After stirring at room temperature for 30 min, a suspension of paraformaldehyde (0.86 g, 28.8 mmol) in THF (20 mL) was added. After an additional 4 h, the reaction was diluted with hexanes (10 mL) and quenched with the dropwise addition of 1 M HCl<sub>(aq)</sub> (5 mL), and the combined mixture was poured into sat. Rochelle's salt in water (100 mL). After stirring vigorously for 10 min, the mixture was allowed to stand for 10 min, and the organic layer was separated from the gelatinous aqueous layer. To the aqueous layer was added hexanes (10 mL) and EtOAc (10 mL), and the combined mixture was vigorously stirred for 1 h, followed by separation of the organic layer. The combined organic layers were dried Na<sub>2</sub>SO<sub>4</sub>, filtered, and concentrated *in vacuo* to afford a yellow oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 5:95 to 45:55) to afford **S3e** as a colorless oil (1.60 g, 45%).

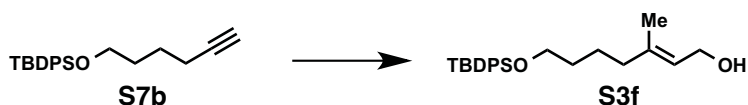
<sup>3</sup> Procedure adapted from the following report: Lipshutz, B. H.; Butler, T.; Lower, A. *J. Am. Chem. Soc.* **2006**, *128*, 15396.

**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>) δ 7.70-7.68 (m, 4H), 7.46-7.38 (m, 6H), 5.40 (t, *J* = 6.9 Hz, 1H), 4.14 (d, *J* = 6.9 Hz, 2H), 3.67 (t, *J* = 6.4 Hz, 2H), 2.12 (t, *J* = 7.7 Hz, 2H), 1.73-1.67 (m, 2H), 1.66 (s, 3H), 1.23 (br, 1H), 1.07 (s, 9H)

**<sup>13</sup>C NMR** (125 MHz, CDCl<sub>3</sub>) δ 139.7, 135.7, 134.2, 129.7, 127.8, 123.6, 63.6, 59.5, 35.9, 30.8, 27.0, 19.4, 16.4

**FT-IR** (ATR, cm<sup>-1</sup>): 3326, 2068, 2931, 2856, 1888, 1825, 1668, 1589, 1472, 1427, 1388, 1304, 1253, 1188, 1106

**HRMS** (DART, *m/z*): [M+NH<sub>4</sub>]<sup>+</sup> calculated for C<sub>23</sub>H<sub>32</sub>O<sub>2</sub>Si: 386.2510, found 386.2501



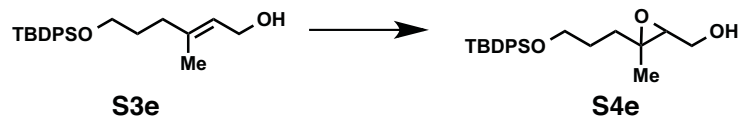
**Alcohol S3f:**<sup>3</sup> To (±)-(ebi)ZrCl<sub>2</sub> (0.40 g, 0.96 mmol) was added AlMe<sub>3</sub> in toluene (14.4 mL, 2.0 M, 28.8 mmol), MAO in toluene (0.64 mL, 10 wt%, 0.96 mmol), and finally alkyne **S7b** (6.46 g, 19.2 mmol). The reaction, which became very viscous, was stirred at room temperature. After 20 h, the reaction mixture was concentrated *in vacuo* (25 °C, 1 torr) and refilled with Ar. The viscous oil was diluted with THF (19 mL), and *n*-BuLi in hexanes (9.4 mL, 2.25 M, 21.1 mmol) was added dropwise over 2 min. After stirring at room temperature for 30 min, a suspension of paraformaldehyde (1.73 g, 57.6 mmol) in THF (40 mL) was added. After an additional 4 h, the reaction was diluted with hexanes (20 mL) and quenched with the dropwise addition of 1 M HCl<sub>(aq)</sub> (5 mL), and the combined mixture was poured into sat. Rochelle's salt in water (200 mL). After stirring vigorously for 10 min, the mixture was allowed to stand for 10 min, and the organic layer was separated from the gelatinous aqueous layer. To the aqueous layer was added hexanes (20 mL) and EtOAc (20 mL), and the combined mixture was vigorously stirred for 2.5 h, followed by separation of the organic layer. The combined organic layers were dried Na<sub>2</sub>SO<sub>4</sub>, filtered, and concentrated *in vacuo* to afford a yellow oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 10:90 to 30:70) to afford **S3f** as a colorless oil (4.1 g, 56%).

**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>) δ 7.69-7.67 (m, 4H), 7.45-7.37 (m, 6H), 5.39 (tq, *J* = 7.0, 1.3 Hz, 1H), 4.15 (d, *J* = 6.9 Hz, 2H), 3.67 (t, *J* = 6.1 Hz, 2H), 2.01 (t, *J* = 7.1 Hz, 2H), 1.66 (d, *J* = 0.4 Hz, 3H), 1.57-1.49 (m, 5H), 1.06 (s, 9H)

**<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>) δ 139.7, 135.7, 134.1, 129.6, 127.7, 123.5, 63.8, 59.4, 39.3, 32.2, 27.0, 23.9, 19.3, 16.2

**FT-IR** (ATR, cm<sup>-1</sup>): 3336, 3067, 2931, 2858, 1665, 1589, 1472, 1428, 1388, 1361, 1305, 1187, 1106

**HRMS** (DART, *m/z*): [M+NH<sub>4</sub>]<sup>+</sup> calculated for C<sub>24</sub>H<sub>34</sub>O<sub>2</sub>Si: 400.2666, found 400.2654



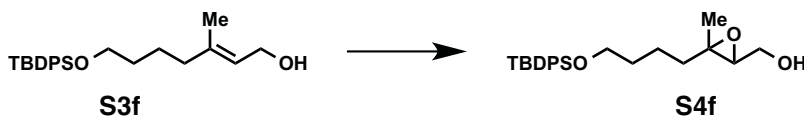
**Epoxide S4e:** To a solution of alcohol **S3e** (1.28 g, 3.47 mmol) in  $\text{CH}_2\text{Cl}_2$  (34 mL) at 0 °C was added *m*CPBA ( $\leq 77$  wt %, 1.13 g, 5.0 mmol) as a solid in one portion. The reaction was allowed to warm to room temperature and stirred for 2 h, and then quenched by addition of 10%  $\text{Na}_2\text{CO}_{3(\text{aq})}$  (50 mL). The aqueous layer was separated and extracted twice with  $\text{CH}_2\text{Cl}_2$  (25 mL each). The combined organic layer was washed with sat.  $\text{NaHSO}_{3(\text{aq})}$  (25 mL), and 10%  $\text{Na}_2\text{CO}_{3(\text{aq})}$  (25 mL). The combined organics were dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo* to afford crude alcohol **S4e** as a colorless oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 10:90 to 40:60) to afford **S4e** as a colorless oil (1.28 g, 96%).

**$^1\text{H}$  NMR** (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.68-7.65 (m, 4H), 7.45-7.38 (m, 6H), 3.80 (dd,  $J = 11.9, 3.9$  Hz, 1H), 3.70-3.66 (m, 3H), 2.95 (dd,  $J = 6.6, 4.4$  Hz, 1H), 1.73-1.58 (m, 5H), 1.28 (s, 3H), 1.06 (s, 9H)

**$^{13}\text{C}$  NMR** (125 MHz,  $\text{CDCl}_3$ )  $\delta$  135.7, 134.01, 134.00, 129.79, 129.79, 127.8, 63.6, 62.9, 61.6, 61.3, 35.0, 28.3, 27.0, 19.4, 17.0

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3410, 3054, 2931, 2857, 1590, 1472, 1427, 1386, 1361, 1255, 1188, 1105, 1087, 1026

**HRMS** (ESI,  $m/z$ ):  $[\text{M}+\text{Na}]^+$  calculated for  $\text{C}_{23}\text{H}_{32}\text{O}_3\text{Si}$ : 407.2013, found 407.2029



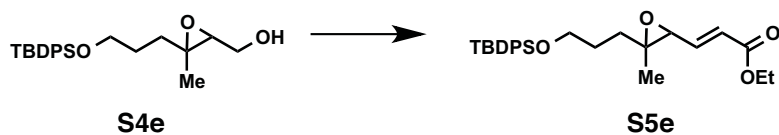
**Epoxide S4f:** To a solution of alcohol **S3f** (3.50 g, 9.2 mmol) in  $\text{CH}_2\text{Cl}_2$  (92 mL) at 0 °C was added *m*CPBA ( $\leq 77$  wt %, 3.08 g, 13.7 mmol) as a solid in one portion. The reaction was allowed to warm to room temperature and stirred for 2 h, and then quenched by addition of 10%  $\text{Na}_2\text{CO}_{3(\text{aq})}$  (90 mL). The aqueous layer was separated and extracted twice with  $\text{CH}_2\text{Cl}_2$  (50 mL each). The combined organic layer was washed with sat.  $\text{NaHSO}_{3(\text{aq})}$  (50 mL), and 10%  $\text{Na}_2\text{CO}_{3(\text{aq})}$  (50 mL). The combined organics were dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo* to afford crude alcohol **S4f** as a colorless oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 10:90 to 40:60) to afford **S4f** as a colorless oil (3.36 g, 92%).

**$^1\text{H}$  NMR** (MHz,  $\text{CDCl}_3$ )  $\delta$  7.69-7.67 (m, 4H), 7.45-7.38 (m, 6H), 3.84 (d,  $J = 11.4$  Hz, 1H), 3.71-3.66 (m, 3H), 2.95 (dd,  $J = 6.7, 4.2$  Hz, 1H), 1.90 (br, 1H), 1.66-1.43 (m, 6H), 1.29 (s, 3H), 1.07 (s, 9H)

**$^{13}\text{C}$  NMR** (125 MHz,  $\text{CDCl}_3$ )  $\delta$  135.7, 134.1, 129.7, 127.8, 63.7, 63.0, 61.6, 61.5, 38.3, 32.5, 27.0, 21.6, 19.4, 16.8

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3405, 3069, 2931, 2858, 1472, 1428, 1386, 1187, 1105, 1027

**HRMS** (ESI,  $m/z$ ):  $[\text{M}+\text{Na}]^+$  calculated for  $\text{C}_{24}\text{H}_{34}\text{O}_3\text{Si}$ : 421.2169, found 421.2186



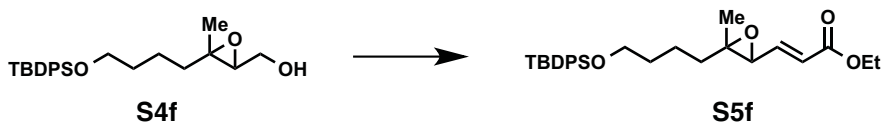
**(E)-Epoxy Enolate S5e:** To a solution of epoxy alcohol **S4e** (1.24 g, 3.21 mmol) in  $\text{CH}_2\text{Cl}_2$  (31 mL) was added DMSO (3.1 mL, 44 mmol) and  $\text{Et}_3\text{N}$  (2.2 mL, 16 mmol), cooled to 0 °C, and  $\text{Pyr}\cdot\text{SO}_3$  (0.99 g, 6.2 mmol) added as a solid. The reaction was allowed to warm to room temperature and stirred for 3 h. At this point, (carbethoxymethylene)triphenylphosphorane (2.63 g, 7.56 mmol) was added as a solid at room temperature and stirred for 4 h. The reaction was quenched by addition of  $\text{H}_2\text{O}$  (20 mL) and diluted with  $\text{CH}_2\text{Cl}_2$  (20 mL). The aqueous layer was separated and extracted twice with  $\text{CH}_2\text{Cl}_2$  (20 mL each). The combined organics were washed with  $\text{H}_2\text{O}$  (20 mL), sat.  $\text{NaCl}_{(\text{aq})}$  (20 mL), dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo* to afford crude enoate **S5e** as a yellow oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 5:95 to 10:90) to afford **S5e** as a colorless oil (1.36 g, 94%, 4:1 *E/Z*). The product was purified further by flash chromatography (EtOAc/hexanes, gradient 6:94 to 12:88) to afford **S5e** as only the (*E*)-alkene (0.77 g, 53%).

**$^1\text{H}$  NMR** (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.68-7.66 (m, 4H), 7.46-7.38 (m, 6H), 6.82 (dd,  $J = 15.7, 6.5$  Hz, 1H), 6.08 (dd,  $J = 15.7, 1.0$  Hz, 1H), 4.23 (qd,  $J = 7.1, 2.3$  Hz, 2H), 3.68 (t,  $J = 5.7$  Hz, 2H), 3.30 (dd,  $J = 6.5, 0.7$  Hz, 1H), 1.79-1.62 (m, 4H), 1.32 (t,  $J = 7.1$  Hz, 3H), 1.26 (s, 3H), 1.06 (s, 9H)

**$^{13}\text{C}$  NMR** (125 MHz,  $\text{CDCl}_3$ )  $\delta$  165.9, 143.0, 135.7, 133.95, 133.92, 129.82, 129.81, 127.84, 127.82, 125.0, 64.3, 63.5, 61.4, 60.7, 34.9, 28.3, 27.0, 19.4, 16.8, 14.4

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3069, 2932, 2858, 1718, 1653, 1589, 1472, 1428, 1387, 1366, 1301, 1259, 1175, 1105, 1038

**HRMS** (DART,  $m/z$ ):  $[\text{M}+\text{NH}_4]^+$  calculated for  $\text{C}_{27}\text{H}_{36}\text{O}_4\text{Si}$ : 470.2721, found 470.2737



**(E)-Epoxy Enolate S5f:** To a solution of epoxy alcohol **S4f** (1.38 g, 3.46 mmol) in  $\text{CH}_2\text{Cl}_2$  (34 mL) was added DMSO (3.5 mL, 49 mmol) and  $\text{Et}_3\text{N}$  (2.4 mL, 17 mmol), cooled to 0 °C, and  $\text{Pyr}\cdot\text{SO}_3$  (1.10 g, 6.9 mmol) added as a solid. The reaction was allowed to warm to room temperature and stirred for 3 h. At this point, (carbethoxymethylene)triphenylphosphorane (2.41 g, 6.9 mmol) was added as a solid at room temperature and stirred for 5 h. The reaction was quenched by addition of  $\text{H}_2\text{O}$  (20 mL) and diluted with  $\text{CH}_2\text{Cl}_2$  (20 mL). The aqueous layer was separated and extracted twice with  $\text{CH}_2\text{Cl}_2$  (20 mL each). The combined organics were washed with  $\text{H}_2\text{O}$  (20 mL), sat.  $\text{NaCl}_{(\text{aq})}$  (20 mL), dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo* to afford crude enoate **S5f** as a yellow oil. The

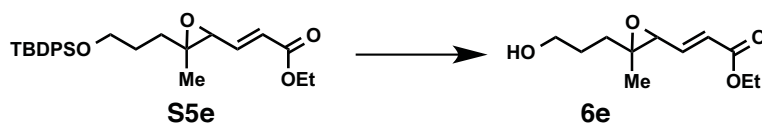
crude product was purified by flash chromatography (EtOAc/hexanes, gradient 5:95 to 10:90) to afford **S5f** as a colorless oil (1.37 g, 85%, 5:1 *E/Z*). The product was purified further by flash chromatography (EtOAc/hexanes, gradient 5:95 to 10:90) to afford **S5f** as only the (*E*)-alkene (1.13 g, 70%).

**<sup>1</sup>H NMR** (600 MHz, CDCl<sub>3</sub>) δ 7.68-7.67 (m, 4H), 7.45-7.38 (m, 6H), 6.85 (dd, *J* = 15.7, 6.4 Hz, 1H), 6.11 (d, *J* = 15.7 Hz, 1H), 4.26-4.20 (m, 2H), 3.68 (t, *J* = 6.0 Hz, 2H), 3.29 (d, *J* = 6.5 Hz, 1H), 1.70-1.65 (m, 1H), 1.60-1.48 (m, 5H), 1.32 (t, *J* = 7.1 Hz, 3H), 1.27 (s, 3H), 1.06 (s, 9H)

**<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>) δ 165.9, 143.1, 135.7, 134.1, 129.7, 127.8, 124.9, 64.5, 63.6, 61.5, 60.8, 38.2, 32.5, 27.0, 21.6, 19.4, 16.6, 14.4

**FT-IR** (ATR, cm<sup>-1</sup>): 2934, 2858, 1716, 1654, 1472, 1428, 1387, 1366, 1301, 1258, 1175, 1105, 1041

**HRMS** (ESI, *m/z*): [M+Na]<sup>+</sup> calculated for C<sub>28</sub>H<sub>38</sub>O<sub>4</sub>Si: 489.2432, found 489.2423



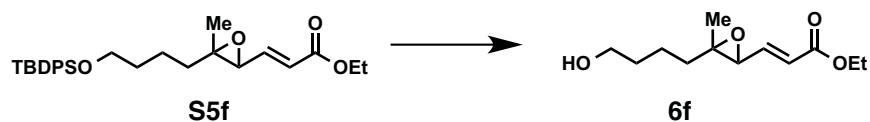
**Epoxy Alcohol 6e:** To a solution of enoate **S5e** (0.77 g, 1.70 mmol) in THF (3.4 mL) at 0 °C was added TBAF (1.0 M in THF, 3.4 mL, 3.4 mmol) dropwise over 1 min. The reaction was stirred and allowed to warm to room temperature over 2 h. The crude reaction mixture was purified without concentration by flash chromatography (pretreated with Et<sub>3</sub>N/EtOAc/Hexanes 1:49:50 then gradient EtOAc/Hex, 50:50 to 60:40) to afford **6e** as a colorless oil (0.35 g, 96%).

**<sup>1</sup>H NMR** (MHz, CDCl<sub>3</sub>) δ 6.81 (dd, *J* = 15.7, 6.4 Hz, 1H), 6.08 (dd, *J* = 15.7, 0.8 Hz, 1H), 4.18 (qd, *J* = 7.1, 1.4 Hz, 2H), 3.63 (t, *J* = 4.4 Hz, 2H), 3.34 (dd, *J* = 6.4, 0.6 Hz, 1H), 2.18 (br, 1H), 1.73-1.63 (m, 4H), 1.27 (t, *J* = 7.1 Hz, 3H), 1.26 (s, 3H)

**<sup>13</sup>C NMR** (125 MHz, CDCl<sub>3</sub>) δ 165.8, 142.6, 125.1, 64.2, 62.3, 61.6, 60.8, 34.7, 28.0, 16.6, 14.3

**FT-IR** (ATR, cm<sup>-1</sup>): 3421, 2941, 2877, 1716, 1654, 1449, 1387, 1368, 1302, 1259, 1177, 1134, 1095, 1032

**HRMS** (DART, *m/z*): [M+NH<sub>4</sub>]<sup>+</sup> calculated for C<sub>11</sub>H<sub>18</sub>O<sub>4</sub>: 232.1543, found 232.1550



**Epoxy Alcohol 6f:** To a solution of enoate **S5f** (0.76 g, 1.63 mmol) in THF (3.3 mL) at 0 °C was added TBAF (1.0 M in THF, 3.3 mL, 3.3 mmol) dropwise over 1 min. The reaction was stirred and allowed to warm to room temperature over 2

h. The crude reaction mixture was purified without concentration by flash chromatography (pretreated with Et<sub>3</sub>N/EtOAc/Hexanes 1:49:50 then gradient EtOAc/Hex, 50:50 to 70:30) to afford **6f** as a colorless oil (0.32 g, 87%).

<sup>1</sup>H NMR (MHz, CDCl<sub>3</sub>) δ 6.82 (dd, *J* = 15.7, 6.5 Hz, 1H), 6.09 (d, *J* = 15.7 Hz, 1H), 4.24-4.17 (m, 2H), 3.66 (t, *J* = 6.1 Hz, 2H), 3.32 (d, *J* = 6.5 Hz, 1H), 1.73-1.67 (m, 1H), 1.61-1.47 (m, 6H), 1.31-1.27 (m, 6H)

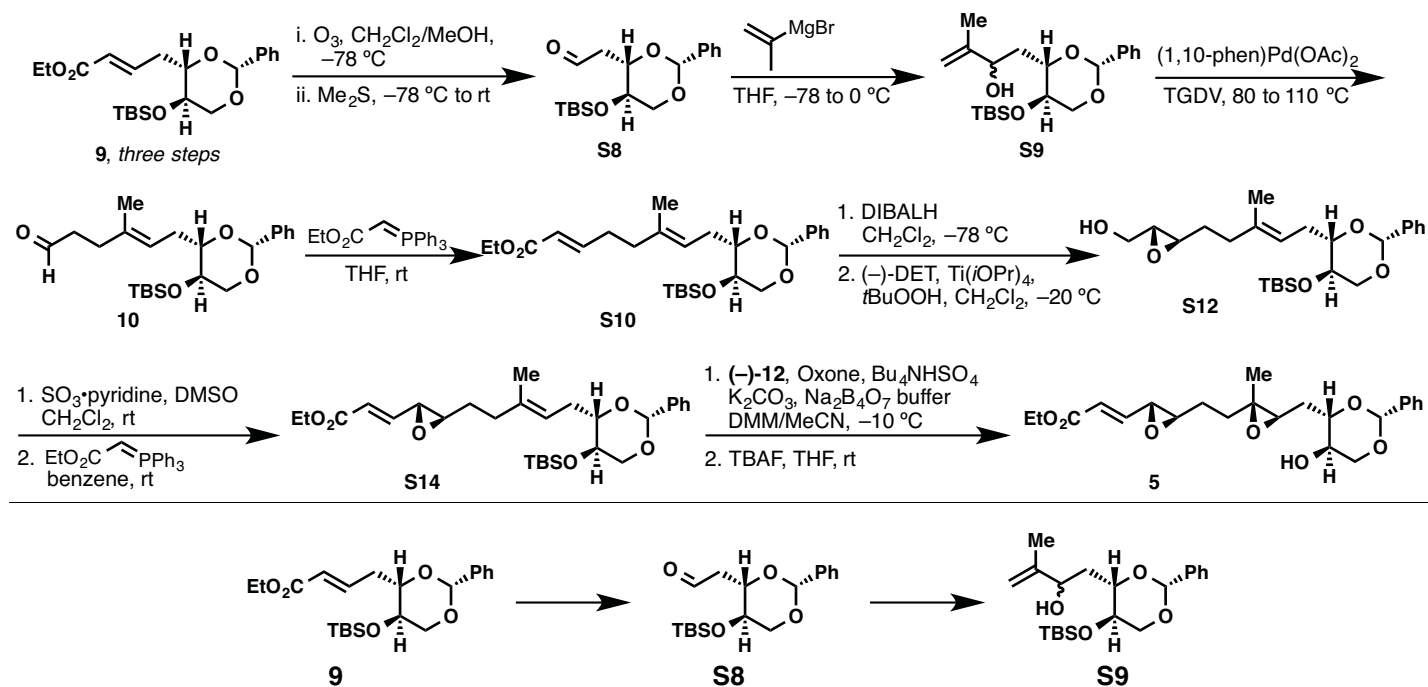
<sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) δ 165.9, 142.9, 125.1, 64.4, 62.7, 61.4, 60.8, 38.2, 32.6, 21.6, 16.7, 14.4

FT-IR (ATR, cm<sup>-1</sup>): 3425, 2939, 2867, 1718, 1653, 1459, 1368, 1304, 1260, 1176, 1096, 1038

HRMS (ESI, *m/z*): [M+Na]<sup>+</sup> calculated for C<sub>12</sub>H<sub>20</sub>O<sub>4</sub>: 251.1254, found 251.1240

#### D. First Generation Synthesis of Diepoxy Alcohol 11:

Scheme S3: Synthetic Route to Diepoxy Alcohol 11.



**Allylic Alcohol S9:** To a cooled (-78 °C) solution of (*E*)-enoate **9**<sup>4</sup> (10.0 g, 24.6 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (50 mL) was bubbled ozone until a pale blue color persisted. The solution was purged with nitrogen and then dimethyl sulfide (9.10 mL, 123 mmol) was added dropwise. The resultant solution was allowed to warm to room temperature, stirred for 12 h, and then diluted with H<sub>2</sub>O (50 mL). The aqueous layer was extracted with Et<sub>2</sub>O (3 x 50mL) and the combined organic layers were dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo*. The crude aldehyde **S8** was used without further purification.

<sup>4</sup> Van Dyke, A. R.; Jamison, T. F. *Angew. Chemie., Int. Ed.* **2009**, *48*, 4430–4432.

To a cooled ( $-78\text{ }^{\circ}\text{C}$ ) solution of crude aldehyde **S8** in THF (180 mL) was added a solution of isopropenyl magnesium bromide in THF (39.2 mL, 0.5 M, 19.6 mmol) dropwise over 20 min. The solution was allowed to warm to  $0\text{ }^{\circ}\text{C}$ , stirred for 1.5 h, and then diluted with saturated aqueous ammonium chloride (50 mL). The aqueous layer was extracted with  $\text{Et}_2\text{O}$  (3 x 50 mL) and the combined organic layers were washed with brine (50 mL), dried over  $\text{MgSO}_4$ , filtered and concentrated *in vacuo*. The resultant yellow oil was purified by flash chromatography (EtOAc/hexanes, gradient 5:95 to 20:80) to afford a diastereomeric mixture (1:1) of the title compound as a colorless oil (6.0 g, 64% over two steps).

The reported characterization was performed on a single isolated diastereomer:

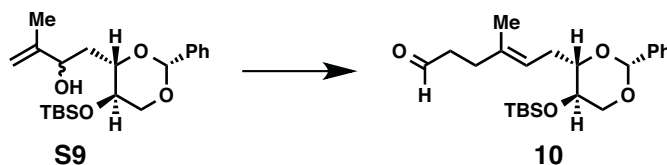
**$^1\text{H}$  NMR** (600 MHz,  $\text{CDCl}_3$ )  $\delta$  7.47 (m, 2H), 7.37 (m, 3H), 5.52 (s, 1H), 5.03 (s, 1H), 4.88 (s, 1H), 4.40 (dd,  $J = 8.5, 4.7$  Hz, 1H), 4.20 (m, 1H), 3.75 (m, 1H), 3.61 (m, 2H), 2.88, (s, 1H), 2.20 (ddd,  $J = 14.3, 4.7, 2.1$  Hz, 1H), 1.74 (m, 4H), 0.90 (s, 9H), 0.11 (d,  $J = 7.8$  Hz, 6H)

**$^{13}\text{C}$  NMR** (150 MHz,  $\text{CDCl}_3$ )  $\delta$  146.6, 137.6, 129.3, 128.6, 126.1, 111.6, 101.1, 82.8, 75.0, 72.0, 66.7, 37.2, 25.8, 18.1, 17.8, -4.0, -4.6

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3464, 3039, 2929, 2857, 1253, 1105

**HRMS** (ESI,  $m/z$ ):  $[\text{M}+\text{H}]^+$  calculated for  $\text{C}_{21}\text{H}_{34}\text{O}_4\text{Si}$ : 379.2299, found 379.2281

$[\alpha]_D^{24} = -36.6$  ( $c = 1.13$ ,  $\text{CHCl}_3$ )



**Aldehyde 10:** To a solution of **S9** (6.00 g, 15.9 mmol) and triethyleneglycol divinyl ether (6.48 mL, 31.7 mmol) was added 1,10-phenanthroline- $\text{Pd}(\text{OAc})_2^5$  (0.322 g, 1.59 mmol). The reaction vessel was fitted with a reflux condenser (open to air) and the solution was heated to  $80\text{ }^{\circ}\text{C}$  for 22 h and then to  $110\text{ }^{\circ}\text{C}$  for an additional 24 h. The reaction mixture was cooled to room temperature and the resultant brown oil was purified by flash chromatography (EtOAc/hexanes, gradient 5:95 to 10:90) to afford an isomeric mixture (7:1 *E/Z*) of the title compound as a colorless oil (4.0 g, 63%).

**$^1\text{H}$  NMR** (600 MHz,  $\text{CDCl}_3$ )  $\delta$  7.48 (m, 2H), 7.36 (m, 3H), 5.48 (s, 1H), 5.41 (t,  $J = 5.35$  Hz, 1H), 4.18 (m, 1H), 3.58 (m, 3H), 2.61 (dd,  $J = 14.2, 6.3$  Hz, 1H), 2.54 (ddd,  $J = 8.1, 6.9, 1.9$  Hz, 2H), 2.37 (t,  $J = 8.3$  Hz, 2H), 2.22 (m, 1H), 1.66 (s, 3H), 0.91 (s, 9H), 0.11 (d,  $J = 9.0$  Hz, 6H)

**$^{13}\text{C}$  NMR** (150 MHz,  $\text{CDCl}_3$ )  $\delta$  202.9, 138.2, 135.2, 129.0, 128.4, 126.2, 121.2, 101.0, 82.6, 71.9, 66.6, 42.4, 32.1, 30.4, 25.9, 18.1, 16.6, -4.0, -4.6

<sup>5</sup> Wei, X.; Lorenz, J. C.; Kapadia, S.; Saha, A.; Haddad, N.; Busacca, C. A.; Senanayake, C. H. *J. Org. Chem.* **2007**, 72, 4250–4253.

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3067, 3036, 2929, 2857, 1725, 1105

**HRMS** (ESI,  $m/z$ ):  $[\text{M}+\text{H}]^+$  calculated for  $\text{C}_{23}\text{H}_{36}\text{O}_4\text{Si}$ : 405.2456, found 405.2474

$[\alpha]_D^{24} = -67.1$  ( $c = 0.495$ ,  $\text{CHCl}_3$ )



**(E)-Enoate S10:** To a solution of **10** (4.00 g, 9.89 mmol) in THF (49 mL) was added (carbethoxymethylene)triphenylphosphorane (4.1 g, 11.9 mmol). The reaction mixture was stirred at room temperature for 17 h and then concentrated *in vacuo*. The resultant orange slurry was purified by flash chromatography (EtOAc/hexanes, gradient 5:95 to 15:85) to afford the title compound as a colorless oil (4.4 g, 94%).

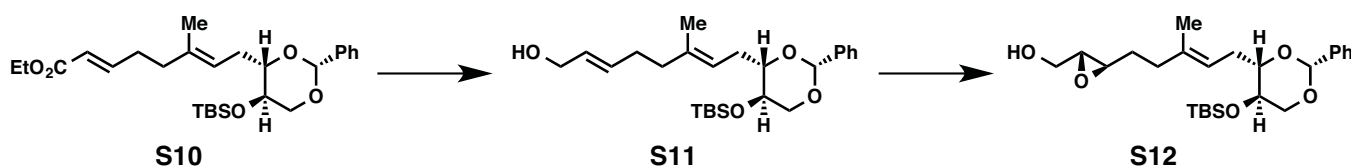
**$^1\text{H}$  NMR** (600 MHz,  $\text{CDCl}_3$ )  $\delta$  7.49 (m, 2H), 7.36 (m, 3H), 6.97 (m, 1H), 5.83 (dd,  $J = 15.7, 1.6$  Hz, 1H), 5.48 (s, 1H), 5.40 (t,  $J = 7.0$  Hz, 1H), 4.17 (m, 3H), 3.57 (m, 3H), 2.61 (m, 1H), 2.15–2.35 (m, 5H), 1.65 (s, 3H), 1.27 (t,  $J = 7.2$  Hz, 3H), 0.91 (s, 9H), 0.11 (d,  $J = 11.0$  Hz, 6H)

**$^{13}\text{C}$  NMR** (150 MHz,  $\text{CDCl}_3$ )  $\delta$  166.9, 149.1, 138.2, 135.8, 128.9, 128.6, 126.2, 121.5, 121.0, 100.9, 82.8, 71.9, 66.6, 60.4, 38.2, 31.0, 30.4, 25.9, 18.1, 16.5, 14.5, -4.0, -4.6

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3066, 3037, 2929, 2857, 1722, 1655

**HRMS** (ESI,  $m/z$ ):  $[\text{M}+\text{H}]^+$  calculated for  $\text{C}_{27}\text{H}_{42}\text{O}_5\text{Si}$ : 475.2874, found 475.2890

$[\alpha]_D^{24} = -57.7$  ( $c = 0.505$ ,  $\text{CHCl}_3$ )



**Epoxy Alcohol S12:** To a cooled ( $-78^\circ\text{C}$ ) solution of **S10** (4.4 g, 9.3 mmol) in  $\text{CH}_2\text{Cl}_2$  (92 mL) was added a solution of DIBAL-H in  $\text{CH}_2\text{Cl}_2$  (23 mL, 1.0 M, 23 mmol) dropwise over 10 min. After 1 h, the reaction mixture was quenched with MeOH (2 mL) and then warmed to room temperature. The solution was diluted with EtOAc (200 mL) and washed with saturated aqueous sodium potassium tartrate (100 mL). The aqueous layer was extracted with EtOAc (3  $\times$  50 mL) and the combined organic layers were washed with brine (50 mL), dried over  $\text{MgSO}_4$ , filtered and concentrated *in vacuo*. The crude alcohol **S11** was used without further purification.

To a cooled ( $-20^\circ\text{C}$ ) solution of 4Å molecular sieves (1.2 g) in  $\text{CH}_2\text{Cl}_2$  (45 mL) was added (–)-diethyl tartrate (0.18 mL, 1.1 mmol),  $\text{Ti}(\text{iOPr})_4$  (0.27 mL, 0.90 mmol), then a solution of crude alcohol **S11** in  $\text{CH}_2\text{Cl}_2$  (10 mL). The solution was



stirred for 20 min and then a solution of *t*BuOOH in decane (2.46 mL, 5.5 M, 13.5 mmol) was added dropwise over 5 min. The reaction mixture was stirred at  $-20\text{ }^{\circ}\text{C}$  for 20 h and then diluted with EtOAc (150 mL) and allowed to warm to room temperature. The organic layer was washed with saturated aqueous sodium sulfate and then dried over  $\text{MgSO}_4$ , filtered and concentrated *in vacuo*. The resultant yellow oil was purified by flash chromatography (EtOAc/hexanes, gradient 5:95 to 10:90) to afford the title compound as a colorless oil (3.5 g, 84% over two steps).

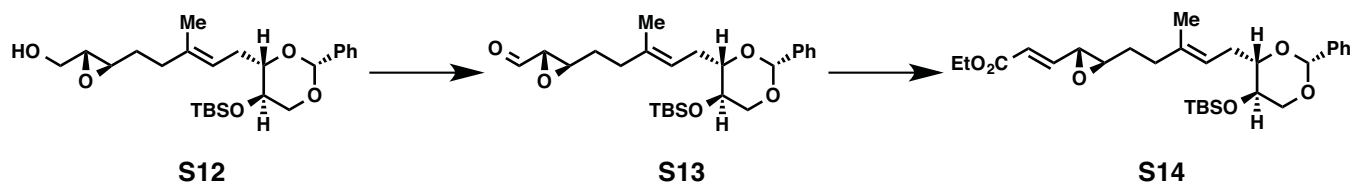
**$^1\text{H}$  NMR** (600 MHz,  $\text{CDCl}_3$ )  $\delta$  7.48 (m, 2H), 7.36 (m, 3H), 5.48 (s, 1H), 5.41 (t,  $J = 7.0$  Hz, 1H), 4.18 (dd,  $J = 10.0$ , 4.3 Hz, 1H), 3.82 (m, 1H), 3.60 (m, 4H), 2.94 (td,  $J = 5.8$ , 2.3 Hz, 1H), 2.91 (dt,  $J = 4.8$ , 2.6 Hz, 1H), 2.61 (m, 1H), 2.20 (m, 3H), 1.61–1.76 (m, 6H), 0.91 (s, 9H), 0.10 (d,  $J = 10.7$  Hz, 6H)

**$^{13}\text{C}$  NMR** (150 MHz,  $\text{CDCl}_3$ )  $\delta$  138.2, 136.1, 129.0, 128.4, 126.2, 120.8, 101.0, 82.7, 71.9, 66.5, 61.9, 58.6, 55.9, 36.0, 30.3, 30.1, 25.9, 18.1, 16.4,  $-4.0$ ,  $-4.6$

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3434, 3036, 2929, 2857, 1104

**HRMS** (ESI,  $m/z$ ):  $[\text{M}+\text{NH}_4]^+$  calculated for  $\text{C}_{25}\text{H}_{40}\text{O}_5\text{Si}$ : 466.2983, found 466.2983

$[\alpha]_D^{24} = -34.2$  ( $c = 1.26$ ,  $\text{CHCl}_3$ )



**(*E*)-Enoate S14:** To a cooled ( $0\text{ }^{\circ}\text{C}$ ) solution of **S12** (5.15 g, 11.5 mmol) in  $\text{CH}_2\text{Cl}_2/\text{DMSO}$  (4:1, 115 mL) was added  $\text{Et}_3\text{N}$  (8.0 mL, 57 mmol) then  $\text{SO}_3\cdot\text{pyridine}$  (5.5 g, 34 mmol) in four equal portions. The solution was allowed to warm to room temperature and after 3 h was diluted with  $\text{Et}_2\text{O}$  (300 mL). The organic layer was washed with saturated aqueous ammonium chloride (100 mL) and brine (100 mL), dried over  $\text{MgSO}_4$ , filtered and concentrated *in vacuo*. The crude aldehyde **S13** was used without further purification.

To a solution of crude aldehyde **S13** in benzene (45 mL) was added (carbethoxymethylene)triphenylphosphorane (4.00 g, 11.5 mmol). The reaction mixture was stirred at room temperature for 17 h and then concentrated *in vacuo*. The resultant orange slurry was purified by flash chromatography (EtOAc/hexanes, gradient 5:95 to 20:80) to afford an isomeric mixture (14:1 *E/Z*) of the title compound as a colorless oil (4.6 g, 78% over two steps).

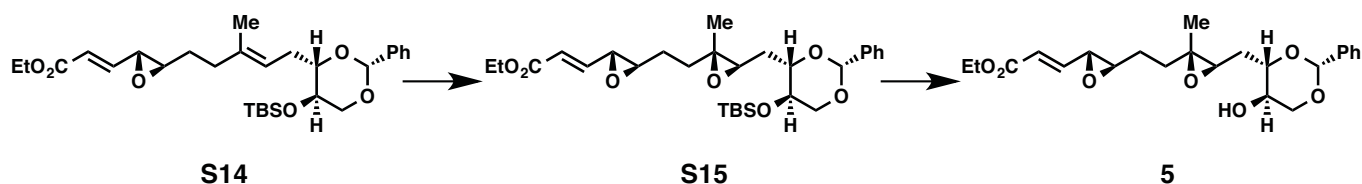
**$^1\text{H}$  NMR** (600 MHz,  $\text{CDCl}_3$ )  $\delta$  7.48 (m, 2H), 7.36 (m, 3H), 6.66 (dd,  $J = 15.6$ , 7.1 Hz, 1H), 6.12 (d,  $J = 15.7$  Hz, 1H), 5.47 (s, 1H), 5.41 (t,  $J = 7.0$  Hz, 1H), 4.19 (m, 3H), 3.51–3.63 (m, 3H), 3.22 (d,  $J = 7.1$  Hz, 1H), 2.90 (td,  $J = 5.5$ , 1.8 Hz, 1H), 2.61 (dd,  $J = 15.2$ , 7.7 Hz, 1H), 2.13–2.26 (m, 3H), 1.74 (m, 2H), 1.65 (s, 3H), 1.29 (t,  $J = 7.6$  Hz, 3H), 0.92 (s, 9H), 0.11 (d,  $J = 10.8$  Hz, 6H)

**$^{13}\text{C}$  NMR** (150 MHz,  $\text{CDCl}_3$ )  $\delta$  165.9, 145.0, 138.2, 135.8, 128.9, 128.4, 126.2, 123.8, 121.0, 100.9, 82.7, 71.9, 66.6, 61.3, 60.8, 56.6, 35.8, 30.6, 30.4, 25.9, 18.1, 16.4, 14.4, -4.0, -4.6

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3066, 3036, 2930, 2857, 1721, 1655

**HRMS** (ESI,  $m/z$ ):  $[\text{M}+\text{Na}]^+$  for  $\text{C}_{29}\text{H}_{44}\text{O}_6\text{Si}$ : 539.2799, found 539.2790

$[\alpha]_D^{24} = -52.3$  ( $c = 0.265$ ,  $\text{CHCl}_3$ )



**Diepoxo Alcohol 11:** To a cooled ( $-10\text{ }^{\circ}\text{C}$ ) solution of **S14** (3.25 g, 6.29 mmol) in DMM/MeCN (2:1, 94 mL) was added a solution of 0.05 M  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$  in  $4 \times 10^{-4}$  M  $\text{Na}_2\text{EDTA}$  (62 mL),  $n\text{Bu}_4\text{HSO}_4$  (0.214 g, 0.629 mmol), and chiral ketone (–)-**12** (0.812 g, 3.14 mmol). To this vigorously stirred reaction mixture was added, simultaneously over 2 h via syringe pump, a solution of Oxone (5.42 g, 8.81 mmol) in  $4 \times 10^{-4}$  M  $\text{Na}_2\text{EDTA}$  (41 mL) and a solution of  $\text{K}_2\text{CO}_3$  in  $\text{H}_2\text{O}$  (41 mL, 0.89 M, 37 mmol). Upon completion of syringe pump addition, the reaction mixture was diluted with  $\text{Et}_2\text{O}/\text{H}_2\text{O}$  (1:1, 200 mL) and warmed to room temperature. The aqueous layer was extracted with  $\text{EtOAc}$  ( $3 \times 50$  mL) and the combined organic layers were washed with brine (50 mL), dried over  $\text{MgSO}_4$ , filtered and concentrated *in vacuo*. The crude diepoxide **S15** was used without further purification.

To a cooled ( $0\text{ }^{\circ}\text{C}$ ) solution of crude diepoxide **S15** (1/3 total mass of crude mixture obtained above) in THF (25 mL) was added a solution of TBAF in THF (3.0 mL, 1.0 M, 3.0 mmol) dropwise over 10 min. The reaction mixture was allowed to warm to room temperature over 1.5 h and then diluted with  $\text{Et}_2\text{O}$  (100 mL). The solution was washed with  $\text{H}_2\text{O}$  (25 mL), dried over  $\text{MgSO}_4$ , filtered and concentrated *in vacuo*. The resultant pale yellow oil was purified by flash chromatography ( $\text{EtOAc}/\text{hexanes}$ , gradient 50:50 to 70:30) to afford the title compound as a colorless oil (0.73 g, 77% over two steps).

**$^1\text{H}$  NMR** (600 MHz,  $\text{CDCl}_3$ )  $\delta$  7.49 (m, 2H), 7.37 (m, 3H), 6.66 (dd,  $J = 15.7, 7.1$  Hz, 1H), 6.12 (d,  $J = 15.7$  Hz, 1H), 5.52 (s, 1H), 4.32 (dd,  $J = 10.7, 5.1$  Hz, 1H), 4.20 (m, 2H), 3.91 (m, 1H), 3.79 (ddd,  $J = 9.1, 5.1, 3.6$  Hz, 1H), 3.63 (t,  $J = 10.4$  Hz, 1H), 3.22 (dd,  $J = 7.1, 1.9$  Hz, 1H), 3.13 (dd,  $J = 8.1, 3.9$  Hz, 1H), 2.92 (ddd,  $J = 6.1, 4.5, 2.0$  Hz, 1H), 2.49 (s, 1H), 2.16 (dt,  $J = 15.1, 3.8$  Hz, 1H), 1.98 (ddd,  $J = 15.1, 8.0, 5.2$  Hz, 1H), 1.62–1.79 (m, 4H), 1.32 (s, 3H), 1.29 (t,  $J = 7.1$  Hz, 3H).

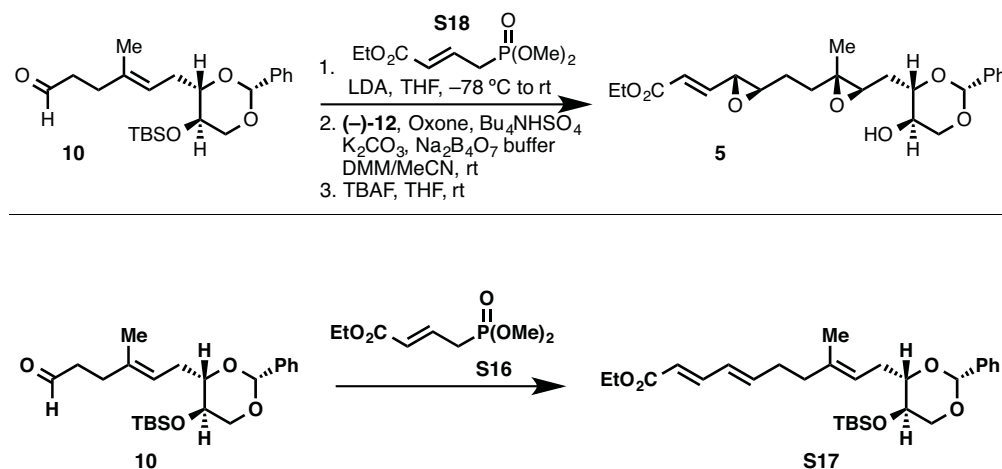
**$^{13}\text{C}$  NMR** (150 MHz,  $\text{CDCl}_3$ )  $\delta$  165.9, 144.6, 137.8, 129.2, 128.5, 126.3, 124.1, 101.4, 80.4, 71.3, 64.9, 61.0, 60.9, 60.1, 59.7, 56.6, 34.6, 31.1, 27.6, 17.0, 14.4

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3447, 2925, 2859, 1718, 1654

**HRMS** (ESI,  $m/z$ ):  $[M+Na]^+$  for  $C_{23}H_{30}O_7$ : 441.1884, found 441.1902

$[\alpha]^{24}_D = +5.52$  ( $c = 0.155$ ,  $CHCl_3$ )

**Scheme S4: Alternative route to diepoxide **11**.**



**Triene S17:** To a cooled ( $-78\text{ }^{\circ}\text{C}$ ) solution of diisopropylamine (0.11 mL, 0.79 mmol) in THF (7 mL) was added a solution of *n*-butyllithium (0.29 mL, 2.6 M, 0.75 mmol). The reaction mixture was allowed to warm to  $0\text{ }^{\circ}\text{C}$  and stirred for 30 min. The reaction mixture was then cooled to  $-78\text{ }^{\circ}\text{C}$  and a solution of phosphonate ester **S16**<sup>6</sup> (160 mg, 0.74 mmol) in THF (1 mL) was added dropwise. After stirring at  $-78\text{ }^{\circ}\text{C}$  for 30 min, a solution of aldehyde **10** (180 mg, 0.43 mmol) in THF (1 mL) was added dropwise and the reaction mixture was allowed to warm to room temperature. After 15 h, saturated aqueous ammonium chloride (20 mL) was added dropwise. The aqueous layer was extracted with EtOAc (3 x 20 mL) and the combined organic layers were dried over  $MgSO_4$ , filtered and concentrated *in vacuo*. The resultant yellow oil was purified by flash chromatography (EtOAc/hexanes, gradient 1:99 to 10:90) to afford an isomeric mixture (2:1 *E/Z*)<sup>7</sup> of the title compound as a colorless oil (180 mg, 84%).

**$^1\text{H}$  NMR** (600 MHz,  $CDCl_3$ )  $\delta$  7.49 (m, 2H), 7.36 (m, 3H), 7.24 (dd,  $J = 15.4, 10.5$  Hz, 1H), 6.15 (m, 2H), 5.77 (d,  $J = 15.4$  Hz, 1H), 5.48 (s, 1H), 5.39 (m, 1H), 4.20 (q,  $J = 7.1$  Hz, 3H), 3.58 (m, 3H), 2.61 (ddd,  $J = 14.7, 7.4, 2.8$  Hz, 1H), 2.30 (m, 2H), 2.23 (m, 1H), 2.15 (m, 2H), 1.65 (s, 3H), 1.29 (t,  $J = 7.1$  Hz, 3H), 0.91 (s, 9H), 0.11 (d,  $J = 11.2$  Hz, 6H)

**$^{13}\text{C}$  NMR** (150 MHz,  $CDCl_3$ )  $\delta$  167.5, 145.2, 144.3, 138.2, 136.1, 128.9, 128.6, 128.4, 126.2, 120.8, 119.5, 101.0, 82.3, 71.9, 66.6, 60.4, 38.9, 31.7, 30.3, 25.9, 18.1, 16.4, 14.5, -4.0, -4.6

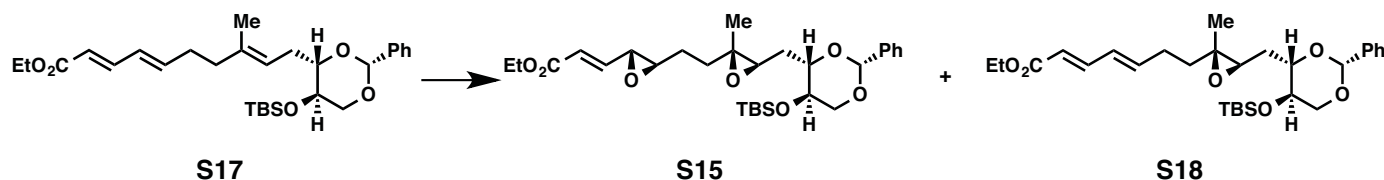
<sup>6</sup> The phosphonate ester was prepared in two steps by the literature method: Mitton-Fry, M. J.; Cullen, A. J.; Sammakia, T. *Angew. Chem., Int. Ed.* **2007**, *46*, 1066–1070.

<sup>7</sup> The isomeric mixture could be carried forward to the next synthetic operation or subjected to literature conditions ( $I_2$ ,  $CHCl_3$ ) to improve the isomeric ratio to 5:1 (*E/Z*). See, for example: (a) Nazaré, M.; Waldmann, H. *Chem. Eur. J.* **2001**, *7*, 3363–3376. (b) Xu, J.; Caro-Diaz, E. J. E.; Trzoss, L.; Theodorakis, E. A. *J. Am. Chem. Soc.* **2012**, *134*, 5072–5075.

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3029, 2930, 2857, 1714, 1643, 1105

**HRMS** (ESI,  $m/z$ ):  $[\text{M}+\text{H}]^+$  for  $\text{C}_{29}\text{H}_{44}\text{O}_5\text{Si}$ : 501.3031, found 501.3043

$[\alpha]_D^{24} = -36.4$  ( $c = 0.410$ ,  $\text{CHCl}_3$ )



**Diepoxide S15:** To a solution of **S17** (60 mg, 0.12 mmol) in DMM/MeCN (2:1, 5.3 mL) was added a solution of 0.05 M  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$  in  $4 \times 10^{-4}$   $\text{Na}_2\text{EDTA}$  (3.5 mL),  $n\text{Bu}_4\text{HSO}_4$  (4.1 mg, 0.012 mmol), and chiral ketone (–)-**12** (47 mg, 0.18 mmol). To this vigorously stirred reaction mixture was added, simultaneously over 1.5 h via syringe pump, a solution of Oxone (260 mg, 0.43 mmol) in  $4 \times 10^{-4}$   $\text{Na}_2\text{EDTA}$  (2.3 mL) and a solution of  $\text{K}_2\text{CO}_3$  in  $\text{H}_2\text{O}$  (2.3 mL, 0.89 M, 2.1 mmol). Upon completion of syringe pump addition, the reaction mixture was diluted with EtOAc/ $\text{H}_2\text{O}$  (2:1, 10 mL). The aqueous layer was extracted with EtOAc ( $3 \times 10$  mL) and the combined organic layers were washed with brine (10 mL), dried over  $\text{MgSO}_4$ , filtered and concentrated *in vacuo*. The resultant pale yellow oil was purified by flash chromatography (EtOAc/hexanes, gradient 5:95 to 20:80) to afford recovered monoepoxide **S18** (32 mg, 51%) and the title compound as a colorless oil (14 mg, 22% [45% based on recovered monoepoxide]).

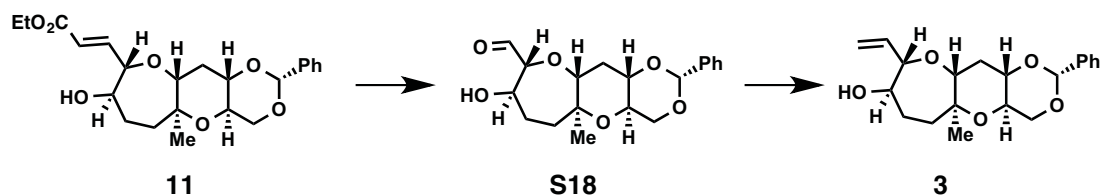
**$^1\text{H}$  NMR** (600 MHz,  $\text{CDCl}_3$ )  $\delta$  7.48 (m, 2H), 7.37 (m, 3H), 6.64 (dd,  $J = 15.7, 7.2$  Hz, 1H), 6.10 (d,  $J = 15.7$  Hz 1H), 5.51 (s, 1H), 4.20 (m, 3H), 3.69 (m, 2H), 3.58 (m, 1H), 3.18 (d,  $J = \text{Hz}$ , 1H), 3.07 (t,  $J = 6.2$  Hz, 1H), 2.92 (m, 1H), 1.99 (m, 2H), 1.75 (m, 2H), 1.63 (m, 2H), 1.29 (m, 6H), 0.89 (s, 9H), 0.11 (d,  $J = 5.7$  Hz, 6H)

**$^{13}\text{C}$  NMR** (150 MHz,  $\text{CDCl}_3$ )  $\delta$  165.8, 144.6, 137.9, 129.1, 128.5, 126.2, 124.0, 101.0, 80.8, 72.0, 66.0, 61.0, 60.8, 59.8, 59.7, 56.6, 34.6, 31.0, 27.8, 25.9, 18.0, 16.9, 14.4, -4.0, -4.6

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 2932, 2858, 1718, 1656, 1102

**HRMS** (ESI,  $m/z$ ):  $[\text{M}+\text{Na}]^+$  for  $\text{C}_{29}\text{H}_{44}\text{O}_7\text{Si}$ : 550.3195, found 550.3187

$[\alpha]_D^{24} = -20.7$  ( $c = 1.20$ ,  $\text{CHCl}_3$ )

**E. Completion of Formal Synthesis of 3:**

**Vinyl-Capped EF-Ring System 3:** Through a cooled ( $-78\text{ }^{\circ}\text{C}$ ) solution of **11** (13 mg, 0.031 mmol) in  $\text{CH}_2\text{Cl}_2/\text{MeOH}$  (4:1, 2.5 mL) was bubbled ozone until a blue color persisted. The solution was sparged with argon and triphenylphosphine (10 mg, 0.038 mmol) was added. The reaction mixture was allowed to warm to room temperature, stirred for 2 h, and concentrated *in vacuo*. The crude aldehyde **S18** was used without further purification.

To a solution of methyltriphenylphosphonium bromide (0.043 g, 0.12 mmol) in THF (0.5 mL) was added a solution of  $\text{KO}^t\text{Bu}$  (9.4 mg, 0.084 mmol) in THF (0.5 mL). The reaction mixture was stirred for 30 min and then cooled to  $0\text{ }^{\circ}\text{C}$ . A solution of crude aldehyde **S18** in THF (1 mL) was added and the reaction mixture was allowed to warm to room temperature over 16 h. Saturated aqueous ammonium chloride (2 mL) was added dropwise and the aqueous layer was extracted with  $\text{Et}_2\text{O}$  (3 x 2 mL). The combined organic layers were dried over  $\text{MgSO}_4$ , filtered and concentrated *in vacuo*. The resultant pale yellow oil was purified by flash chromatography ( $\text{EtOAc}$ /hexanes, gradient 30:70 to 50:50) to afford the title compound as a colorless amorphous solid (9.0 mg, 84% over two steps).

The spectral data correlate with the previously reported data for **3**.<sup>8</sup>

**$^1\text{H}$  NMR** (600 MHz,  $\text{CDCl}_3$ )  $\delta$  7.51–7.49 (m, 2H), 7.39–7.35 (m, 3H), 5.78 (ddd,  $J = 16.8, 10.5, 5.8\text{ Hz}$ , 1H), 5.52 (s, 1H), 5.35 (dd,  $J = 17.2, 1.6\text{ Hz}$ , 1H), 5.18 (dd,  $J = 10.6, 1.5\text{ Hz}$ , 1H), 4.25 (dd,  $J = 9.9, 4.5\text{ Hz}$ , 1H), 4.19–4.17 (m, 1H), 3.97–3.95 (m, 1H), 3.84 (dd,  $J = 11.9, 4.6\text{ Hz}$ , 1H), 3.66 (t,  $J = 9.9\text{ Hz}$ , 1H), 3.61 (td,  $J = 9.5, 4.3\text{ Hz}$ , 1H), 3.50 (ddd,  $J = 11.7, 9.0, 4.3\text{ Hz}$ , 1H), 2.21 (dt,  $J = 11.6, 4.4\text{ Hz}$ , 1H), 2.02–1.97 (m, 1H), 1.84–1.80 (m, 2H), 1.66 (d,  $J = 3.3\text{ Hz}$ , 1H), 1.61 (ddd,  $J = 13.7, 5.9, 3.0\text{ Hz}$ , 1H), 1.33 (s, 3H)

**$^{13}\text{C}$  NMR** (150 MHz,  $\text{CDCl}_3$ )  $\delta$  137.7, 137.1, 129.2, 128.6, 126.6, 116.4, 101.9, 85.3, 78.4, 78.1, 76.7, 74.3, 70.4, 66.3, 34.7, 33.0, 25.7, 16.6

**HRMS** (ESI,  $m/z$ ):  $[\text{M}+\text{H}]^+$  for  $\text{C}_{20}\text{H}_{26}\text{O}_5$ : 347.1853, found 347.1865

$[\alpha]_D^{24} = -11.4$  ( $c = 0.175$ ,  $\text{CHCl}_3$ )

<sup>8</sup> Kuranaga, T.; Ohtani, N.; Tsutsumi, R.; Baden, D. G.; Wright, J. L. C.; Satake, M.; Tachibana, K. *Org. Lett.* **2011**, *13*, 696–699.

Comparison of  $^1\text{H}$  NMR data for **3** and previously reported synthesis (ref. 8)

| $^1\text{H}$ NMR (600 MHz, $\text{CDCl}_3$ ) $\delta$<br><b>3</b> | $^1\text{H}$ NMR (500 MHz, $\text{CDCl}_3$ ) $\delta$<br>ref. 8 |
|---|---|
| Referenced at $\text{CHCl}_3 = 7.27$ ppm                          | Referenced at $\text{CHCl}_3 = 7.24$ ppm                        |
| 7.51–7.49 (m, 2H)   | 7.48–7.46 (m, 2H)   |
| 7.39–7.35 (m, 3H)   | 7.36–7.31 (m, 3H)   |
| 5.78 (ddd, $J = 16.8, 10.5, 5.8$ Hz, 1H)                          | 5.75 (ddd, $J = 16.8, 11.3, 5.6$ Hz, 1H)                        |
| 5.52 (s, 1H)  | 5.49 (s, 1H)  |
| 5.35 (dd, $J = 17.2, 1.6$ Hz, 1H)                                 | 5.32 (dd, $J = 17.2, 1.3$ Hz, 1H)                               |
| 5.18 (dd, $J = 10.6, 1.5$ Hz, 1H)                                 | 5.14 (dd, $J = 10.5, 1.3$ Hz, 1H)                               |
| 4.25 (dd, $J = 9.9, 4.5$ Hz, 1H)                                  | 4.22 (dd, $J = 9.9, 4.0$ Hz, 1H)                                |
| 4.19–4.17 (m, 1H)   | 4.15–4.13 (m, 1H)   |
| 3.97–3.95 (m, 1H)   | 3.92–3.90 (m, 1H)   |
| 3.84 (dd, $J = 11.9, 4.6$ Hz, 1H)                                 | 3.81 (dd, $J = 12.0, 4.4$ Hz, 1H)                               |
| 3.66 (t, $J = 9.9$ Hz, 1H)  | 3.63 ( $J = 9.9, 9.9$ Hz, 1H)                                   |
| 3.61 (td, $J = 9.5, 4.3$ Hz, 1H)                                  | 3.58 (ddd, $J = 9.7, 9.7, 4.6$ Hz, 1H)                          |
| 3.50 (ddd, $J = 11.7, 9.0, 4.3$ Hz, 1H)                           | 3.47 (ddd, $J = 12.0, 8.6, 3.7$ Hz, 1H)                         |
| 2.21 (dt, $J = 11.6, 4.4$ Hz, 1H)                                 | 2.18 (ddd, $J = 11.8, 4.4, 4.4$ Hz, 1H)                         |
| 2.02–1.97 (m, 1H)   | 1.97 (ddd, $J = 14.3, 10.4, 4.6$ Hz, 1H)                        |
| 1.84–1.80 (m, 2H),  | 1.84–1.76 (m, 3H)   |
| 1.66 (d, $J = 3.3$ Hz, 1H)  |   |
| 1.61 (ddd, $J = 13.7, 5.9, 3.0$ Hz, 1H)                           | 1.60–1.56 (m, 1H)   |
| 1.33 (s, 3H)  | 1.30 (s, 3H)  |

Comparison of  $^{13}\text{C}$  NMR data for **3** and previously reported synthesis (ref. 8)

| $^{13}\text{C}$ NMR<br>(150 MHz, $\text{CDCl}_3$ ) $\delta$<br><b>3</b> | $^{13}\text{C}$ NMR<br>(100 MHz, $\text{CDCl}_3$ ) $\delta$<br>ref. 8 |
|---|---|
| Referenced at $\text{CDCl}_3$<br>center peak (77.2 ppm)                 | Referenced at $\text{CDCl}_3$<br>center peak (77.0 ppm)               |
| 137.7   | 137.5   |
| 137.1   | 136.9   |
| 129.2   | 129.0   |
| 128.6   | 128.3   |
| <sup>1</sup>  | 128.3   |
| 126.6   | 126.2   |
| <sup>1</sup>  | 126.2   |
| 116.4   | 116.0   |
| 101.9   | 101.6   |
| 85.3  | 85.1  |
| 78.4  | 78.2  |
| 78.1  | 77.9  |
| 76.7  | 76.5  |
| 74.3  | 74.0  |
| 70.4  | 70.1  |
| 66.3  | 66.0  |
| 34.7  | 34.4  |
| 33.0  | 32.7  |
| 25.7  | 25.5  |
| 16.6  | 16.3  |

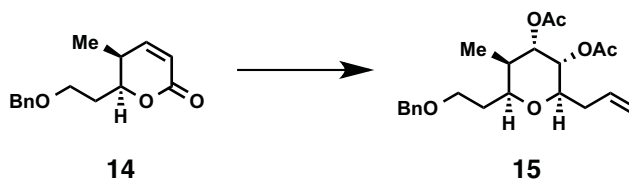
<sup>1</sup> We ascribe the absence of these resonances to the pseudo symmetry in the aromatic ring.

To a solution of the epoxy alcohol in  $\text{CH}_2\text{Cl}_2$  (22 mL) cooled to 0 °C was added  $\text{Et}_3\text{N}$  (0.93 mL, 6.7 mmol) and TBSCl (0.40 g, 2.68 mmol), and then warmed to room temperature. After 24 h, the reaction was quenched by the addition of sat.  $\text{NH}_4\text{Cl}_{(\text{aq})}$  (25 mL) and extracted with  $\text{CH}_2\text{Cl}_2$  (2 x 20 mL). The combined organic layers were dried over  $\text{Na}_2\text{SO}_4$ , filtered, and concentrated *in vacuo*. The resultant yellow oil was purified by flash chromatography (EtOAc/hexanes, gradient 5:95 to 20:80) to yield **18** as a colorless oil (0.53g, 46% over two steps). The ee of **18** was determined to be 93%. Determination of the ee of **18** was accomplished by formation of the benzoate ester of the intermediate epoxy alcohol, and comparison to the racemic epoxy benzoate on chiral analytical HPLC analysis (Chiracel OJ-H; 0.5% *i*PrOH in hexanes, 1.00 mL/min;  $t_{\text{R}}(\text{major}) = 13.0$  min,  $t_{\text{R}}(\text{minor}) = 14.2$  min).

$$[\alpha]_{\text{D}}^{24} = -2.5 \ (c = 0.51, \text{CHCl}_3)$$

<sup>9</sup> For the synthesis of **47**, please see: Yang, D.; Xu, M. *Org. Lett.* **2001**, 3, 1785.





**Alkene 15:** To a solution of **14**<sup>10</sup> (3.42 g, 13.9 mmol) and NMO (50 wt% in H<sub>2</sub>O, 4.3 mL, 20.8 mmol) in acetone/H<sub>2</sub>O (4:1, 139 mL) cooled to 0 °C was added OsO<sub>4</sub> (2.5 wt% in *t*-BuOH, 8.7 mL, 0.70 mmol). After 10 min at 0 °C, the reaction was allowed to warm to room temperature. After 5 h, the reaction was diluted with EtOAc (250 mL), mixed with H<sub>2</sub>O (50 mL), and the two layers separated. The aqueous layer was extracted with EtOAc (3 x 100 mL), and the combined organic layers were dried over MgSO<sub>4</sub>, filtered, and concentrated *in vacuo*. The resultant brown oil was purified via by flash chromatography (EtOAc/hexanes, gradient 70:30 to 100:0) to yield a colorless oil that was used directly in the next reaction.

The previously obtained oil was diluted in THF (700 mL), cooled –78 °C, and allylmagnesium bromide in Et<sub>2</sub>O (97 mL, 1.0 M, 97 mmol) was added dropwise over 1 h. After an additional 2.5 h at –78 °C, the reaction was warmed to 0 °C and quenched by dropwise addition of sat. NH<sub>4</sub>Cl<sub>(aq)</sub> (50 mL). The reaction mixture was extracted with EtOAc (3 x 100 mL), and the combined organic layers were dried over MgSO<sub>4</sub>, filtered, and concentrated *in vacuo* to provided a yellow-brown oil that was carried forward into the next reaction.

To the previously obtained oil diluted in CH<sub>3</sub>CN (139 mL) was added Et<sub>3</sub>SiH (4.0 mL, 25.0 mmol), cooled to 0 °C, and then TMSOTf (0.50 mL, 2.8 mmol) was added dropwise over 1 min. After an addition 10 min the reaction was quenched by the addition of sat. NaHCO<sub>3(aq)</sub> (50 mL) and extracted EtOAc (3 x 50 mL). The combined organic layers were washed with sat. NaCl<sub>(aq)</sub>, dried over MgSO<sub>4</sub>, filtered, and concentrated *in vacuo*. The resultant brown oil was purified by flash chromatography (EtOAc/hexanes, gradient 40:60 to 60:40) to yield a colorless oil that was used directly in the next reaction.

To the previously obtained oil diluted in CH<sub>2</sub>Cl<sub>2</sub> (60 mL) was added DMAP (12 mg, 0.1 mmol), pyridine (4.4 mL, 55 mmol), and Ac<sub>2</sub>O (3.4 mL, 36.4 mmol). The reaction was heated to 30 °C for 18 h, then concentrated *in vacuo*. The resultant yellow oil was purified by flash chromatography (EtOAc/hexanes, gradient 15:85 to 30:70) to yield **15** as a colorless oil (2.02 g, 37% over 4 steps)

**<sup>1</sup>H NMR** (600 MHz, CDCl<sub>3</sub>) δ 7.36-7.29 (m, 5H), 5.83 (ddt, *J* = 17.1, 10.3, 6.8 Hz, 1H), 5.20 (t, *J* = 3.0 Hz, 1H), 5.07-5.03 (m, 2H), 4.80 (dd, *J* = 10.2, 3.1 Hz, 1H), 4.55-4.49 (m, 2H), 4.01 (dt, *J* = 9.5, 2.9 Hz, 1H), 3.74 (ddd, *J* = 10.5, 7.9, 2.9 Hz, 1H), 3.62-3.54 (m, 2H), 2.31-2.27 (m, 1H), 2.17-2.13 (m, 1H), 2.12 (s, 3H), 2.00 (s, 3H), 1.89-1.83 (m, 1H), 1.80 (ddd, *J* = 14.4, 9.6, 4.9 Hz, 1H), 1.64-1.58 (m, 1H), 1.06 (d, *J* = 7.3 Hz, 3H)

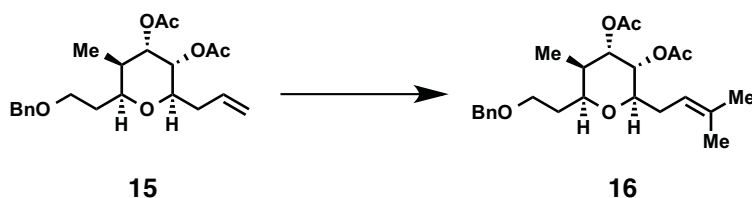
<sup>10</sup> Ohtani, N.; Tsutsumi, R.; Kuranaga, T.; Shirai, T.; Wright, J. L.; Baden, D. G.; Satake, M.; Tachibana, K. *Heterocycles* **2010**, *80*, 825.

**$^{13}\text{C}$  NMR** (150 MHz,  $\text{CDCl}_3$ )  $\delta$  170.4, 170.1, 138.6, 134.3, 128.6, 127.83, 127.77, 117.0, 73.9, 73.2, 72.6, 71.3, 68.8, 67.1, 38.1, 36.4, 32.4, 21.3, 21.1, 10.6

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 2965, 2919, 2860, 1743, 1454, 1370, 1242, 1219, 1102, 1054

**HRMS** (DART,  $m/z$ ):  $[\text{M}+\text{H}]^+$  for  $\text{C}_{22}\text{H}_{30}\text{O}_6$ : 391.2115, found 391.2114

$[\alpha]_D^{24} = +0.86$  ( $c = 0.40$ ,  $\text{CHCl}_3$ )



**Trisubstituted Alkene 16:** To a solution of **15** (417 mg, 1.07 mmol) in 2-methyl-2-butene (3.4 mL, 31.6 mmol) was added benzoquinone (17 mg, 0.16 mmol) and Hoveyda-Grubbs 2<sup>nd</sup> Generation Catalyst (15 mg, 0.024 mmol) and stirred at room temperature. After consumption of **15** (1 h, determined by  $^1\text{H}$  NMR analysis of aliquot of reaction mixture), the reaction mixture was concentrated *in vacuo*. The resultant green oil was purified by flash chromatography (EtOAc/hexanes, gradient 10:90 to 25:75) to afford **16** as a pale green oil (387 mg, 87%).

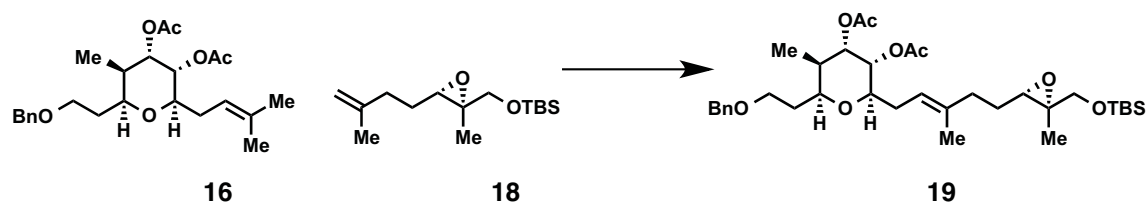
**$^1\text{H}$  NMR** (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.37-7.28 (m, 5H), 5.21-5.17 (m, 2H), 4.80 (dd,  $J = 10.2, 3.1$  Hz, 1H), 4.55-4.50 (m, 2H), 4.00 (ddd,  $J = 9.5, 3.6, 2.5$  Hz, 1H), 3.68 (ddd,  $J = 10.5, 7.4, 3.3$  Hz, 1H), 3.62-3.54 (m, 2H), 2.25-2.20 (m, 1H), 2.13-2.08 (m, 1H), 2.11 (s, 3H), 2.00 (s, 3H), 1.87-1.77 (m, 2H), 1.69 (s, 3H), 1.63-1.60 (m, 1H), 1.57 (s, 3H), 1.06 (d,  $J = 7.3$  Hz, 3H)

**$^{13}\text{C}$  NMR** (125 MHz,  $\text{CDCl}_3$ )  $\delta$  170.4, 170.1, 138.7, 133.8, 128.6, 127.80, 127.77, 119.6, 74.5, 73.3, 72.8, 71.3, 69.0, 67.2, 38.2, 32.5, 30.8, 26.0, 21.3, 21.1, 18.1, 10.6

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 2965, 2919, 2860, 1743, 1454, 1370, 1242, 1219, 1102, 1054

**HRMS** (ESI,  $m/z$ ):  $[\text{M}+\text{Na}]^+$  for  $\text{C}_{24}\text{H}_{34}\text{O}_6$ : 441.2248, found 441.2260

$[\alpha]_D^{24} = -2.1$  ( $c = 1.51$ ,  $\text{CH}_2\text{Cl}_2$ )



**Trisubstituted Alkene 19:** To a 10 mL Schlenk tube containing **16** (350 mg, 0.86 mmol), **18** (465 mg, 1.72 mmol), and benzoquinone (10 mg, 0.09 mmol) was added Hoveyda-Grubbs 2<sup>nd</sup> Generation Catalyst (27 mg, 0.043 mmol) and flushed with argon. This mixture was heated with stirring on an oil bath at 80 °C. After 18 h, the reaction mixture was transferred out of the Schlenk tube with CH<sub>2</sub>Cl<sub>2</sub> (3x5 mL) and the reaction mixture was concentrated *in vacuo*. The resultant green oil was purified by flash chromatography (EtOAc/hexanes, gradient 5:95 to 20:80) to afford **19** as a pale green oil (423 mg, 78%, 2:1 *E/Z*). Enrichment to >9:1 *E/Z* of **50** could be achieved through repeated flash chromatography (EtOAc/hexanes, gradient 10:90 to 20:80).

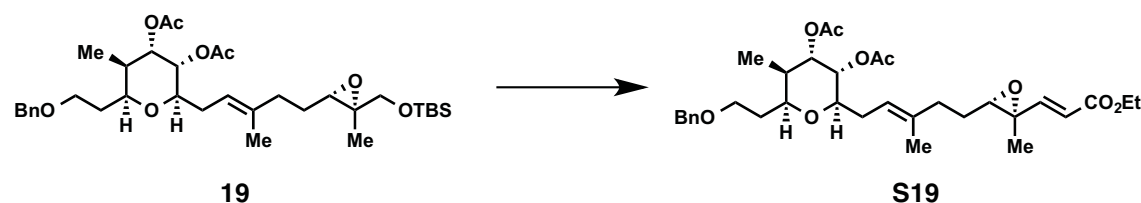
**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>) δ 7.37-7.29 (m, 5H), 5.27-5.24 (m, 1H), 5.20 (t, *J* = 3.1 Hz, 1H), 4.79 (dd, *J* = 10.2, 3.1 Hz, 1H), 4.54-4.48 (m, 2H), 4.00 (ddd, *J* = 9.4, 3.6, 2.5 Hz, 1H), 3.70 (ddd, *J* = 10.4, 7.5, 3.1 Hz, 1H), 3.60-3.55 (m, 4H), 2.85 (t, *J* = 6.3 Hz, 1H), 2.24-2.21 (m, 1H), 2.18-2.05 (m, 3H), 2.11 (s, 3H), 2.00 (s, 3H), 1.87-1.78 (m, 2H), 1.67-1.62 (m, 3H), 1.58 (s, 3H), 1.27 (s, 3H), 1.05 (d, *J* = 7.3 Hz, 3H), 0.90 (s, 9H), 0.07 (s, 3H), 0.06 (s, 3H)

**<sup>13</sup>C NMR** (125 MHz, CDCl<sub>3</sub>) δ 170.4, 170.1, 138.7, 136.6, 128.6, 127.8, 120.0, 74.4, 73.2, 72.7, 71.4, 68.9, 68.0, 67.3, 61.2, 60.8, 38.1, 36.5, 32.5, 30.6, 27.3, 26.1, 21.3, 21.1, 18.5, 16.5, 14.3, 10.6, -5.2

**FT-IR** (ATR, cm<sup>-1</sup>): 2958, 2930, 2850, 1748, 1455, 1371, 1245, 1223, 1101, 1057

**HRMS** (ESI, *m/z*): [M+Na]<sup>+</sup> for C<sub>35</sub>H<sub>56</sub>O<sub>8</sub>Si: 655.3637, found 655.3644

[α]<sub>D</sub><sup>24</sup> = -8.0 (*c* = 0.92, CH<sub>2</sub>Cl<sub>2</sub>)



**Enoate S19:** To a solution of **19** (57 mg, 0.09 mmol) in THF (0.9 mL) at 0 °C was added TBAF (1.0 M in THF, 0.11 mL, 0.11 mmol). The reaction was stirred for 30 min, and quenched with H<sub>2</sub>O (2 mL). The reaction was extracted with Et<sub>2</sub>O (3x5 mL), and the combined organic layers were washed with sat. NaCl<sub>(aq)</sub> (10 mL), dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated *in vacuo* to provide a crude alcohol. The crude alcohol was purified by flash chromatography (30% EtOAc in hexanes to 70% EtOAc in hexanes) to provide an alcohol intermediate as a colorless oil (39 mg).

To a solution of the alcohol intermediate in  $\text{CH}_2\text{Cl}_2$  (0.7 mL) was added DMSO (0.15 mL, 2 mmol) and  $\text{Et}_3\text{N}$  (0.10 mL, 0.73 mmol), cooled to 0 °C, and  $\text{Pyr}\cdot\text{SO}_3$  (35 mg, 0.22 mmol) added as a solid. The reaction was allowed to warm to room temperature and stirred for 4 h. At this point, (carbethoxymethylene)triphenylphosphorane (77 mg, 0.22 mmol) was added as a solid at room temperature and stirred for 1 h. The reaction was quenched by addition of  $\text{H}_2\text{O}$  (5 mL) and diluted with  $\text{CH}_2\text{Cl}_2$  (5 mL). The aqueous layer was separated and extracted twice with  $\text{CH}_2\text{Cl}_2$  (5 mL each). The combined organics were washed with  $\text{H}_2\text{O}$  (3 mL), sat.  $\text{NaCl}_{(\text{aq})}$  (3 mL), dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo* to afford crude enoate **S19** as a yellow oil. The crude product was purified by flash chromatography (EtOAc/hexanes, gradient 10:90 to 40:60) to afford **S19** as a colorless oil (39 mg, 91%, 95:5 *E/Z*).

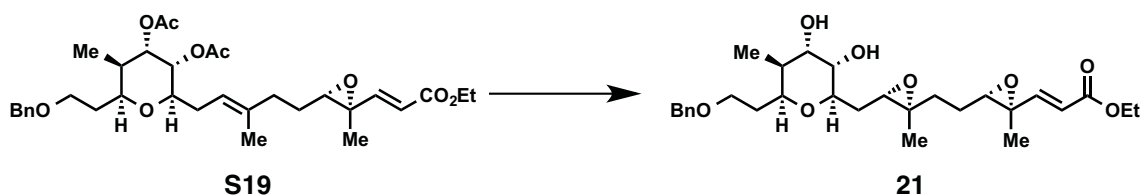
**$^1\text{H}$  NMR** (600 MHz,  $\text{CDCl}_3$ )  $\delta$  7.37-7.29 (m, 5H), 6.74 (d,  $J$  = 15.8 Hz, 1H), 6.01 (d,  $J$  = 15.7 Hz, 1H), 5.25 (t,  $J$  = 6.4 Hz, 1H), 5.19 (t,  $J$  = 3.0 Hz, 1H), 4.79 (dd,  $J$  = 10.2, 3.1 Hz, 1H), 4.54-4.49 (m, 2H), 4.22-4.18 (m, 2H), 4.01-3.99 (m, 1H), 3.70 (ddd,  $J$  = 10.4, 7.5, 3.1 Hz, 1H), 3.60-3.53 (m, 2H), 2.84 (t,  $J$  = 6.2 Hz, 1H), 2.25-2.21 (m, 1H), 2.18-2.08 (m, 3H), 2.11 (s, 3H), 2.00 (s, 3H), 1.87-1.77 (m, 2H), 1.72-1.68 (m, 2H), 1.63-1.59 (m, 1H), 1.58 (s, 3H), 1.42 (s, 3H), 1.30-1.27 (m, 3H), 1.04 (d,  $J$  = 7.3 Hz, 3H)

**$^{13}\text{C}$  NMR** (150 MHz,  $\text{CDCl}_3$ )  $\delta$  170.4, 170.1, 166.3, 150.1, 138.6, 136.2, 128.6, 127.78, 127.74, 121.7, 120.4, 74.3, 73.2, 72.6, 71.3, 68.8, 67.2, 65.6, 60.7, 58.7, 38.1, 36.3, 32.4, 30.5, 27.4, 21.3, 21.1, 16.4, 15.3, 14.4, 10.6

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 2963, 2928, 2862, 1744, 1718, 1654, 1454, 1368, 1304, 1242, 1221, 1175, 1101, 1054, 1031

**HRMS** (ESI,  $m/z$ ):  $[\text{M}+\text{Na}]^+$  for  $\text{C}_{33}\text{H}_{46}\text{O}_9$ : 609.3034, found 609.3029

$[\alpha]_D^{24} = -3.2$  ( $c$  = 1.95,  $\text{CH}_2\text{Cl}_2$ )



**Diol 21:** To a solution of **S19** (36 mg, 0.06 mmol) and chiral ketone (+)-**12**<sup>11</sup> (16 mg, 0.061 mmol) in DMM/MeCN (2:1, 2.8 mL) was added a solution of 0.05 M  $\text{Na}_2\text{B}_4\text{O}_7\cdot 10\text{H}_2\text{O}$  in  $4 \times 10^{-4}$   $\text{Na}_2\text{EDTA}$  (1.85 mL) and  $n\text{Bu}_4\text{HSO}_4$  (4 mg, 0.01 mmol), and the mixture was cooled to -10 °C. To this vigorously stirred reaction mixture was added, simultaneously over 1 h via syringe pump, a 0.212 M solution of Oxone® in  $4 \times 10^{-4}$   $\text{Na}_2\text{EDTA}$  (0.86 mL) and a 0.89 M solution of  $\text{K}_2\text{CO}_3$  in  $\text{H}_2\text{O}$  (0.86 mL). Upon completion of syringe pump addition, the reaction mixture was diluted with  $\text{Et}_2\text{O}/\text{H}_2\text{O}$  (1:1, 10 mL) and warmed to room temperature. The aqueous layer was extracted with EtOAc (2 x 5 mL) and the combined organic layers were washed with sat.  $\text{NaCl}_{(\text{aq})}$  (5 mL), dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo*. The crude diepoxide

<sup>11</sup> Jamison, T. F.; Ikeuchi, Y. Epoxidation Catalysts. U.S. Patent 8,680,303 B2, Mar. 25, 2014

was purified by flash chromatography (EtOAc/hexanes, gradient 20:80 to 40:60) to provide a diepoxide intermediate as a colorless oil (31 mg).

To the previous diepoxide in EtOH (0.9 mL) at 0 °C was added a premixed solution of EtOH (0.25 mL) containing guanidinium•HCl (0.7 mg, 7  $\mu$ mol) and NaOEt (0.4 mg, 6  $\mu$ mol). After 2 h, the reaction was allowed to warm to room temperature. After 6 h, the reaction was concentrated *in vacuo*, and directly purified by flash chromatography (EtOAc/hexanes, gradient 50:50 to 100:0) to provide **21** as a colorless film (19.1 mg, 72%).

**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>)  $\delta$  7.36-7.28 (m, 5H), 6.74 (d,  $J$  = 15.7 Hz, 1H), 6.01 (d,  $J$  = 15.7 Hz, 1H), 4.53-4.48 (m, 2H), 4.20 (q,  $J$  = 7.1 Hz, 2H), 4.03 (ddd,  $J$  = 9.3, 3.7, 2.4 Hz, 1H), 3.89 (br, 1H), 3.69-3.65 (m, 2H), 3.57 (dd,  $J$  = 7.3, 5.8 Hz, 2H), 3.01 (dd,  $J$  = 7.3, 4.5 Hz, 1H), 2.84 (t,  $J$  = 5.8 Hz, 1H), 2.57 (d,  $J$  = 6.0 Hz, 1H), 2.45 (br, 1H), 2.01-1.96 (m, 1H), 1.93-1.87 (m, 1H), 1.84-1.77 (m, 2H), 1.75-1.68 (m, 3H), 1.68-1.60 (m, 2H), 1.43 (s, 3H), 1.29 (t,  $J$  = 7.1 Hz, 3H), 1.28 (s, 3H), 0.96 (d,  $J$  = 7.3 Hz, 3H)

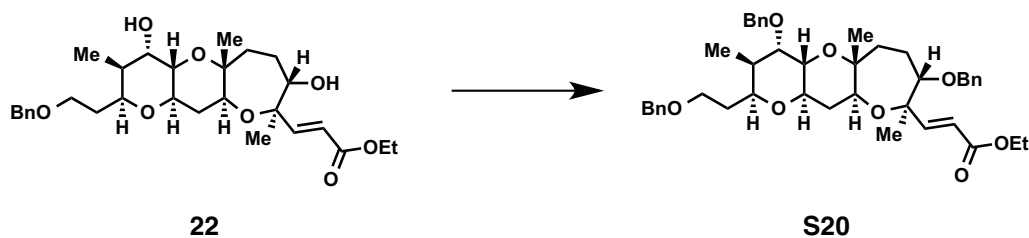
**<sup>13</sup>C NMR** (125 MHz, CDCl<sub>3</sub>)  $\delta$  166.3, 149.8, 138.7, 128.5, 127.75, 127.70, 121.8, 74.5, 73.6, 73.1, 71.0, 68.1, 67.6, 65.5, 60.8, 60.4, 59.8, 58.8, 39.7, 35.2, 32.5, 31.6, 24.4, 16.9, 15.3, 14.4, 10.8

**FT-IR** (ATR, cm<sup>-1</sup>): 3434, 2965, 2927, 2866, 2362, 1717, 1659, 1456, 1387, 1368, 1307, 1266, 1210, 1177, 1104, 1071, 1038

**HRMS** (DART,  $m/z$ ): [M+NH<sub>4</sub>]<sup>+</sup> for C<sub>29</sub>H<sub>42</sub>O<sub>8</sub>: 519.2925, found 519.2937

[ $\alpha$ ]<sub>D</sub><sup>24</sup> = -16.0 ( $c$  = 0.40, CH<sub>2</sub>Cl<sub>2</sub>)

### G. Completion of Formal Synthesis of **2**:



**Enoate S20:** To a solution of **22** (5.0 mg, 9.6  $\mu$ mol) in THF (0.96 mL) was added NaH (95%, 9 mg, 0.38 mmol), TBAI (7 mg, 0.02 mmol), and BnBr (45  $\mu$ L, 0.38 mmol). The reaction was heated in an oil bath at 40 °C for 3 h, then at 60 °C for an additional 2 h. After cooling to room temperature, the reaction was quenched by the careful addition of sat. NH<sub>4</sub>Cl<sub>(aq)</sub> (2 mL) and extracted with EtOAc (3 x 3 mL). The combined organic layers were dried over Na<sub>2</sub>SO<sub>4</sub>, filtered, and concentrated *in vacuo*. The resultant colorless film was purified by flash chromatography (EtOAc/hexanes, gradient 5:95 to 40:60) to afford **S20** as a colorless oil (5.0 mg, 75%).

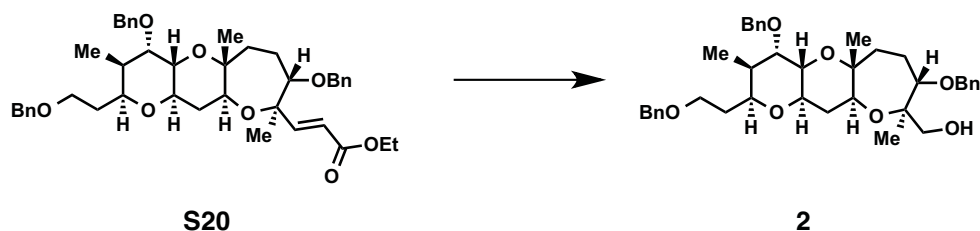
**$^1\text{H}$  NMR** (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.37-7.29 (m, 10H), 7.27-7.23 (m, 5H), 6.68 (d,  $J$  = 15.4 Hz, 1H), 6.08 (d,  $J$  = 15.4 Hz, 1H), 4.86 (d,  $J$  = 12.0 Hz, 1H), 4.65 (d,  $J$  = 11.9 Hz, 1H), 4.60 (d,  $J$  = 12.0 Hz, 1H), 4.51 (d,  $J$  = 12.0 Hz, 1H), 4.47 (d,  $J$  = 12.0 Hz, 1H), 4.32 (d,  $J$  = 11.9 Hz, 1H), 4.25-4.15 (m, 2H), 4.02 (dt,  $J$  = 9.1, 3.1 Hz, 1H), 3.96 (dd,  $J$  = 12.0, 4.8 Hz, 1H), 3.64 (ddd,  $J$  = 11.8, 10.0, 4.5 Hz, 1H), 3.60-3.52 (m, 4H), 3.45 (dd,  $J$  = 9.9, 2.5 Hz, 1H), 1.96-1.77 (m, 5H), 1.60-1.55 (m, 4H), 1.34 (s, 3H), 1.31 (t,  $J$  = 7.1 Hz, 3H), 1.25 (s, 3H), 0.96 (d,  $J$  = 7.3 Hz, 3H)

**$^{13}\text{C}$  NMR** (125 MHz,  $\text{CDCl}_3$ )  $\delta$  167.1, 152.4, 139.9, 138.8, 138.2, 128.63, 128.48, 128.32, 127.88, 127.74, 127.62, 127.53, 127.3, 120.1, 81.1, 80.7, 79.6, 76.9, 73.10, 73.07, 71.92, 71.79, 71.69, 71.4, 70.4, 67.7, 60.7, 39.3, 34.9, 34.1, 32.7, 21.32, 21.22, 16.0, 14.5, 11.8

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 3065, 3032, 2926, 2863, 1717, 1660, 1497, 1454, 1365, 1291, 1241, 1179, 1096, 1064, 1028

**HRMS** (ESI,  $m/z$ ):  $[\text{M}+\text{Na}]^+$  for  $\text{C}_{43}\text{H}_{54}\text{O}_8$ : 721.3711, found 721.3725

$[\alpha]_D^{24} = -17.5$  ( $c$  = 0.18,  $\text{CH}_2\text{Cl}_2$ )



**Alcohol 2:** To a solution of **S20** (4.0 mg, 5.7  $\mu\text{mol}$ ) in  $t\text{-BuOH}/\text{H}_2\text{O}$  (2:1, 0.42 mL) was added citric acid monohydrate (2.4 mg, 0.012 mmol), NMO (as solid, 2.0 mg, 0.017 mmol), and  $\text{K}_2\text{OsO}_2(\text{OH})_4 \cdot 2\text{H}_2\text{O}$  (0.4 mg, 12  $\mu\text{mol}$ ), and the green reaction mixture was stirred at room temperature. After 16 h, the colorless reaction was quenched by addition of 1M  $\text{HCl}_{(\text{aq})}$  (0.2 mL), then extracted EtOAc (3 x 2 mL). The combined organic layers were washed sat.  $\text{Na}_2\text{CO}_{3(\text{aq})}$  (1 x 2.5 mL), sat.  $\text{NaCl}_{(\text{aq})}$  (1 x 2.5 mL), dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo* to provide the crude diol as a pale green oil, which was used without further purification.

To a solution of the crude diol in  $\text{CH}_2\text{Cl}_2$  (0.3 mL) was added  $\text{Ph}_3\text{BiCO}_3$  (17 mg, 0.034 mmol) and heated to 60  $^\circ\text{C}$  in an oil bath. After 2 h, the reaction was removed from the oil bath, filtered through Celite (washed  $\text{CH}_2\text{Cl}_2$  3 x 1 mL), and concentrated *in vacuo*. The crude beige gel was purified by flash chromatography (EtOAc/hexanes, gradient 10:90 to 30:70) to afford an aldehyde that was used immediately in the next step.

To a solution of aldehyde in MeOH (0.3 mL) at 0  $^\circ\text{C}$  was added  $\text{NaBH}_4$  (1.6 mg, 0.04 mmol). The reaction was quenched after 5 min by the addition of 1M  $\text{HCl}_{(\text{aq})}$  (0.1 mL), EtOAc (1 mL), and  $\text{H}_2\text{O}$  (0.2 mL). The reaction mixture was extracted with EtOAc (3 x 2 mL), and the combined organic layers were washed with sat.  $\text{NaCl}_{(\text{aq})}$  (2 mL), dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo*. The colorless film was purified by flash chromatography (EtOAc/hexanes, gradient 20:80 to 50:50) to yield **2** as a colorless film (2.1 mg, 60% over 3 steps).

The spectral data correlate with the previously reported data for **2**.<sup>12</sup>

**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>) δ 7.36-7.28 (m, 10H), 7.27-7.22 (m, 5H), 4.84 (d, *J* = 12.0 Hz, 1H), 4.62 (d, *J* = 11.8 Hz, 1H), 4.60 (d, *J* = 11.9 Hz, 1H), 4.51 (d, *J* = 12.0 Hz, 1H), 4.47 (d, *J* = 12.0 Hz, 1H), 4.30 (d, *J* = 11.8 Hz, 1H), 4.04-4.00 (m, 1H), 3.80 (dd, *J* = 12.1, 4.7 Hz, 1H), 3.64 (ddd, *J* = 11.6, 10.0, 4.5 Hz, 1H), 3.59 (t, *J* = 2.6 Hz, 1H), 3.56-3.52 (m, 2H), 3.45-3.42 (m, 2H), 3.38 (d, *J* = 10.7 Hz, 1H), 3.24 (d, *J* = 10.7 Hz, 1H), 2.02-1.93 (m, 3H), 1.89 (dt, *J* = 11.7, 4.7 Hz, 1H), 1.80-1.77 (m, 1H), 1.72-1.67 (m, 1H), 1.60-1.58 (m, 1H), 1.57-1.53 (m, 1H), 1.52-1.49 (m, 1H), 1.29 (s, 3H), 1.21 (s, 3H), 0.95 (d, *J* = 7.3 Hz, 3H)

**<sup>13</sup>C NMR** (125 MHz, CDCl<sub>3</sub>): δ 139.8, 138.74, 138.57, 128.56, 128.49, 128.32, 127.88, 127.70, 127.64, 127.58, 127.54, 127.3, 81.1, 80.4, 79.6, 77.4, 73.11, 73.08, 72.08, 71.95, 71.51, 71.34, 70.4, 69.3, 67.6, 39.3, 35.1, 34.0, 32.7, 22.8, 17.5, 15.7, 11.8

**FT-IR** (ATR, cm<sup>-1</sup>): 3427, 3030, 2925, 2858, 1718, 1670, 1605, 1496, 1453, 1361, 1260, 1215, 1156, 1089, 1062, 1027

**HRMS** (DART, *m/z*): [M+H]<sup>+</sup> for C<sub>39</sub>H<sub>50</sub>O<sub>7</sub>: 631.3629, found 631.3629

[α]<sub>D</sub><sup>24</sup> = -17.5 (*c* = 0.105, CHCl<sub>3</sub>)

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<sup>12</sup> Characterization data for **2** matches except the optical rotation data differs by a factor of 10 (reported: [α]<sub>D</sub><sup>27</sup> = -168 (*c* = 0.111, CHCl<sub>3</sub>)) as reported in Kuranaga, T.; Ohtani, N.; Tsutsumi, R.; Baden, D. G.; Wright, J. L. C.; Satake, M.; Tachibana, K. *Org. Lett.* **2011**, *13*, 696.

Comparison of  $^1\text{H}$  NMR data for **2** and previously reported synthesis (ref. 8)

| $^1\text{H}$ NMR (600 MHz, $\text{CDCl}_3$ ) $\delta$<br><b>2</b> | $^1\text{H}$ NMR (500 MHz, $\text{CDCl}_3$ ) $\delta$<br>ref. 8 |
|---|---|
| Referenced at $\text{CHCl}_3 = 7.27$ ppm                          | Referenced at $\text{CHCl}_3 = 7.24$ ppm                        |
| 7.36-7.28 (m, 10H)  | 7.35–7.25 (m, 15H)  |
| 7.27-7.22 (m, 5H)   |   |
| 4.84 (d, $J = 12.0$ Hz, 1H)                                       | 4.81 (d, $J = 11.7$ Hz, 1H)                                     |
| 4.62 (d, $J = 11.8$ Hz, 1H)                                       | 4.59 (d, $J = 12.6$ Hz, 1H)                                     |
| 4.60 (d, $J = 11.9$ Hz, 1H)                                       | 4.58 (d, $J = 12.6$ Hz, 1H)                                     |
| 4.51 (d, $J = 12.0$ Hz, 1H)                                       | <sup>1</sup>  |
| 4.47 (d, $J = 12.0$ Hz, 1H)                                       | <sup>1</sup>  |
| 4.30 (d, $J = 11.8$ Hz, 1H)                                       | 4.28 (d, $J = 11.8$ Hz, 1H)                                     |
| 4.04-4.00 (m, 1H)   | 4.00 (ddd, $J = 9.2, 2.0, 2.0$ Hz, 1H)                          |
| 3.80 (dd, $J = 12.1, 4.7$ Hz, 1H)                                 | 3.77 (dd, $J = 11.8, 4.6$ Hz, 1H),                              |
| 3.64 (ddd, $J = 11.6, 10.0, 4.5$ Hz, 1H)                          | 3.61 (ddd, $J = 11.8, 10.1, 4.2$ Hz, 1H)                        |
| 3.59 (t, $J = 2.6$ Hz, 1H)  | 3.56 (dd, $J = 2.5, 2.5$ Hz, 1H)                                |
| 3.56-3.52 (m, 2H)   | 3.54–3.45 (m, 2H)   |
| 3.45-3.42 (m, 2H)   | 3.42–3.40 (m, 2H)   |
| 3.38 (d, $J = 10.7$ Hz, 1H)                                       | 3.36 (d, $J = 10.9$ Hz, 1H)                                     |
| 3.24 (d, $J = 10.7$ Hz, 1H)                                       | 3.21 (dd, $J = 10.5, 6.7$ Hz, 1H)                               |
| 2.02-1.93 (m, 3H)   | 2.01–1.90 (m, 3H)   |
| 1.89 (dt, $J = 11.7, 4.7$ Hz, 1H)                                 | 1.86 (ddd, $J = 11.7, 4.6, 4.6$ Hz, 1H)                         |
| 1.80-1.77 (m, 1H)   | 1.77 (dddd, $J = 14.7, 9.6, 5.5, 5.5$ Hz, 1H)                   |
| 1.72-1.67 (m, 1H)   | 1.67 (dd, $J = 13.4, 13.4$ Hz, 1H)                              |
| 1.60-1.58 (m, 1H)   | 1.57 (ddd, $J = 11.3, 7.1, 3.8$ Hz, 1H)                         |
| 1.57-1.53 (m, 1H)   | 1.54–1.44 (m, 2H)   |
| 1.52-1.49 (m, 1H)   |   |
| 1.29 (s, 3H)  | 1.26 (s, 3H)  |
| 1.21 (s, 3H)  | 1.18 (s, 3H)  |
| 0.95 (d, $J = 7.3$ Hz, 3H)  | 0.93 (d, $J = 7.2$ Hz, 3H)                                      |

<sup>1</sup> While not tabulated in the reported data from ref. 8, these peaks are observed in the  $^1\text{H}$  spectrum, as well as are necessary for the six benzylic protons between 4.30–4.84 ppm. Additionally, we observe coupling to reported  $^{13}\text{C}$  peaks on the  $^1\text{H}$ – $^{13}\text{C}$  HSQC spectrum.

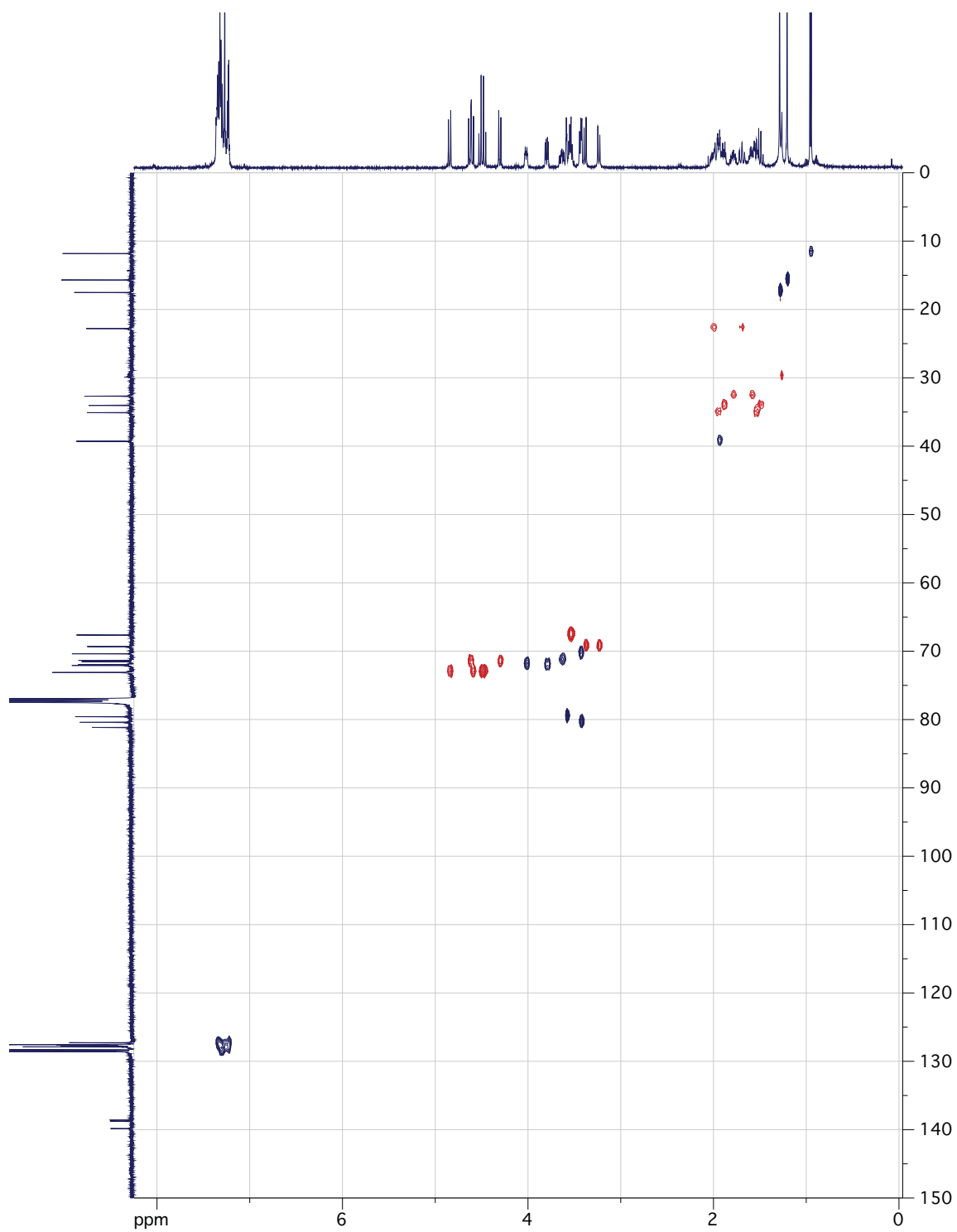


Comparison of  $^{13}\text{C}$  NMR data for **2** and previously reported synthesis (ref. 8)

| $^{13}\text{C}$ NMR<br>(150 MHz, $\text{CDCl}_3$ ) $\delta$<br><b>2</b> | $^{13}\text{C}$ NMR<br>(100 MHz, $\text{CDCl}_3$ ) $\delta$<br>ref. 8 |
|---|---|
| Referenced at $\text{CDCl}_3$<br>center peak (77.2 ppm)                 | Referenced at $\text{CDCl}_3$<br>center peak (77.0 ppm)               |
| 139.8   | 139.7   |
| 138.74  | 138.5   |
| 138.57  | 138.4   |
| 128.56  | 128.4   |
| 128.49  | 128.3   |
| 128.32  | 128.1   |
| 127.88  | 127.7   |
| 127.70  | 127.5   |
| 127.64  | 127.4   |
| 127.58  | 127.4   |
| 127.54  | 127.4   |
| 127.3   | 127.1   |
| 81.1  | 81.0  |
| 80.4  | 80.2  |
| 79.6  | 79.4  |
| 77.4  | 77.2  |
| 73.11   | 72.9  |
| 73.08   | <sup>1</sup>  |
| 72.08   | 71.9  |
| 71.95   | 71.8  |
| 71.51   | 71.3  |
| 71.34   | 71.1  |
| 70.4  | 70.2  |
| 69.3  | 69.1  |
| 67.6  | 67.4  |
| 39.3  | 39.1  |
| 35.1  | 34.9  |
| 34.0  | 33.8  |
| 32.7  | 32.5  |
| 22.8  | 22.6  |
| 17.5  | 17.3  |
| 15.7  | 15.5  |
| 11.8  | 11.6  |

<sup>1</sup> We ascribe this missing resonance from ref. 8 to be coincident with the peak listed at 72.9. This peak is necessary for the 13 C-O  $^{13}\text{C}$  peaks, and is also observed in the  $^1\text{H}$ - $^{13}\text{C}$  HSQC to couple to listed  $^1\text{H}$  resonances.

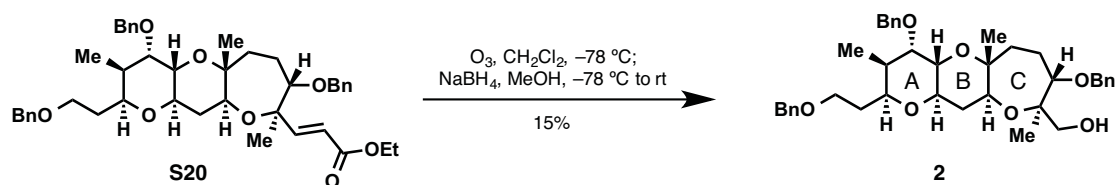
$^1\text{H}$ - $^{13}\text{C}$  HSQC spectrum of **2** (500 MHz,  $\text{CDCl}_3$ )



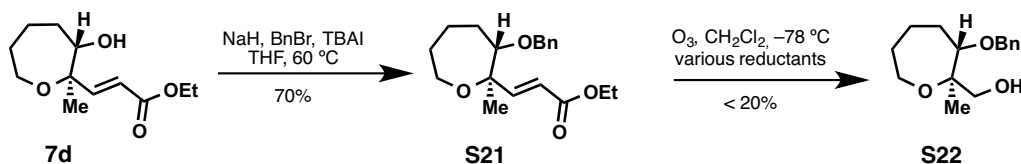
## H. Studies on Enoate Oxidative Cleavage Towards **2**

Our first attempts to oxidatively cleave enoate **S20** via ozonolysis with subsequent reductive quenching with NaBH<sub>4</sub> yielded only small amounts of the desired formal synthesis intermediate **2**, with what appeared to be significant amounts of oxidation of benzyloxy to benzoate groups (Scheme S5). With limited quantities of **S20**, we synthesized **S21** for model studies to allow rapid screening of oxidation conditions (Scheme S6).

Scheme S5: Low yield from initial attempts at ozonolysis toward **2**.

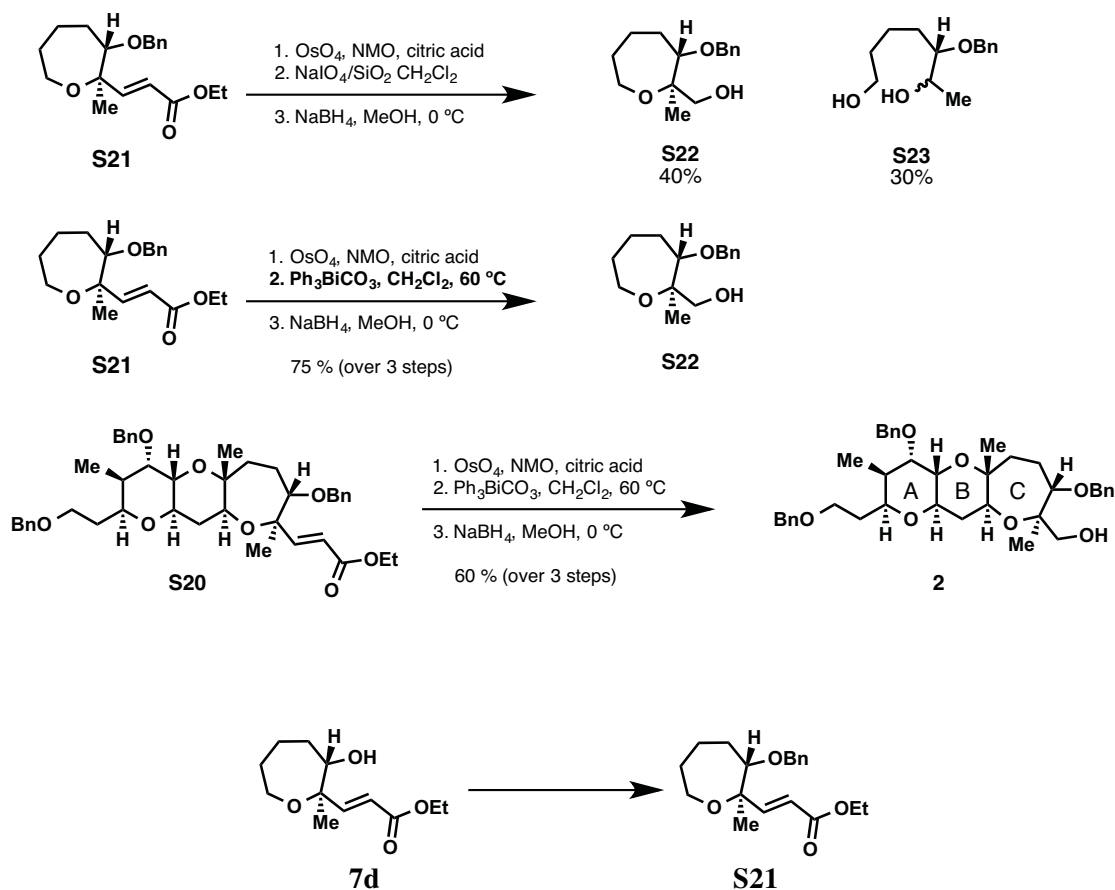


Scheme S6: Synthesis of model system **S21** and exploration of alternative ozonolysis conditions.



Attempts to limit undesired benzyloxylation by reverse addition of a saturated O<sub>3</sub> solution in CH<sub>2</sub>Cl<sub>2</sub>, or use of Ph<sub>3</sub>P to first provide an aldehyde saw no improvement in the yield of **S22**. The combination of low yields and difficulty obtaining high purity product prompted us to explore an alternative sequence of dihydroxylation, oxidative diol cleavage, and reduction (Scheme S7). Dihydroxylation of **S21**, followed by periodate cleavage and subsequent reduction with NaBH<sub>4</sub> provided the desired alcohol **S22**. In addition to the moderate yield of **S22**, a significant side product was observed: diol **S23**. We reasoned the acidic nature of NaIO<sub>4</sub> was resulting in opening the oxepane, with subsequent oxidative cleavage yielding a ketone and ultimately producing diol **S23**. Use of a neutral diol oxidative cleavage reagent, Ph<sub>3</sub>BiCO<sub>3</sub>, provided the desired **S23** in 75% yield.<sup>13</sup> Application of this three-step sequence to tricycle **S20** provided the formal synthesis target alcohol **2** in high purity and 60% yield over three steps.

<sup>13</sup> (a) Barton, D. H. R.; Kitchin, J. P.; Lester, D. J.; Motherwell, W. B.; Papoula, M. T. B. *Tetrahedron* **1981**, 37, 73. (b) Anaya, J. Barton, D. H. R., Gero, S. D.; Grande, M.; Martin, N.; Tachdjian, C. *Angew. Chem., Int. Ed. Engl.* **1993**, 32, 867.

Scheme S7: Application of dihydroxylation, oxidative diol cleavage, and reduction towards **2**.

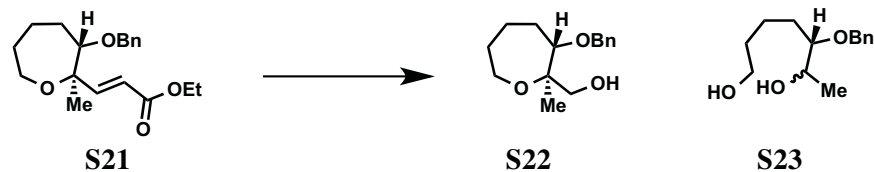
**Enone S21:** To a solution of **7d** (190 mg, 0.83 mmol) in THF (8.3 mL) was added NaH (95%, 40 mg, 1.66 mmol), TBAI (30 mg, 0.08 mmol), and BnBr (217  $\mu\text{L}$ , 1.83 mmol). The reaction was stirred at room temperature for 17 h then quenched by the careful addition of sat.  $\text{NH}_4\text{Cl}_{(\text{aq})}$  (5 mL) and extracted with EtOAc (3 x 10mL). The combined organic layers were dried over  $\text{Na}_2\text{SO}_4$ , filtered, and concentrated *in vacuo*. The resultant colorless film was purified by flash chromatography (5–20% EtOAc/hexanes) to afford **S21** as a colorless oil (160 mg, 60%).

**$^1\text{H}$  NMR** (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.39–7.29 (m, 5H), 7.02 (d,  $J = 15.7$  Hz, 1H), 6.04 (d,  $J = 15.7$  Hz, 1H), 4.65 (d,  $J = 11.7$  Hz, 1H), 4.41 (d,  $J = 11.7$  Hz, 1H), 4.21 (q,  $J = 7.1$  Hz, 2H), 3.83–3.78 (m, 1H), 3.51 (d,  $J = 9.1$  Hz, 1H), 3.44 (ddd,  $J = 12.4, 8.2, 3.8$  Hz, 1H), 1.95–1.89 (m, 1H), 1.86–1.79 (m, 2H), 1.67–1.60 (m, 2H), 1.40–1.35 (m, 1H), 1.31 (t,  $J = 7.1$  Hz, 3H), 1.29 (s, 3H)

**$^{13}\text{C}$  NMR** (100 MHz,  $\text{CDCl}_3$ )  $\delta$  167.1, 152.4, 138.4, 128.5, 127.78, 127.72, 119.3, 83.4, 80.3, 71.8, 64.7, 60.5, 31.1, 26.8, 24.6, 21.8, 14.4

**FT-IR** (ATR,  $\text{cm}^{-1}$ ): 2980, 2934, 2875, 1715, 1654, 1497, 1453, 1366, 1298, 1272, 1214, 1173, 1115, 1096, 1067, 1029

**HRMS** (DART,  $m/z$ ):  $[\text{M}+\text{H}]^+$  for  $\text{C}_{19}\text{H}_{26}\text{O}_4$ : 319.1904, found 319.1912



**Alcohol S22:** To a solution of **S21** (8.9 mg, 0.028 mmol) in *t*-BuOH/H<sub>2</sub>O (1:1, 0.56 mL) was added citric acid monohydrate (6 mg, 0.028 mmol), NMO (as solid, 7 mg, 0.056 mmol), and K<sub>2</sub>OsO<sub>2</sub>(OH)<sub>4</sub>•2H<sub>2</sub>O (0.5 mg, 1.4 μmol), and the green reaction mixture was stirred at room temperature. After 8 h, the colorless reaction was quenched by addition of 1M HCl<sub>(aq)</sub> (0.2 mL), then extracted EtOAc (3 x 2 mL). The combined organic layers were washed sat. Na<sub>2</sub>CO<sub>3(aq)</sub> (1 x 2.5 mL), sat. NaCl<sub>(aq)</sub> (1 x 2.5 mL), dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated *in vacuo* to provide the crude diol as a pale green oil, which was used without further purification.

To a solution of the crude diol in CH<sub>2</sub>Cl<sub>2</sub> (0.55 mL) was added NaIO<sub>4</sub>/SiO<sub>2</sub> (1.2 g/mmol, 100 mg, 0.084 mmol) and stirred at room temperature. After 30 min, the reaction was filtered through a cotton plug and washed CH<sub>2</sub>Cl<sub>2</sub> (1 x 1 mL), then Et<sub>2</sub>O (2 x 1 mL), and concentrated *in vacuo*. The crude aldehyde was used directly without purification.

To a solution of crude aldehyde in MeOH (0.3 mL) at 0 °C was added NaBH<sub>4</sub> (6 mg, 0.15 mmol). The reaction was quenched after 10 min by the addition of 1M HCl<sub>(aq)</sub> (0.3 mL), EtOAc (2 mL), and H<sub>2</sub>O (0.4 mL). The reaction mixture was extracted with EtOAc (3 x 5 mL), and the combined organic layers were washed with sat. NaCl<sub>(aq)</sub> (5 mL), dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated *in vacuo*. The resultant colorless film was purified by flash chromatography (20–60% EtOAc/hexanes) to afford **S22** as a colorless oil (4.2 mg, 60%) and **S23** as a colorless film (1.5:1 d.r., 3 mg, 43%).

#### Characterization Data For S22:

**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>) δ 7.37-7.27 (m, 5H), 4.63 (d, *J* = 11.7 Hz, 1H), 4.35 (d, *J* = 11.7 Hz, 1H), 3.73 (ddd, *J* = 12.6, 6.2, 3.6 Hz, 1H), 3.60 (ddd, *J* = 12.6, 7.3, 3.6 Hz, 1H), 3.52 (d, *J* = 10.9 Hz, 1H), 3.47-3.43 (m, 2H), 1.94-1.87 (m, 2H), 1.83-1.79 (m, 1H), 1.67-1.61 (m, 2H), 1.44-1.39 (m, 1H), 1.24 (s, 3H)

**<sup>13</sup>C NMR** (125 MHz, CDCl<sub>3</sub>) δ 138.6, 128.5, 127.77, 127.74, 82.3, 79.9, 71.5, 68.6, 63.8, 31.2, 27.6, 23.3, 17.3

**FT-IR** (ATR, cm<sup>-1</sup>): 3415, 2930, 2873, 1718, 1606, 1497, 1453, 1400, 1367, 1267, 1206, 1062, 1027

**HRMS** (DART, *m/z*): [M+H]<sup>+</sup> for C<sub>15</sub>H<sub>22</sub>O<sub>3</sub>: 251.1642, found 251.1653.

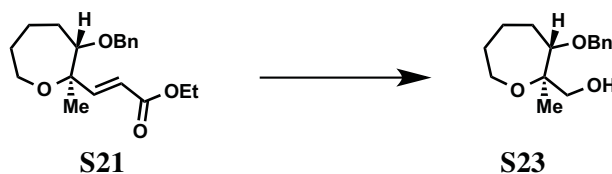
#### Characterization Data For S23 (major diastereomer):

**<sup>1</sup>H NMR** (500 MHz, CDCl<sub>3</sub>) δ 7.37-7.30 (m, 5H), 4.67 (d, *J* = 11.3 Hz, 1H), 4.53 (d, *J* = 11.3 Hz, 1H), 3.77 (quintet, *J* = 6.4 Hz, 1H), 3.66 (t, *J* = 6.4 Hz, 2H), 3.25 (q, *J* = 5.4 Hz, 1H), 1.67-1.48 (m, 6H), 1.20 (d, *J* = 6.4 Hz, 3H)

**<sup>13</sup>C NMR** (125 MHz, CDCl<sub>3</sub>): δ 138.5, 128.7, 128.03, 127.95, 84.1, 72.8, 69.1, 63.0, 33.2, 30.2, 21.3, 19.3

**FT-IR** (ATR, cm<sup>-1</sup>): 3359, 2925, 2859, 1717, 1497, 1454, 1371, 1276, 1208, 1068

**HRMS** (DART, *m/z*): [M+Na]<sup>+</sup> for C<sub>14</sub>H<sub>22</sub>O<sub>3</sub>: 261.1461, found 261.1467.



**Alcohol S23:** To a solution of **S21** (27 mg, 0.085 mmol) in *t*-BuOH/H<sub>2</sub>O (1:1, 0.86 mL) was added citric acid monohydrate (18 mg, 0.085 mmol), NMO (as solid, 20 mg, 0.17 mmol), and K<sub>2</sub>OsO<sub>2</sub>(OH)<sub>4</sub>•2H<sub>2</sub>O (1.5 mg, 4 μmol), and the green reaction mixture was stirred at room temperature. After 14 h, the colorless reaction was quenched by addition of 1M HCl<sub>(aq)</sub> (0.4 mL), then extracted EtOAc (3 x 3 mL). The combined organic layers were washed sat. Na<sub>2</sub>CO<sub>3(aq)</sub> (1 x 5 mL), sat. NaCl<sub>(aq)</sub> (1 x 5 mL), dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated *in vacuo* to provide the crude diol as a pale green oil, which was used without further purification.

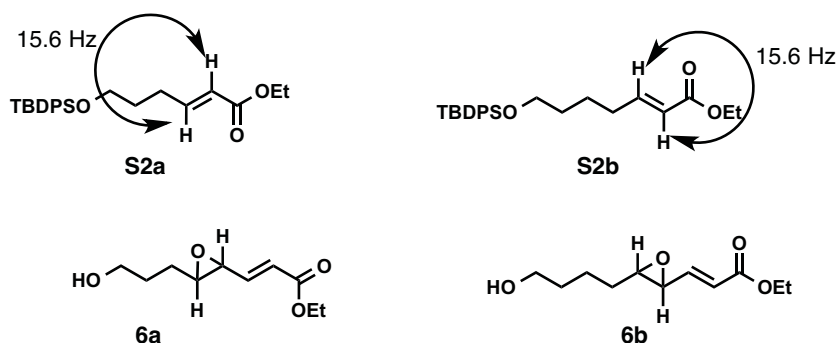
To a solution of the crude diol in CH<sub>2</sub>Cl<sub>2</sub> (1 mL) was added Ph<sub>3</sub>BiCO<sub>3</sub> (85 mg, 0.17 mmol) and heated to 50 °C in an oil bath. After 3 h, the reaction was removed from the oil bath, filtered through Celite (washed CH<sub>2</sub>Cl<sub>2</sub> 3 x 1 mL), and concentrated *in vacuo*. The crude gel was purified by flash chromatography (100% hexanes–6% EtOAc/hexanes) to afford an aldehyde that was used immediately in the next step.

To a solution of aldehyde in MeOH (2 mL) at 0 °C was added NaBH<sub>4</sub> (12 mg, 0.31 mmol). The reaction was quenched after 5 min by the addition of 1M HCl<sub>(aq)</sub> (0.4 mL), EtOAc (2 mL), and H<sub>2</sub>O (0.4 mL). The reaction mixture was extracted with EtOAc (3 x 5 mL), and the combined organic layers were washed with sat. NaCl<sub>(aq)</sub> (5 mL), dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated *in vacuo* to yield **S23** as a colorless film (16 mg, 0.064 mmol, 75% over 3 steps).

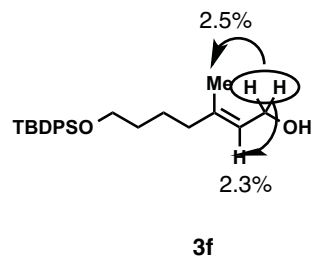
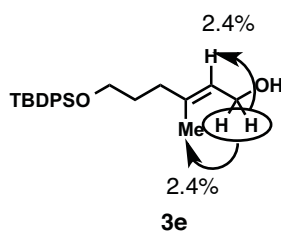
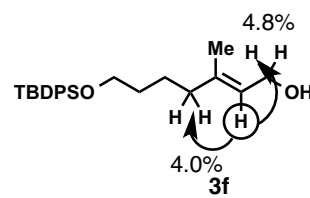
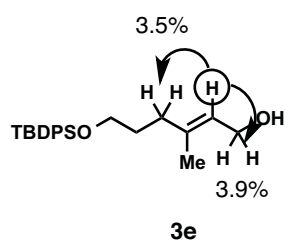
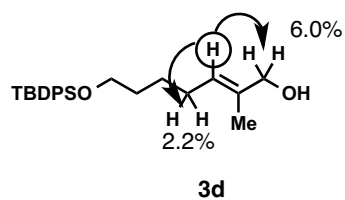
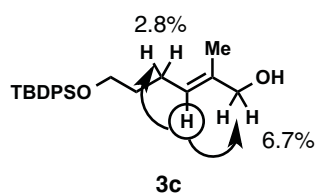
## I. Stereochemical Determination

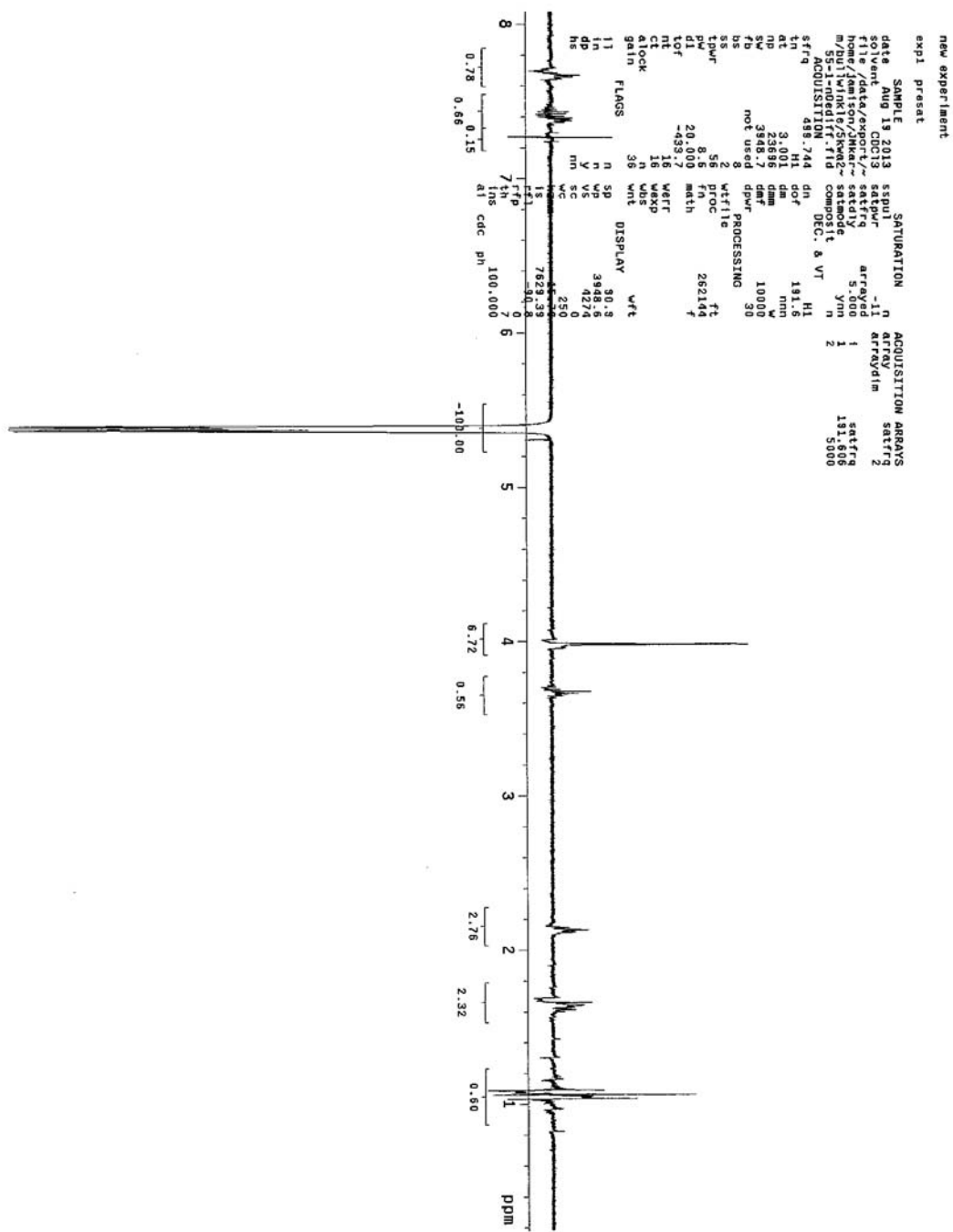
### a. Cyclization Model Systems

Stereochemistry of **6a** and **6b** epoxides were determined by the geometry of the underlying alkenes, from **S2a** and **S2b**, in combination with the accepted stereochemical outcome of the reactions used in the synthetic sequence. Shown below are the relevant coupling constants in **S2a** and **S2b** with corresponding **6a** and **6b**.

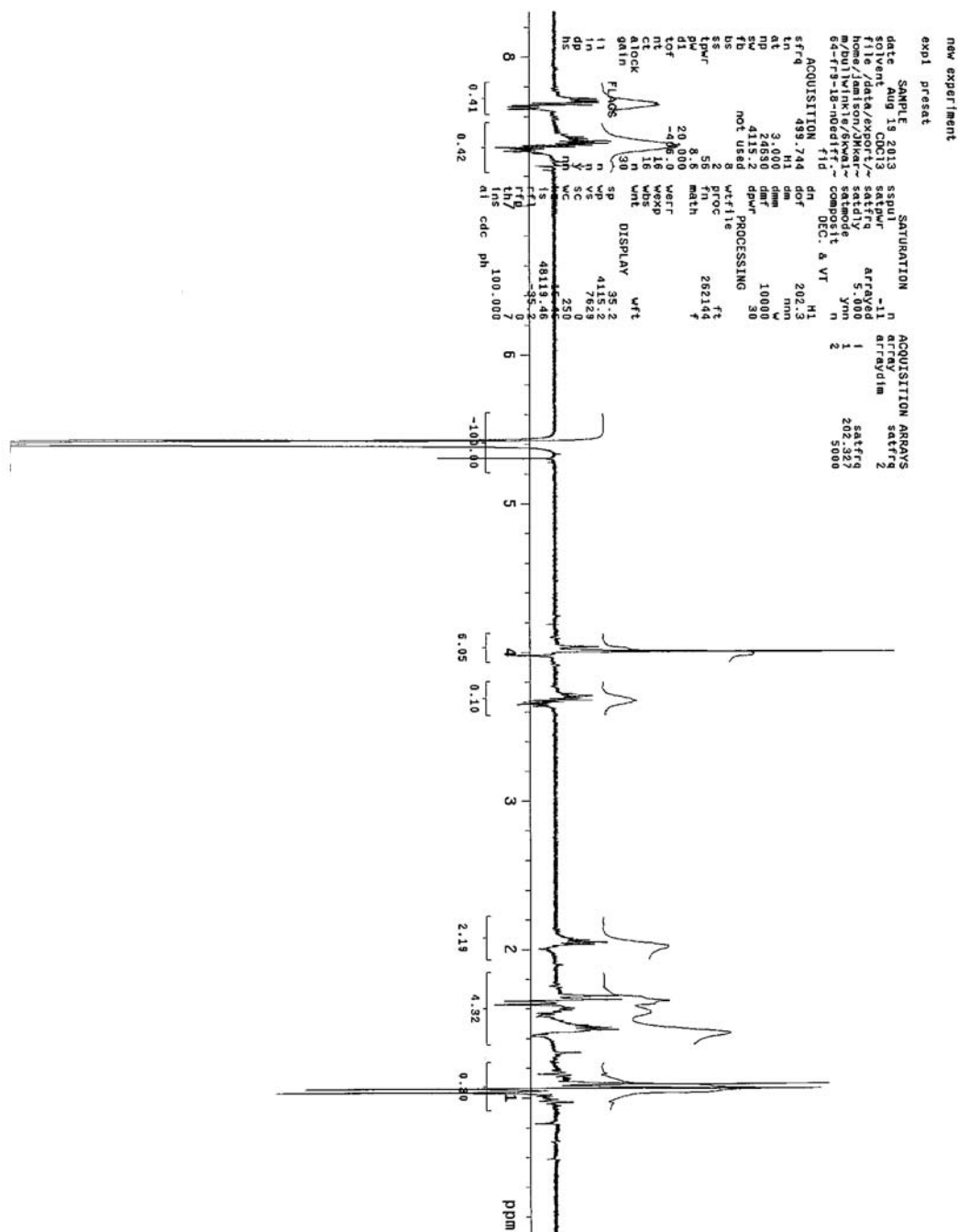


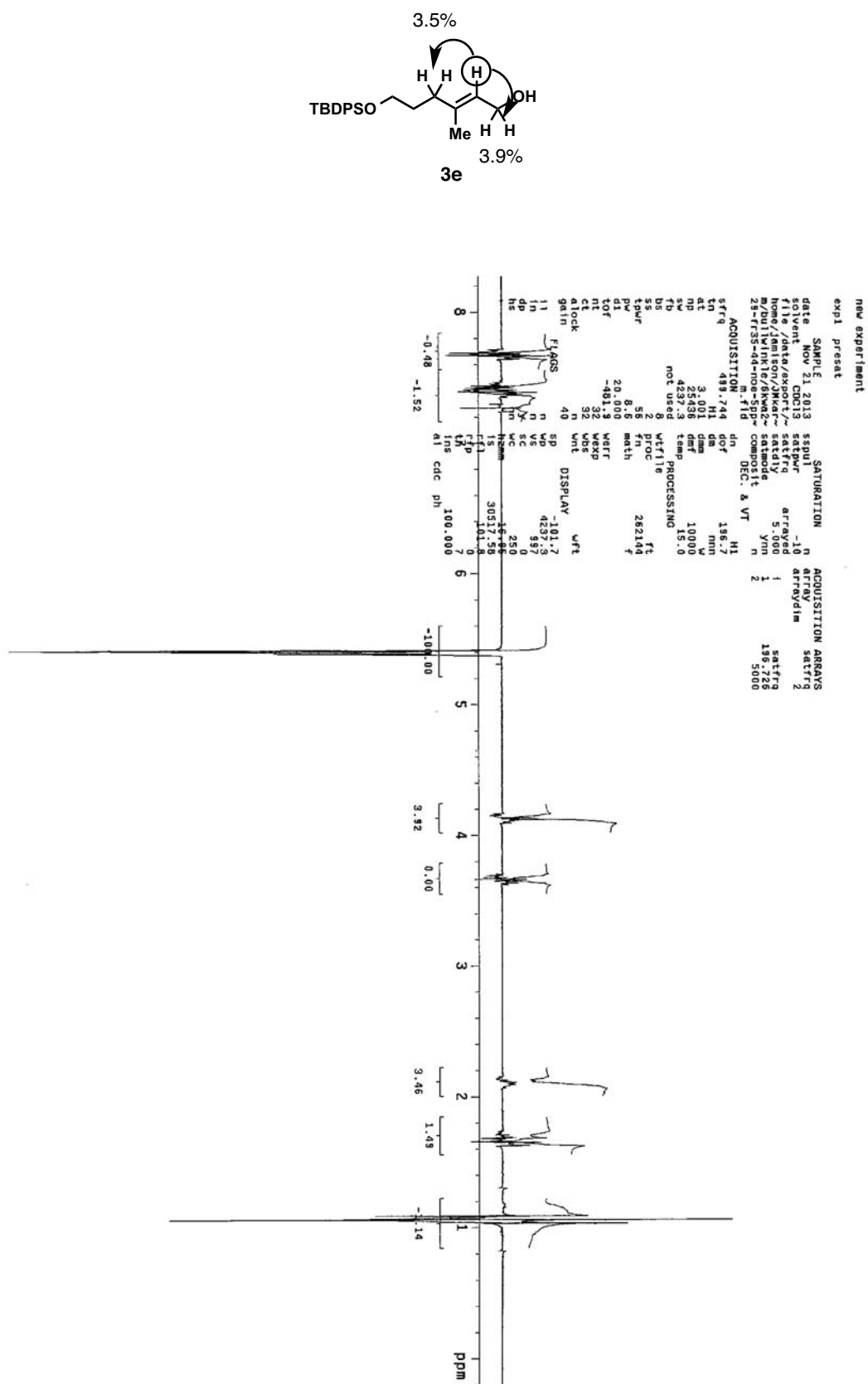
Stereochemical assignment of epoxide geometry for **6c-6f** was made at the corresponding allylic alcohols **S3c-S3f** by 1-D nOe difference spectra. The circled proton was selectively irradiated, and the corresponding nOe are shown by arrows and percentages.

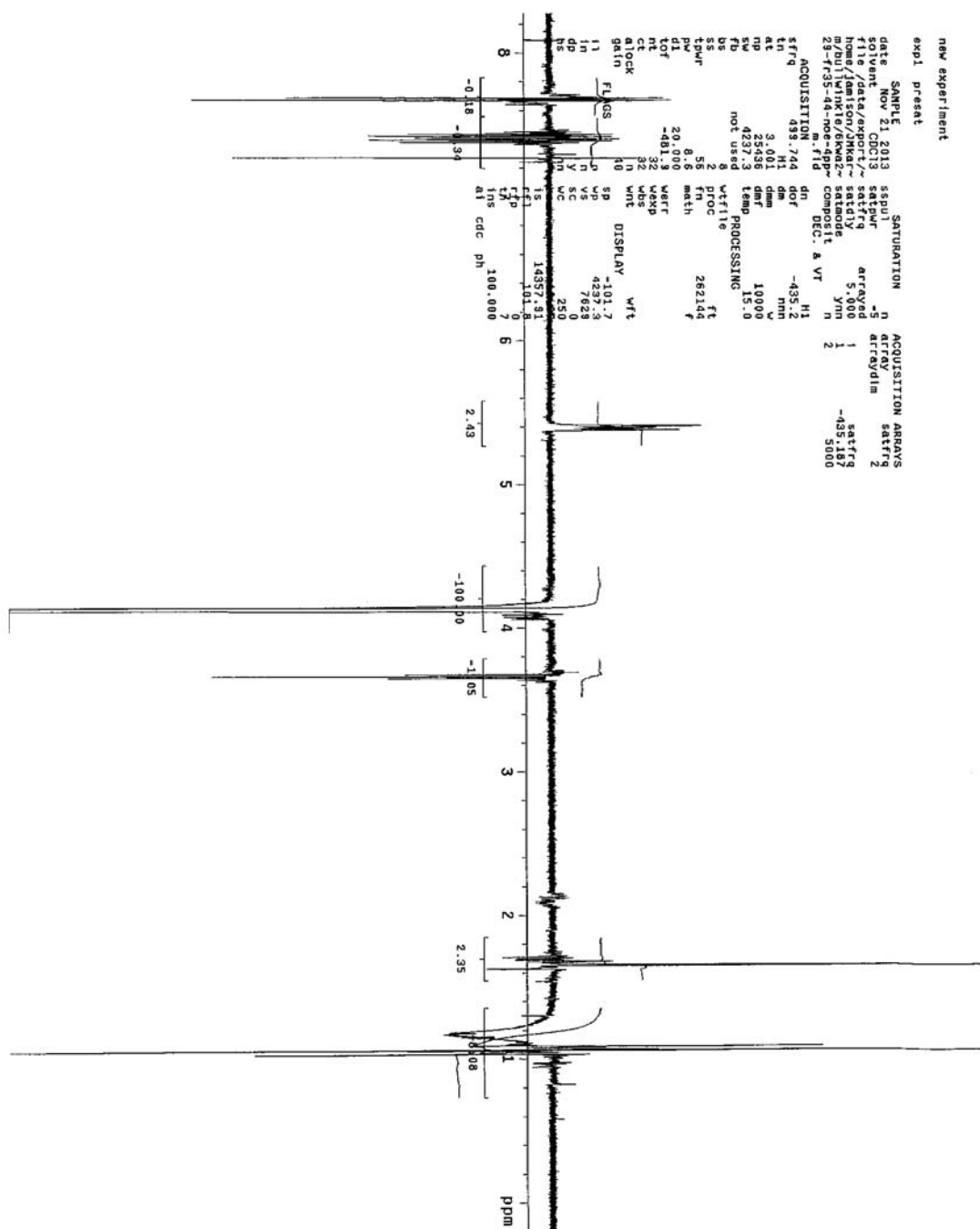
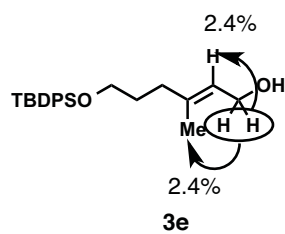


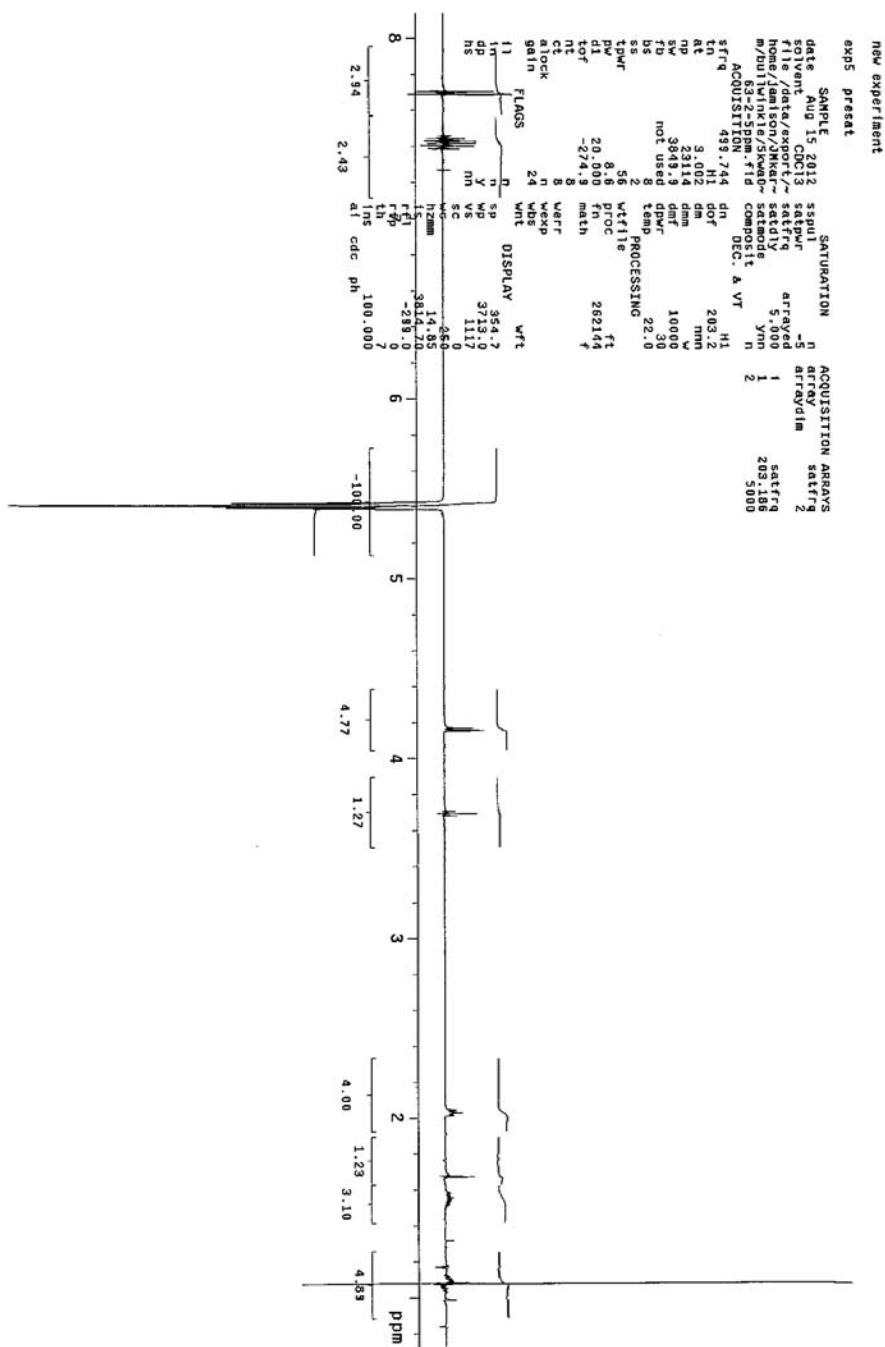


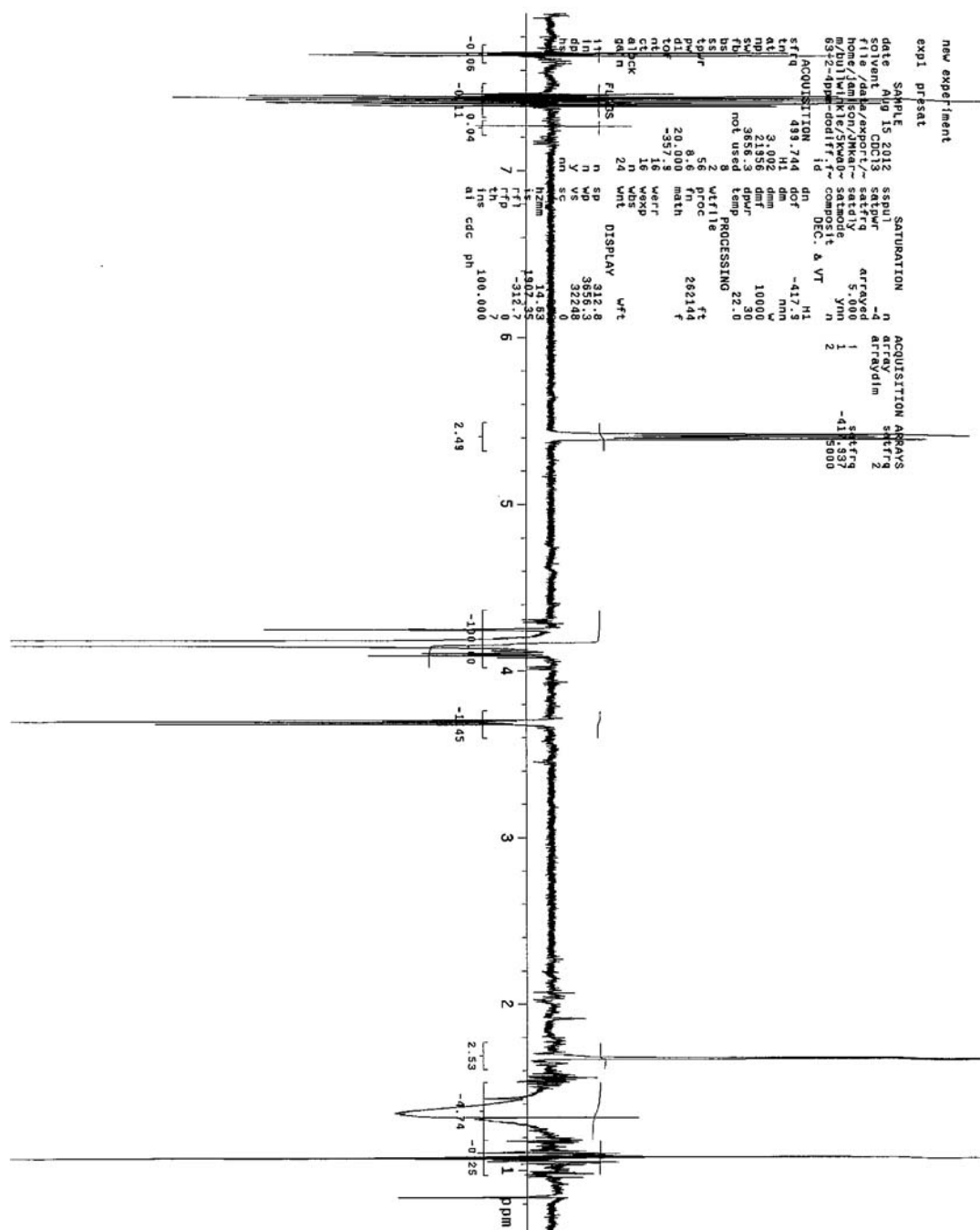












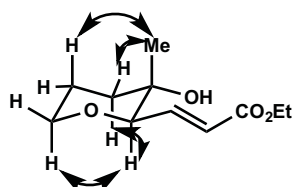
Cyclization products **7a-c** and **8a-c** were assigned by correlation to the following references, utilizing the typically small difference between methyl and ethyl esters. **7d** and **8d** were assigned by comparison to **7c** and **8c**.

References:

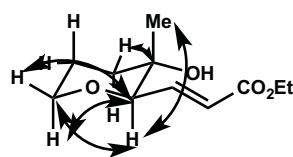
Nicolaou, K. C.; Prasad, C. V. C.; Somers, P. K.; Hwang, C.-K. *J. Am. Chem. Soc.* **1989**, *111*, 5330.

Nicolaou, K. C.; Prasad, C. V. C.; Somers, P. K.; Hwang, C.-K. *J. Am. Chem. Soc.* **1989**, *111*, 5335

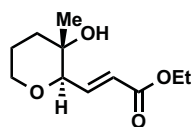
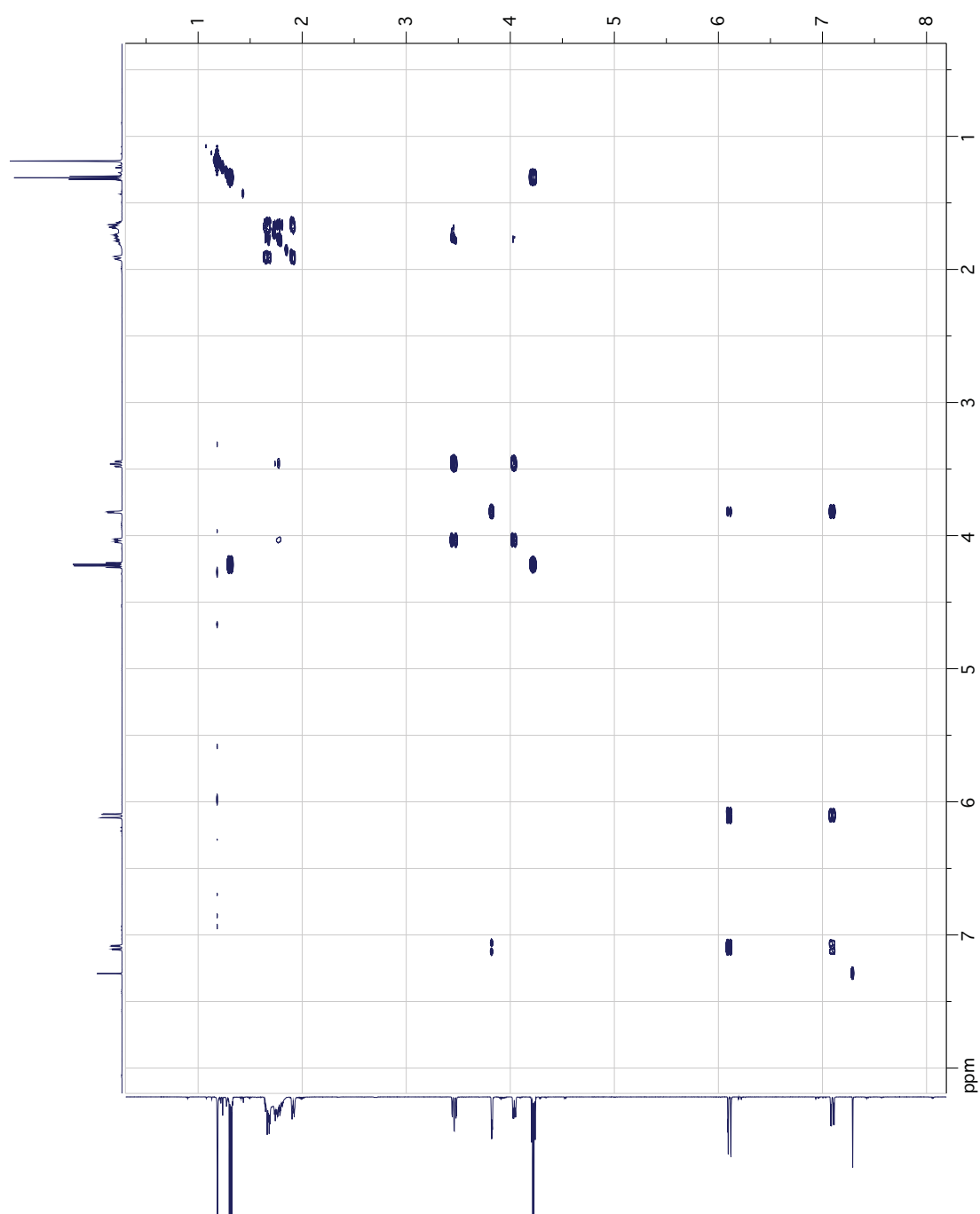
Cyclization product **7e** was assigned using 2-D NMR (gCOSY, HSQC, gHMBC, NOESY). Cyclization product **7f** was assigned by comparison to **7e**. Cyclization products **8e** and **8f** were assigned on the basis of the known stereo-inversion mechanism and exo preference for CSA mediated cyclization, as well as gCOSY analysis.

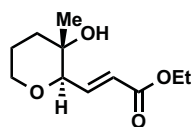


**7e NOESY Correlations**

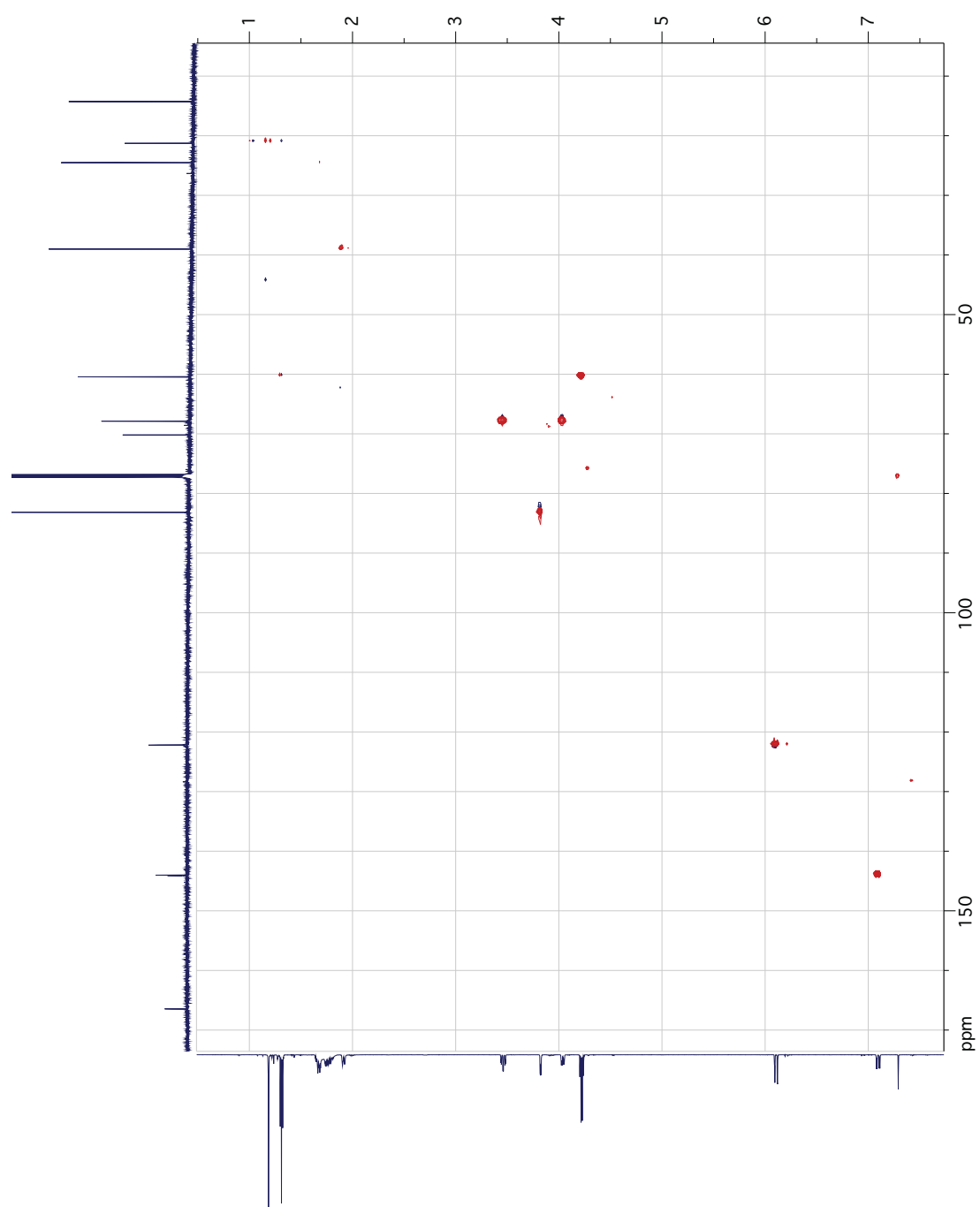


**7e gHMBC Correlations**

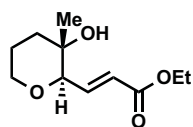
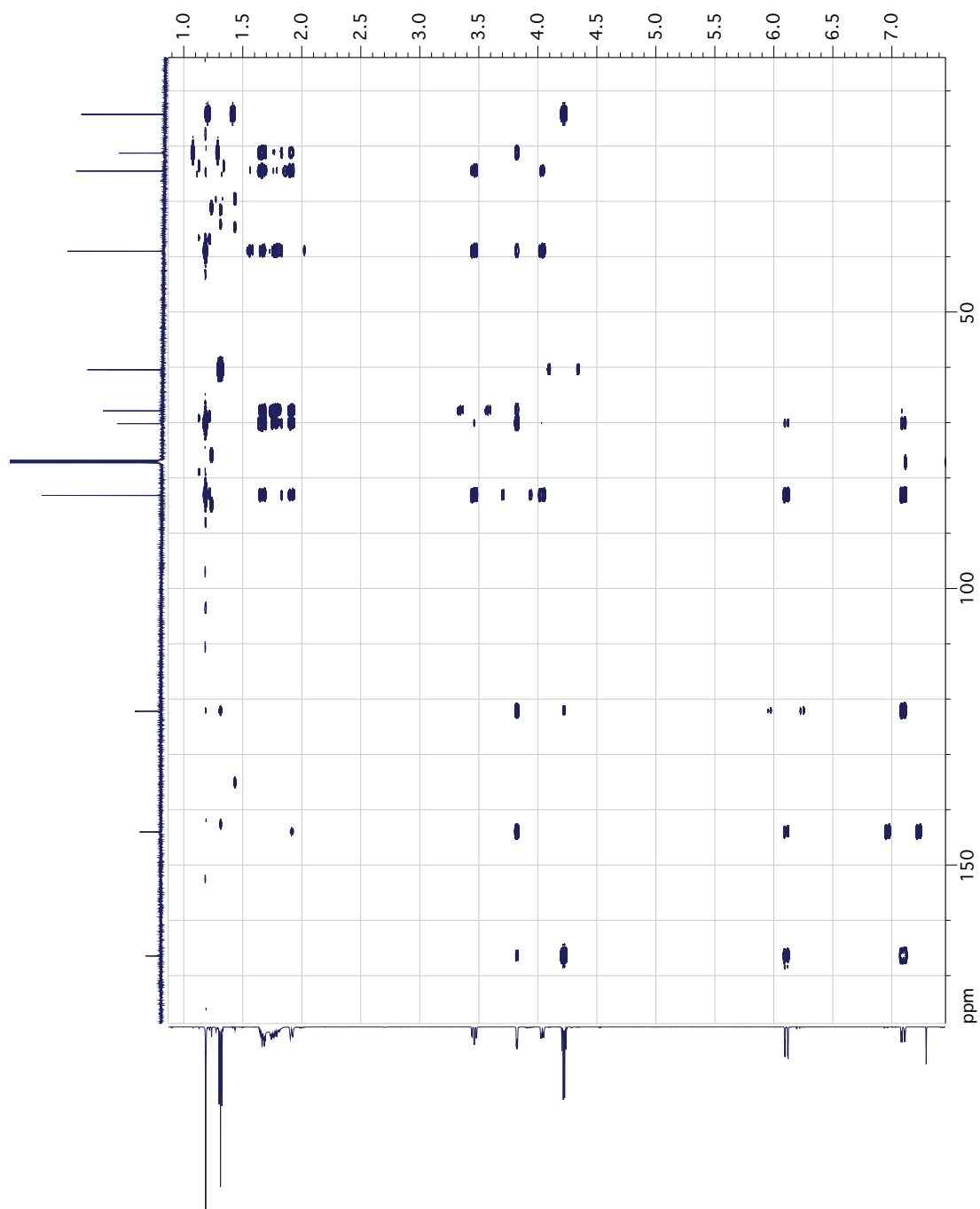
7e (gCOSY, CDCl<sub>3</sub>, 600 MHz)

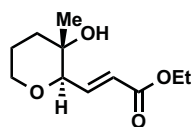


7e (HSQC, CDCl<sub>3</sub>, 600 MHz)

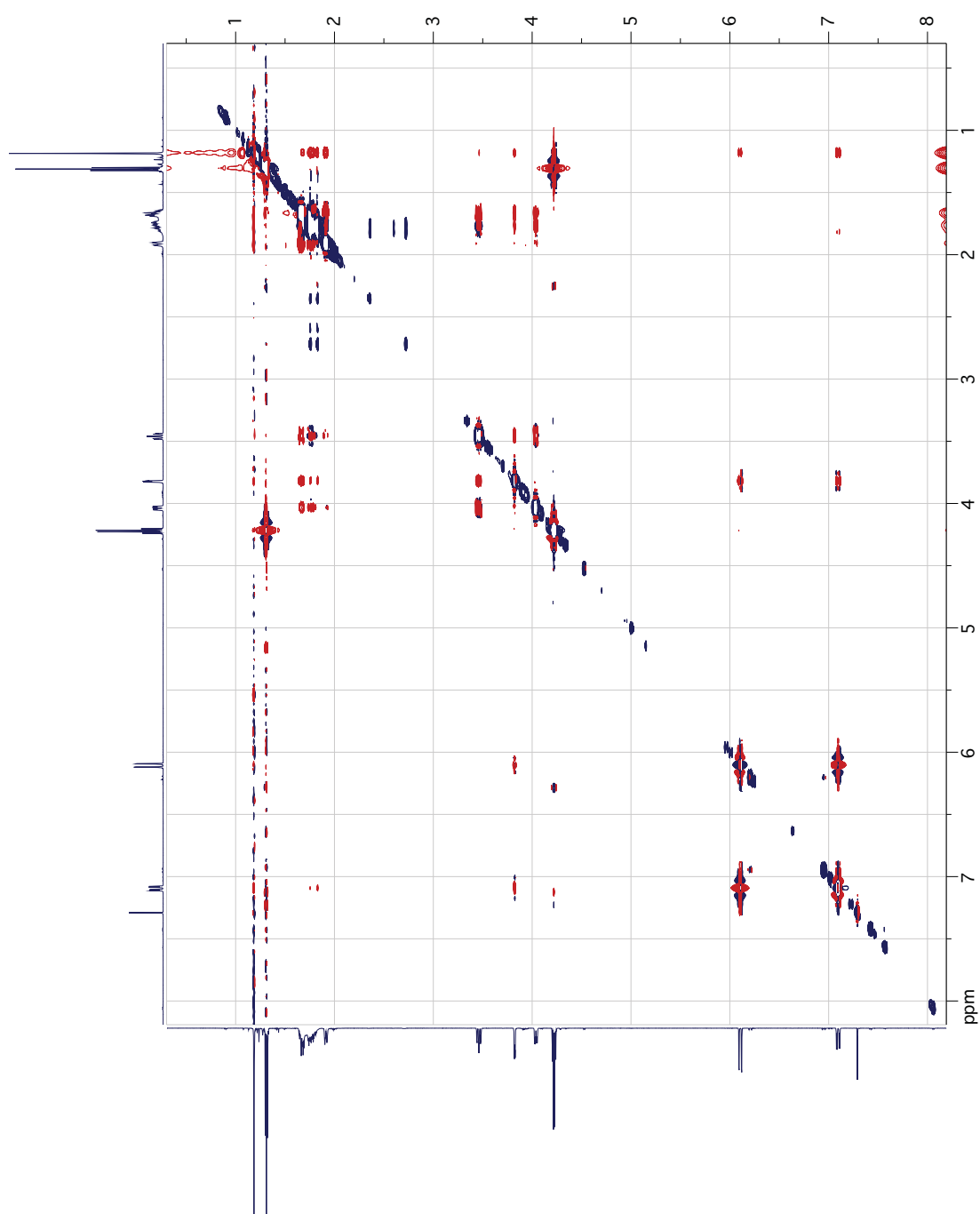




7e (gHMBC, CDCl<sub>3</sub>, 600 MHz)



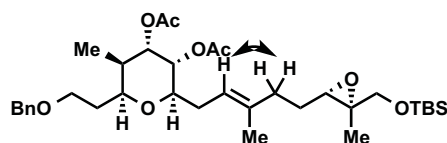
7e (NOESY, CDCl<sub>3</sub>, 600 MHz)



**Assignment of EF Stereochemistry:** The assignment of the stereochemistry of cascade precursor **5** and **13** are based on 1-D NMR and the expected stereochemical outcomes of the Claisen [3,3] rearrangement (*E* olefin geometry predominates) and HWE olefination (*E* olefin geometry predominates), while the epoxide stereochemistry was assigned based on the known catalyst control of the Shi asymmetric epoxidation. Additional evidence to support these assignments comes from the interception of known EF tricycle **3**.

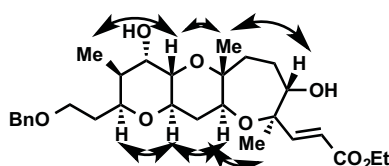
**Assignment of ABC Stereochemistry:** The assignment of the stereochemistry of cascade precursor **21** is based on the underlying olefin geometry assignments and the epoxide stereochemistry assigned based on the known catalyst control of the Shi and Sharpless asymmetric epoxidations.

The olefin geometry of the cross metathesis product **19** was assigned using 2-D NMR (NOESY, attached).

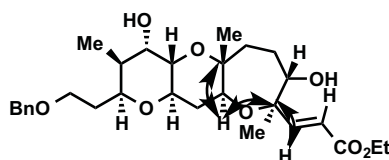


**Key NOESY correlation observed in 19 for *E* olefin geometry**

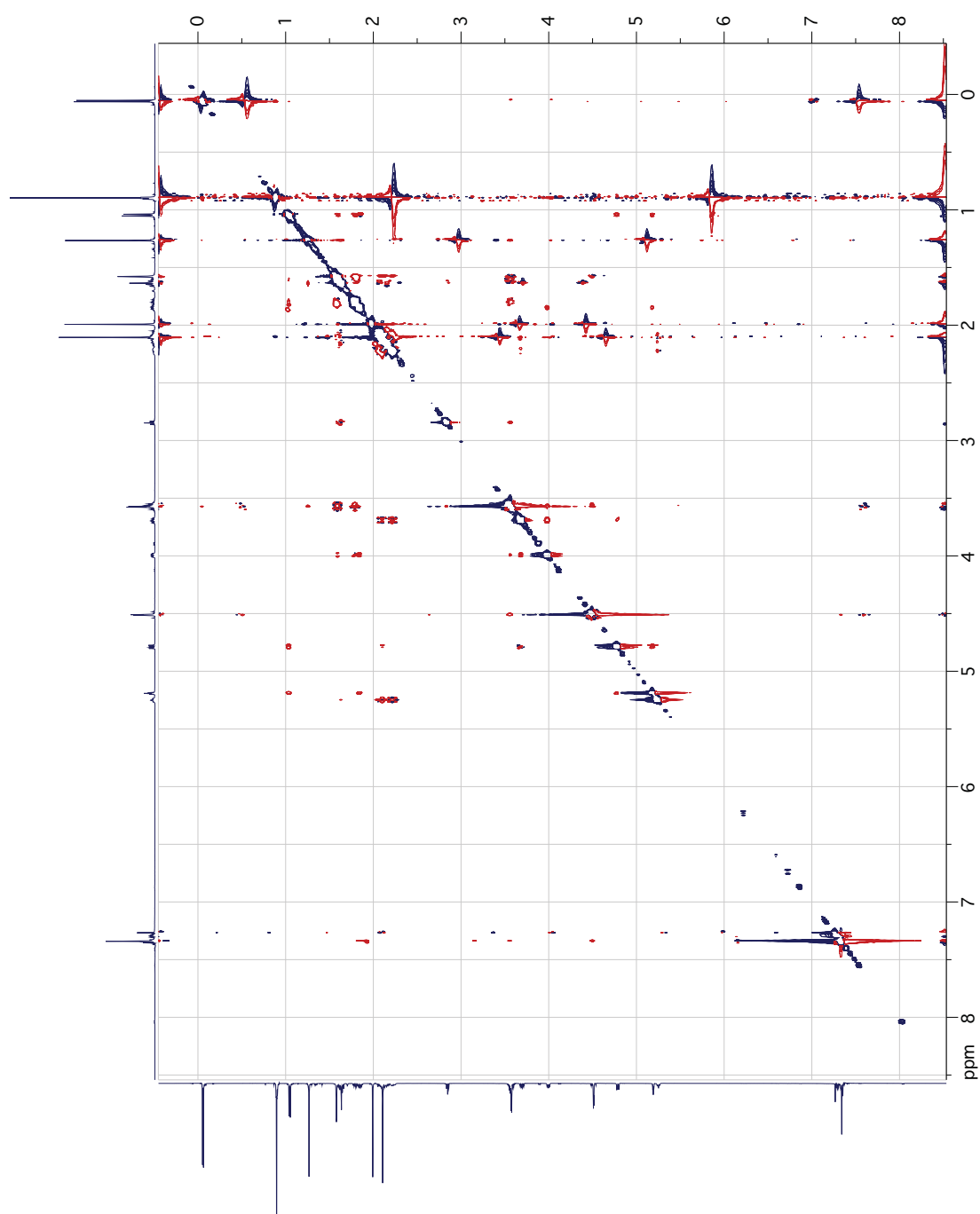
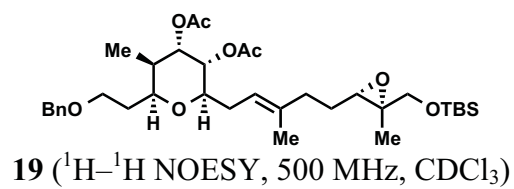
The stereochemistry of the cascade product **22** was assigned by 2-D NMR analysis (gCOSY, HSQC, gHMBC, NOESY, attached) and interception of the known compound **2**.

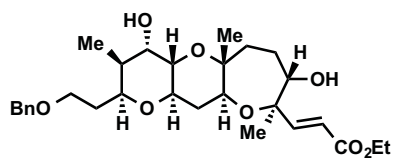


**Key NOESY correlations observed in 22 to support all *trans*-fused product**

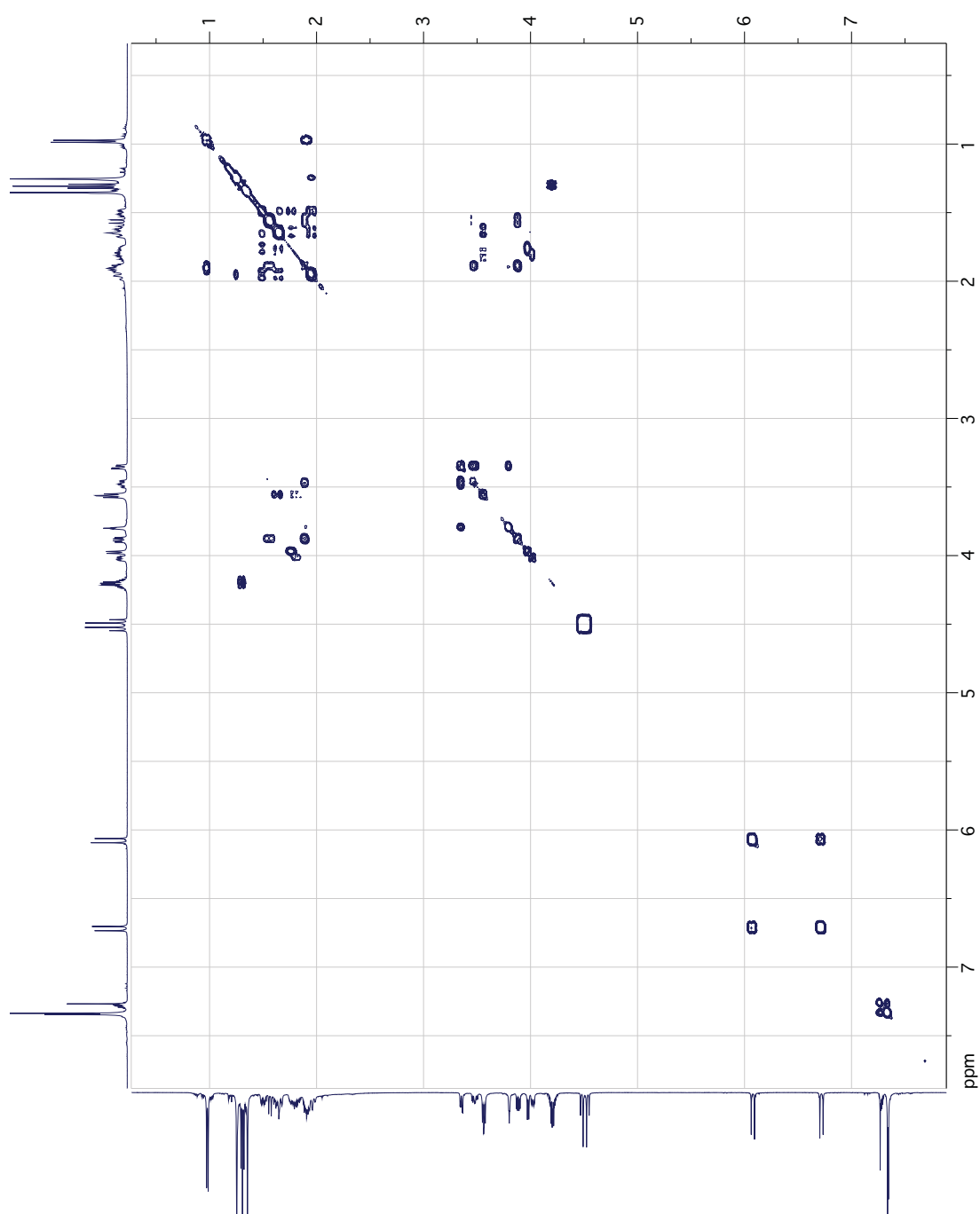


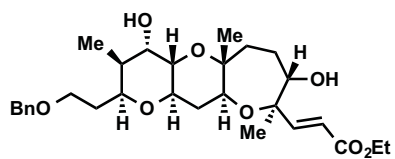
**Selected gHMBC correlations observed in 22 to support formation of C-ring oxepane**



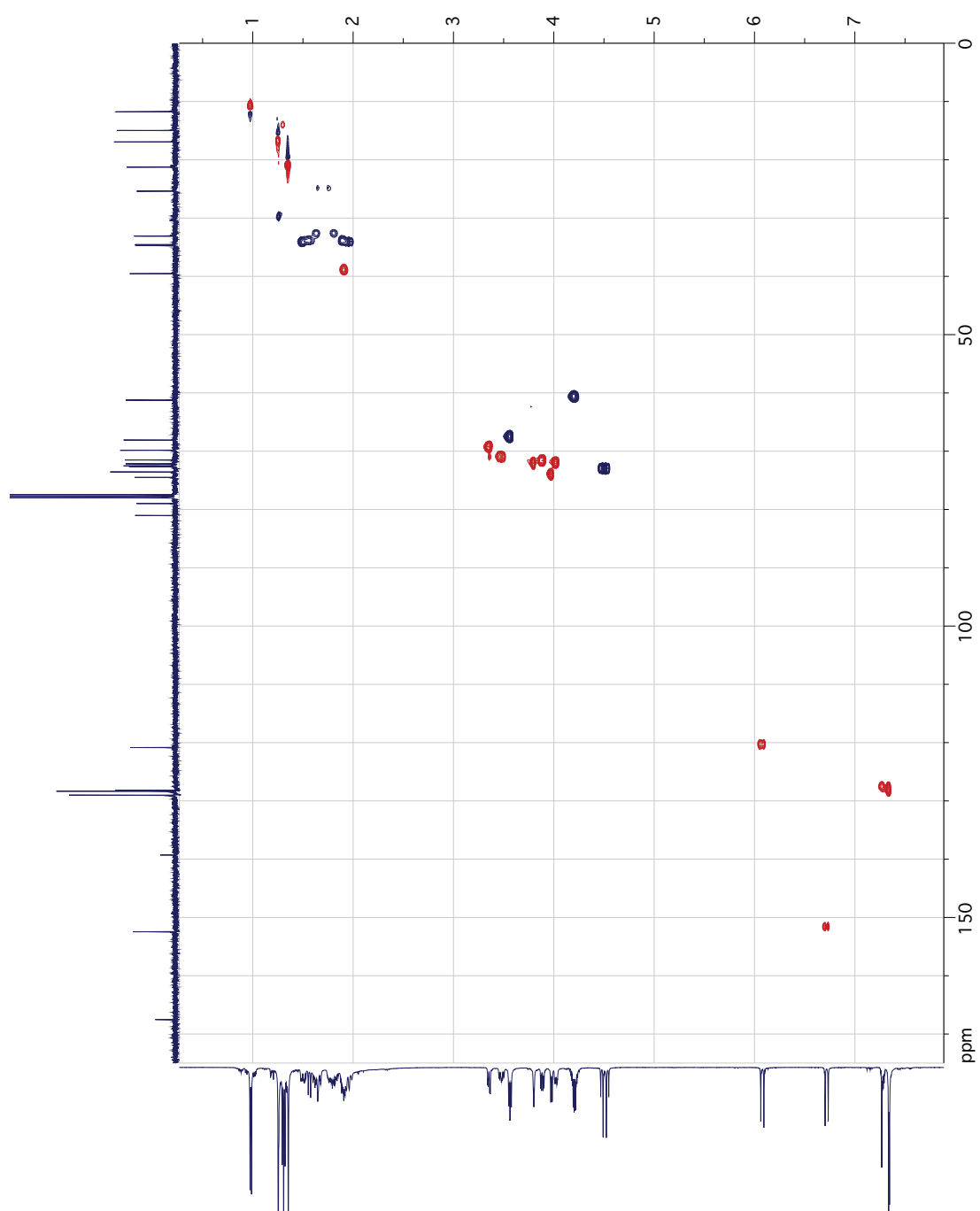


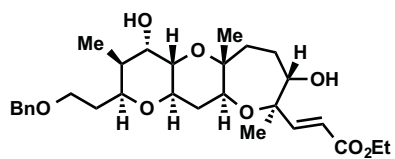
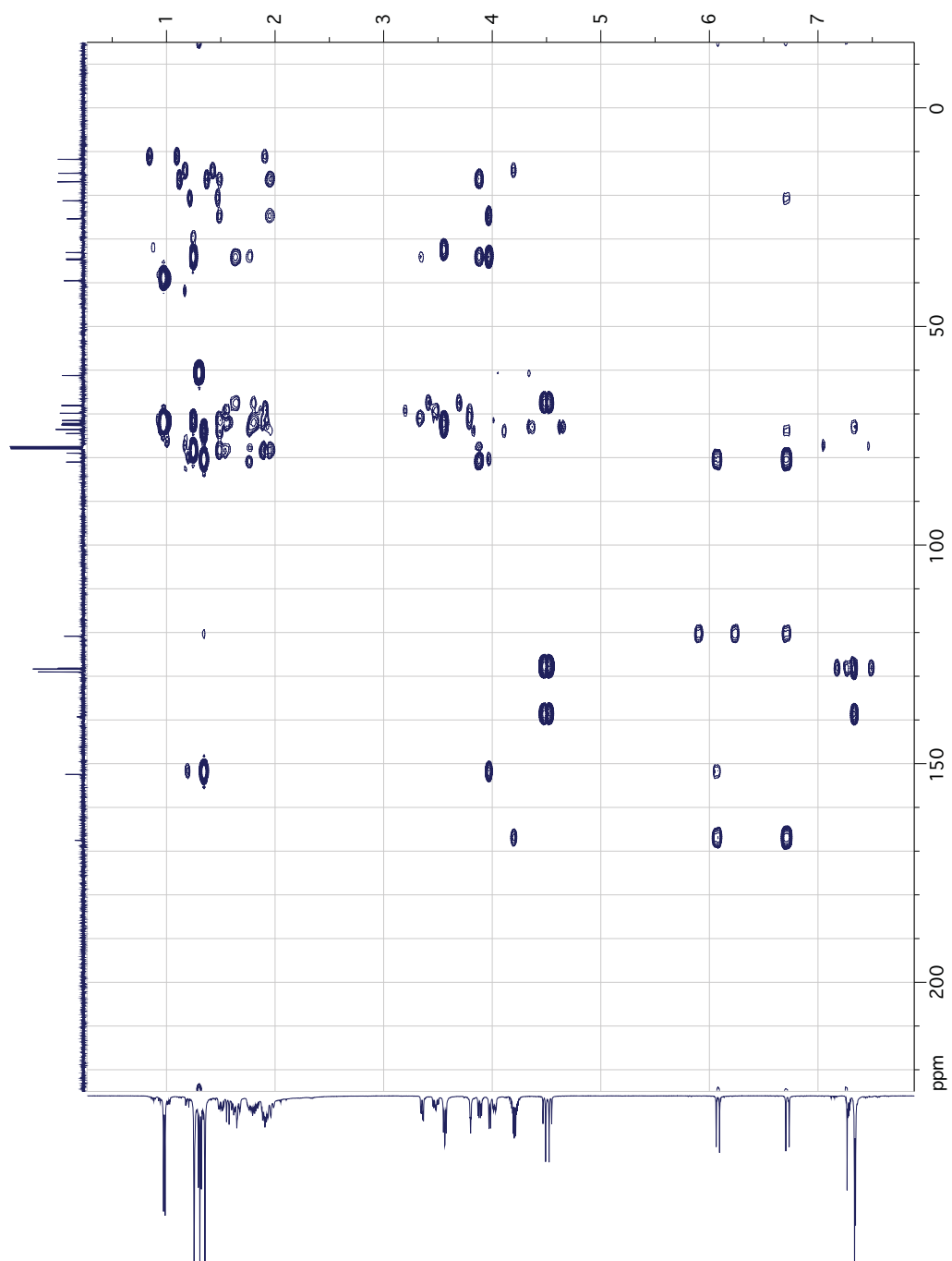
22 (<sup>1</sup>H-<sup>1</sup>H gCOSY, 500 MHz, CDCl<sub>3</sub>)

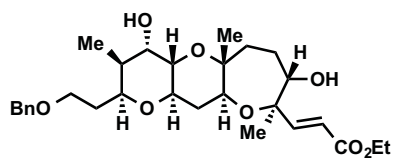




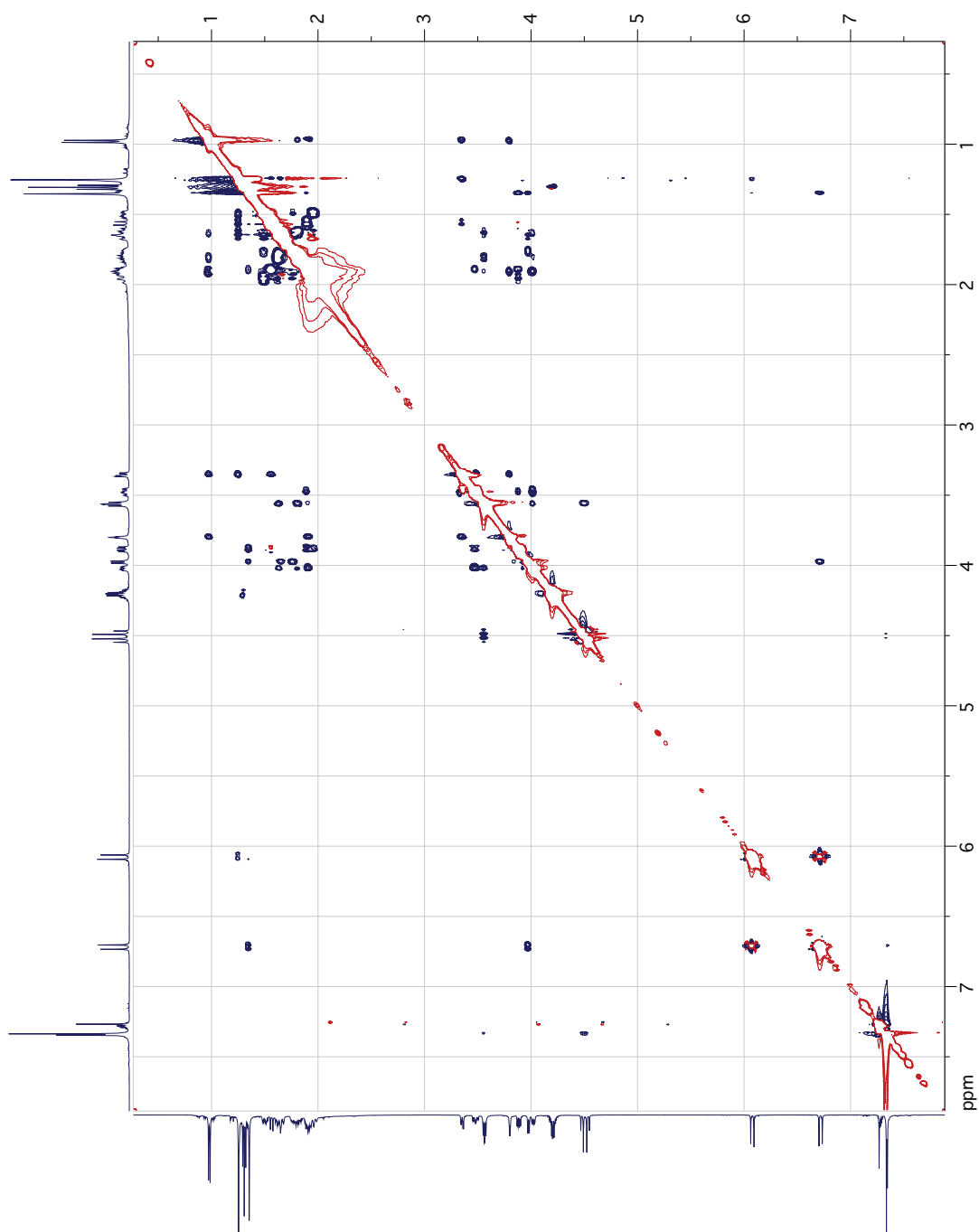
22 (<sup>1</sup>H-<sup>13</sup>C HSQC, 500 MHz, CDCl<sub>3</sub>)



22 (<sup>1</sup>H-<sup>13</sup>C gHMBC, 500 MHz, CDCl<sub>3</sub>)



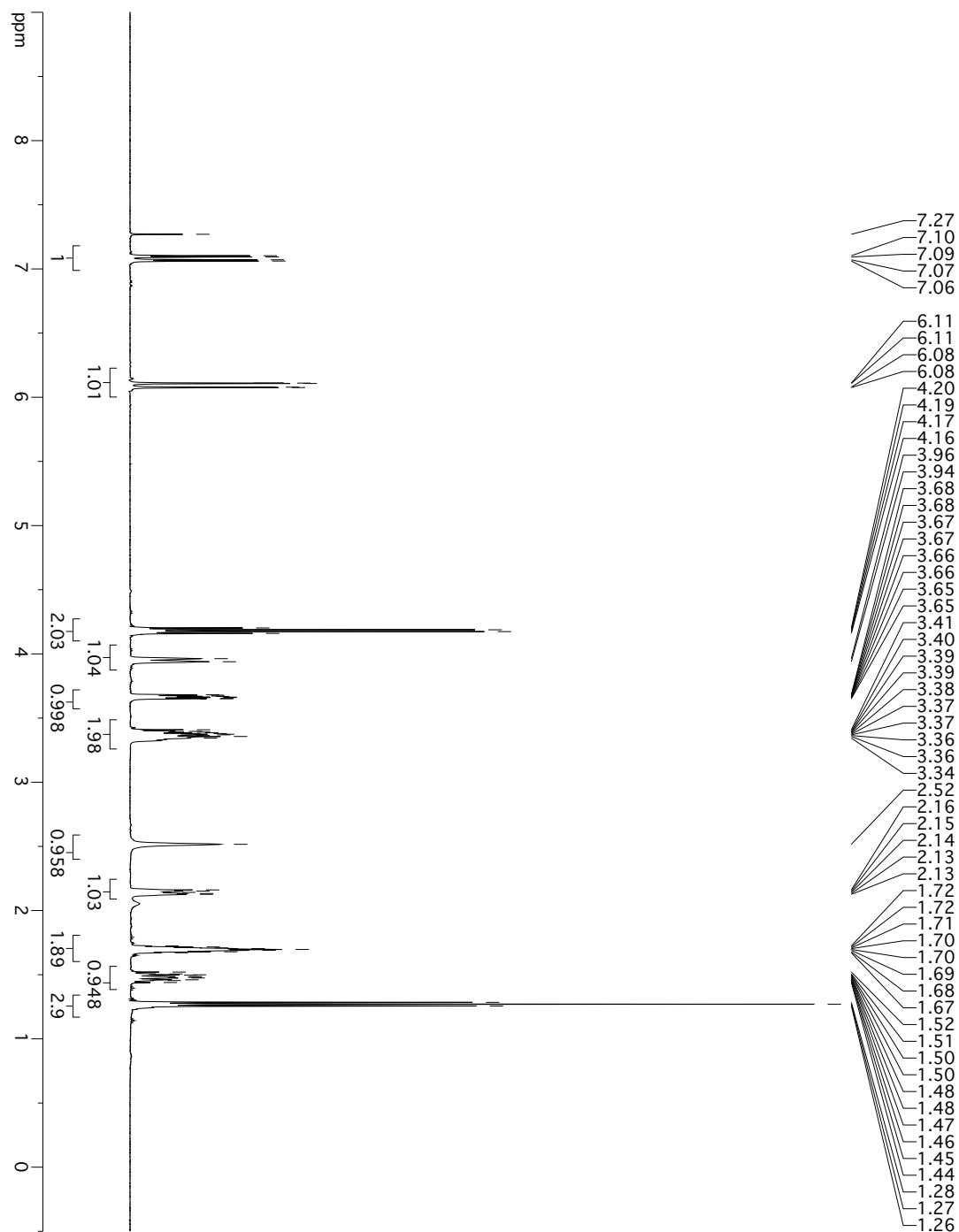
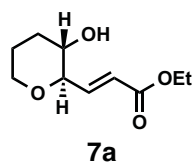
22 (<sup>1</sup>H-<sup>1</sup>H NOESY, 500 MHz, CDCl<sub>3</sub>)

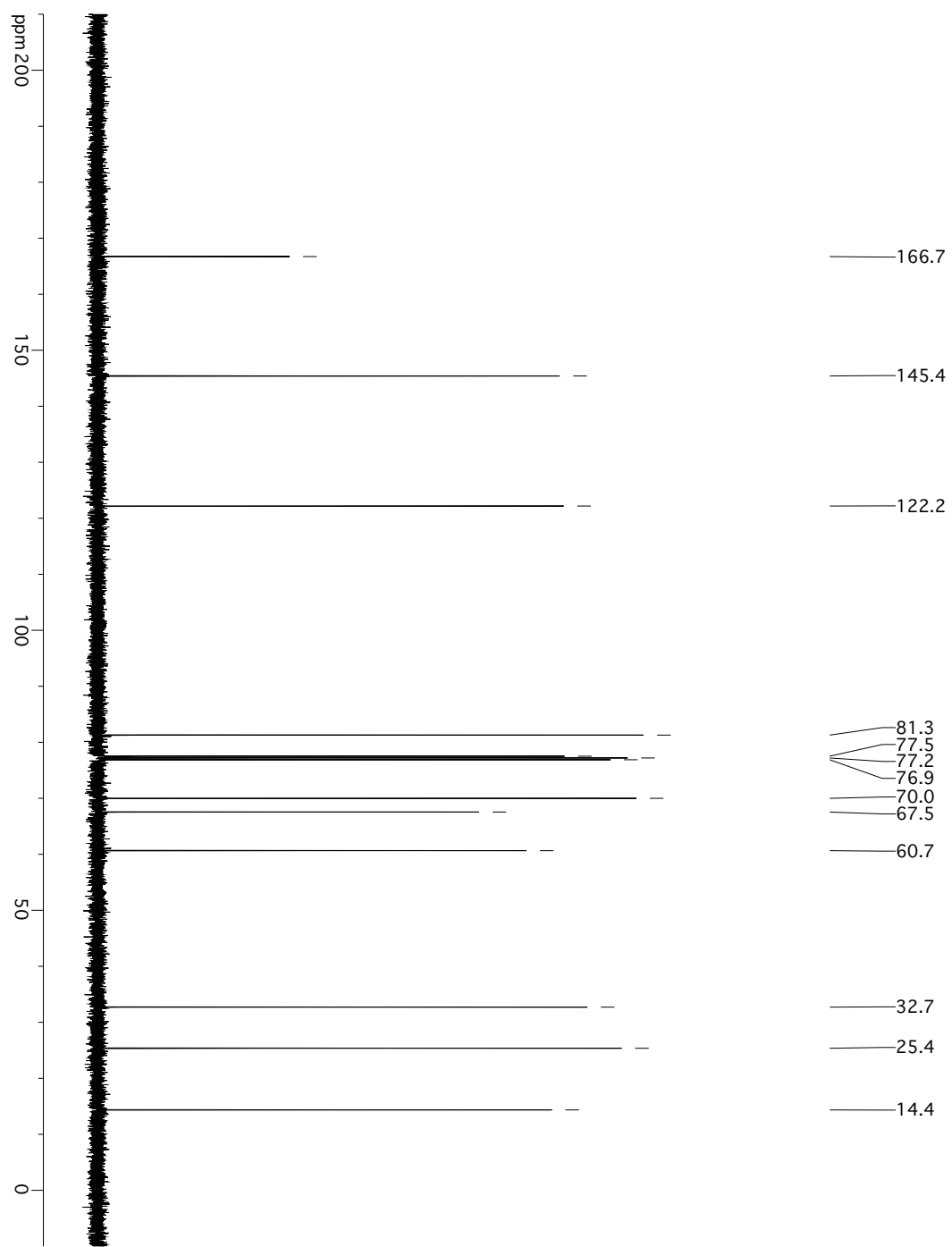
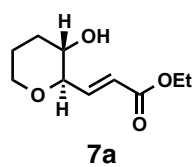


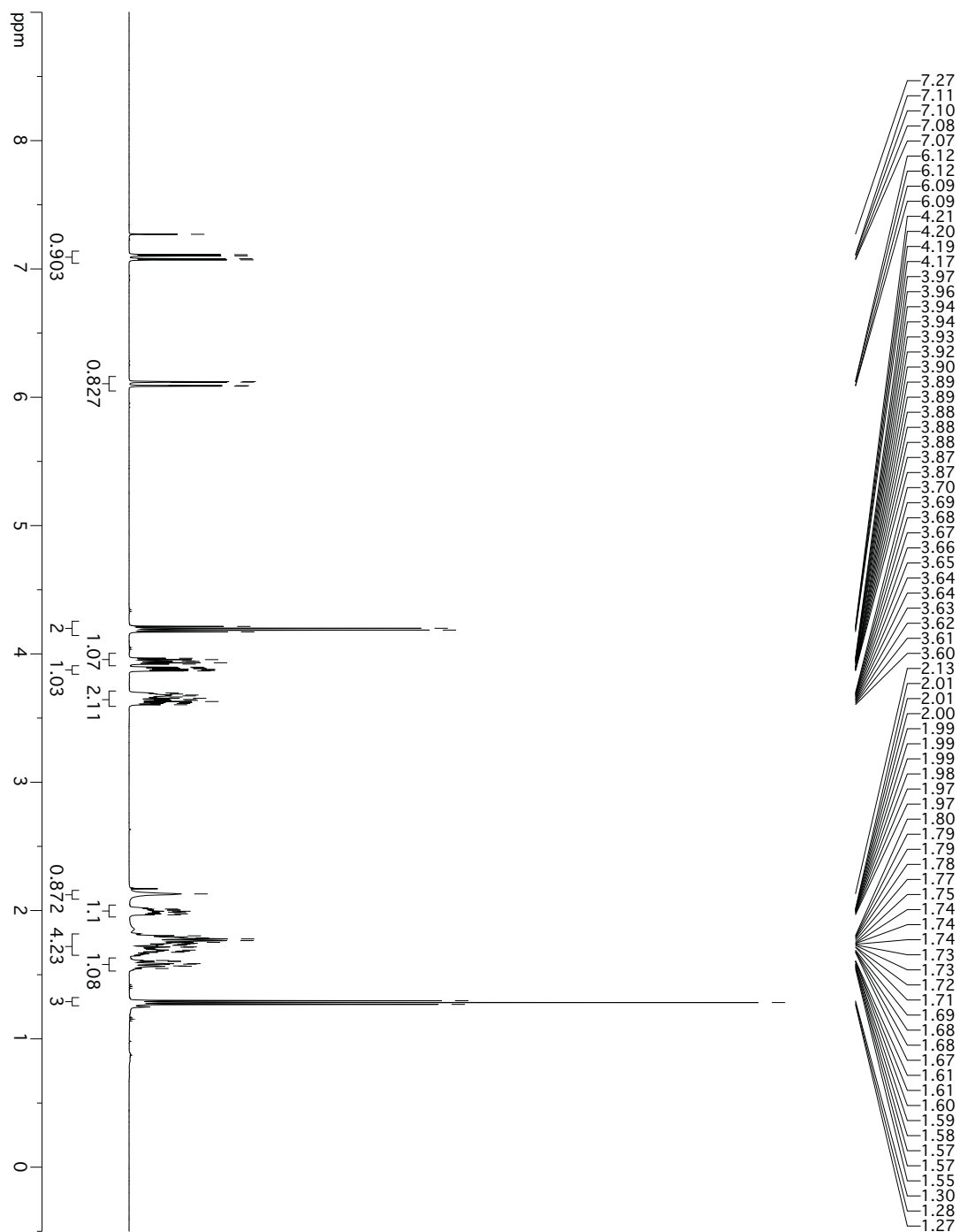
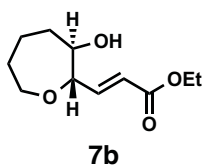


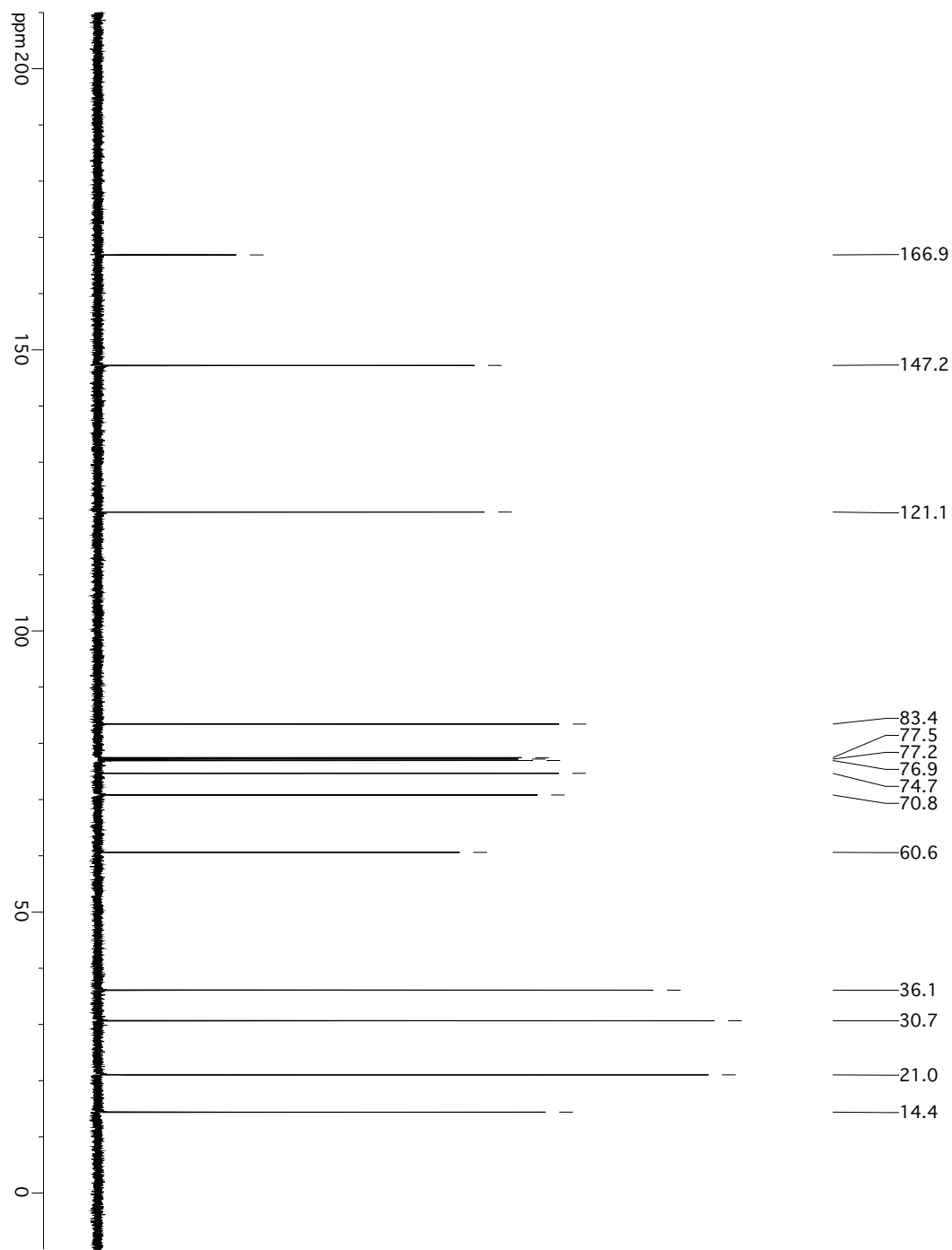
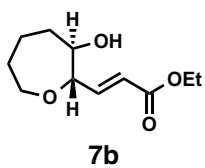
II. Analytical Data

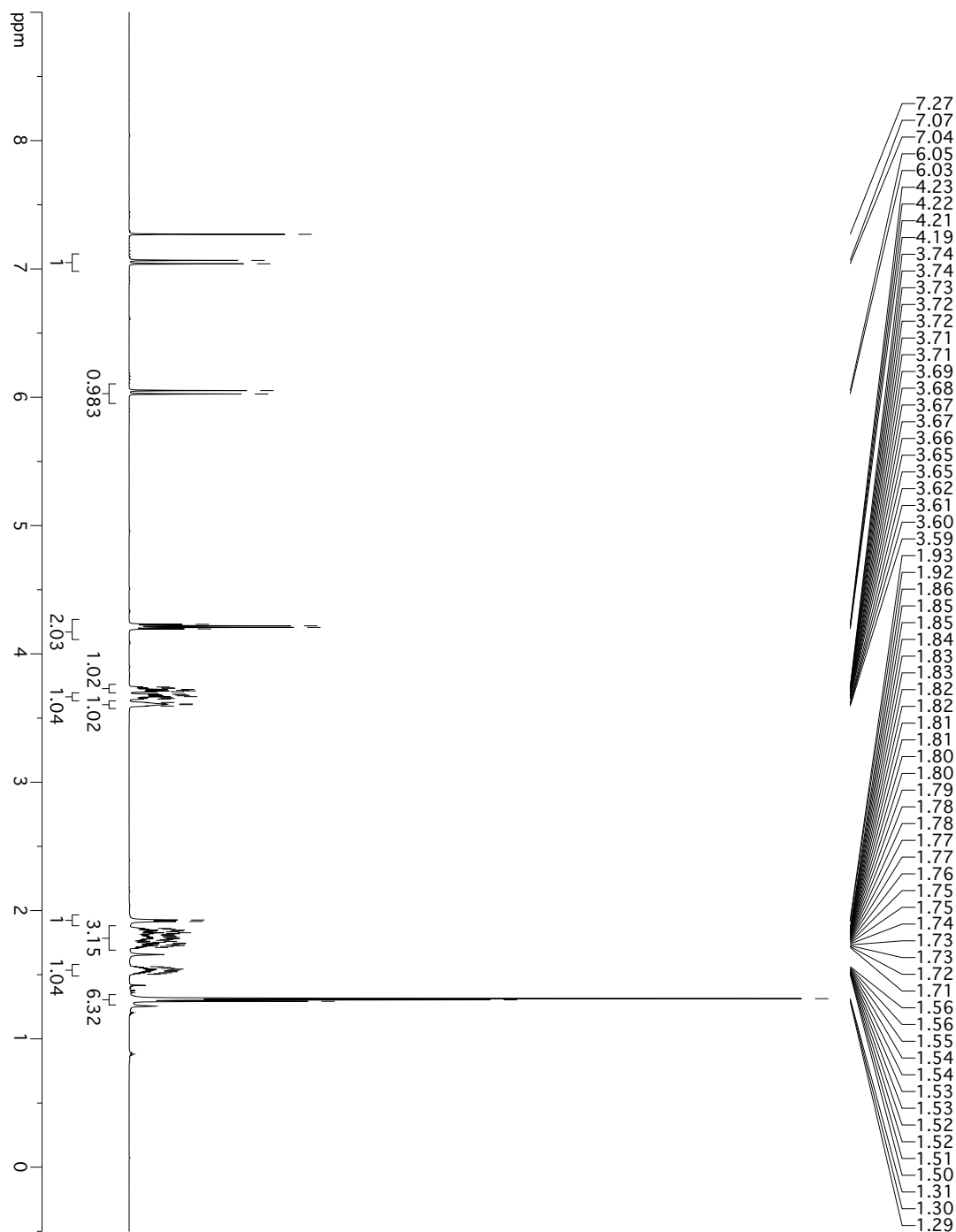
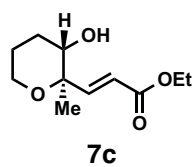
**A.  $^1\text{H}$  and  $^{13}\text{C}$  NMR Spectroscopy Data:**

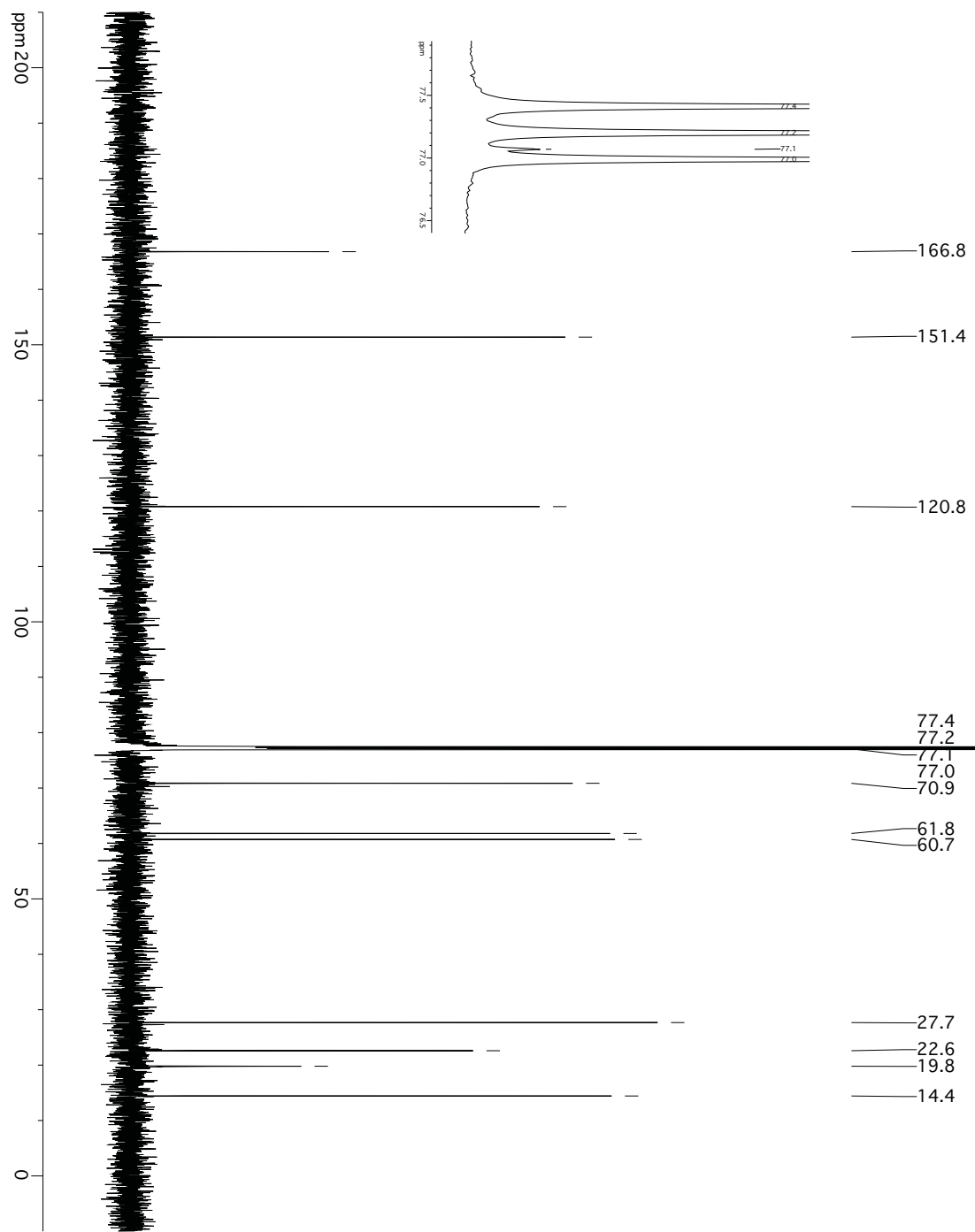
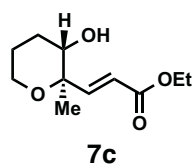


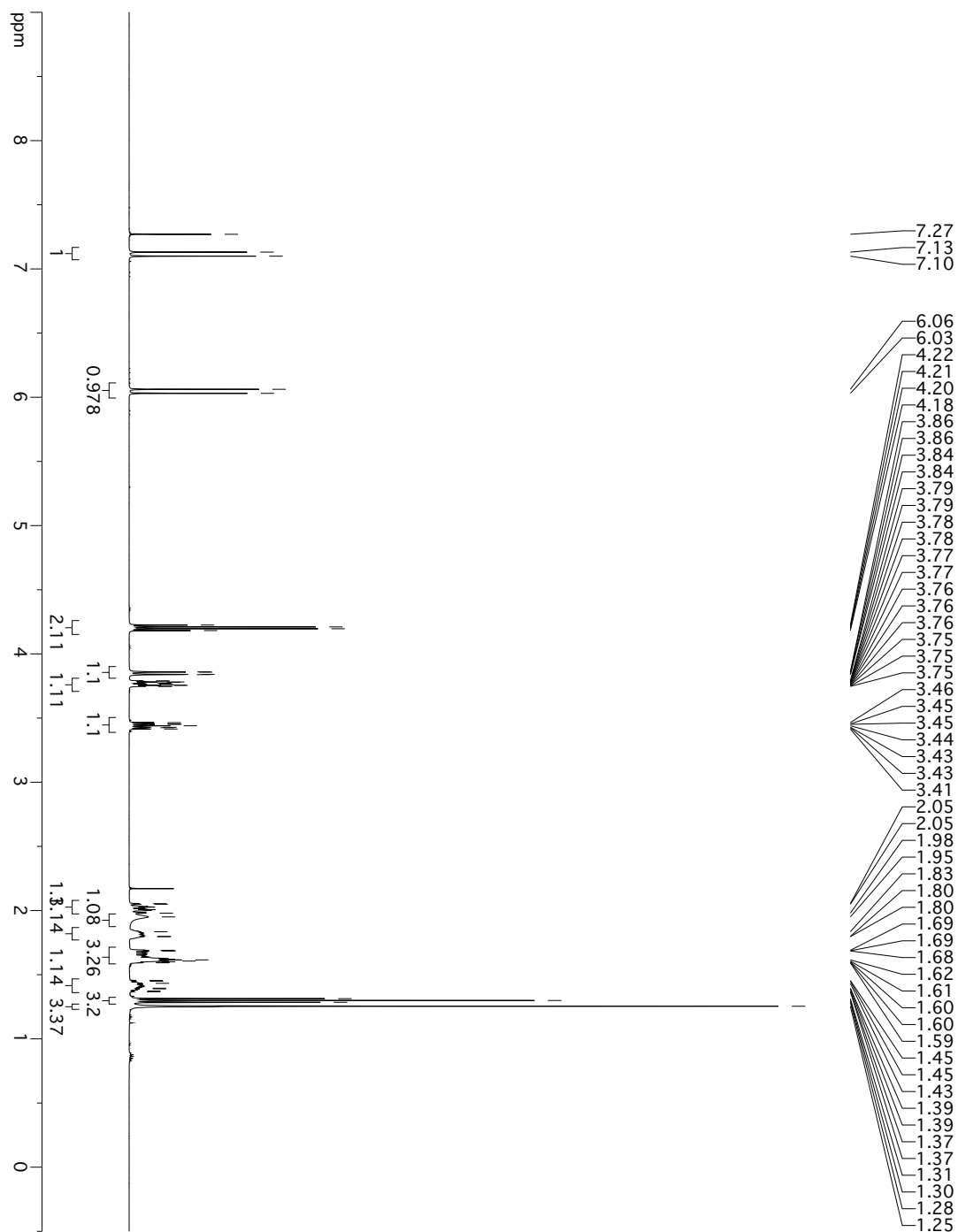
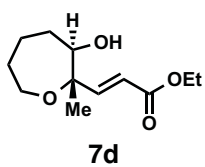




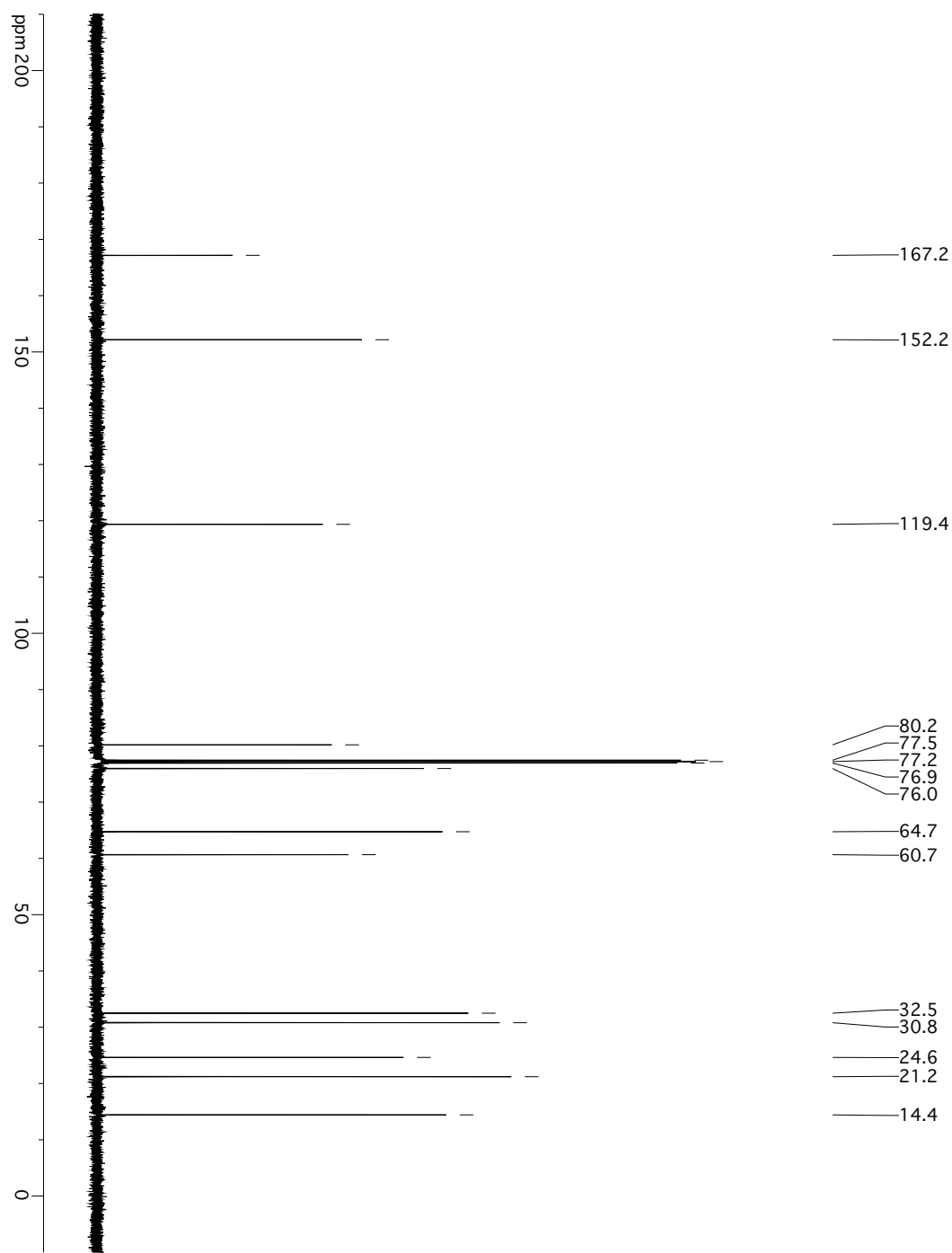
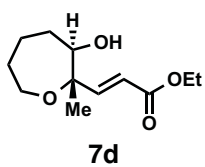


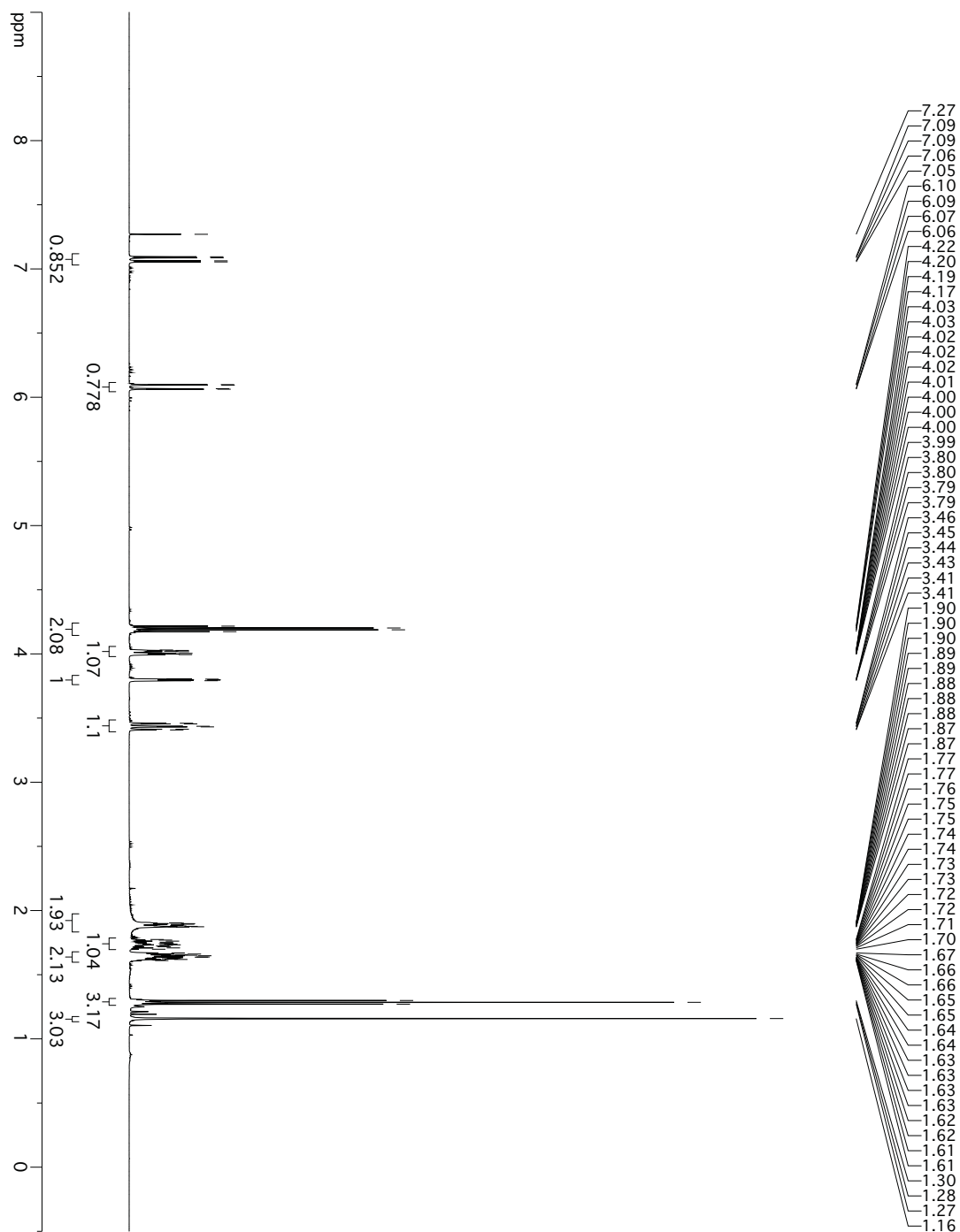
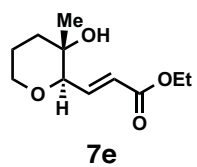


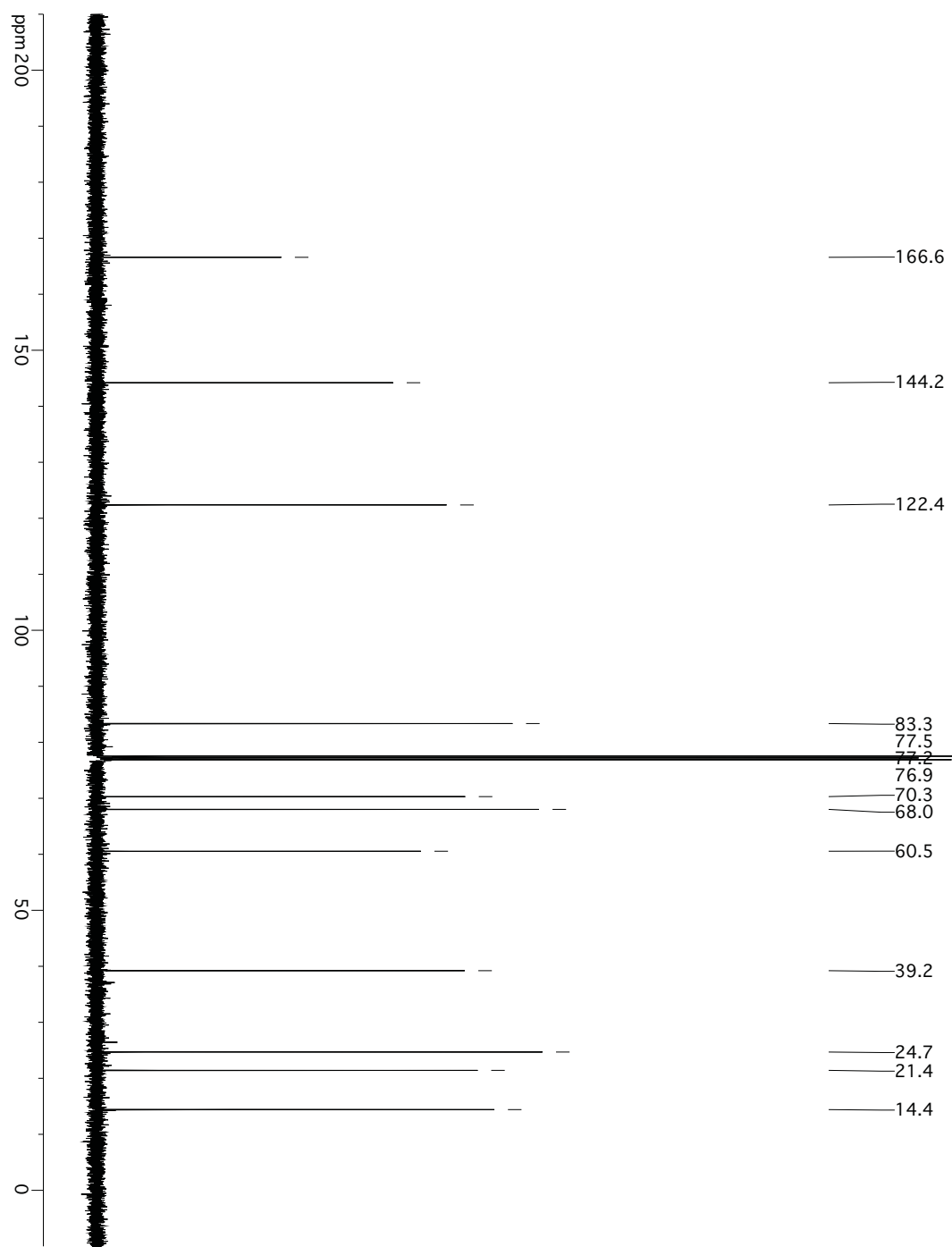
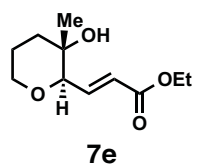


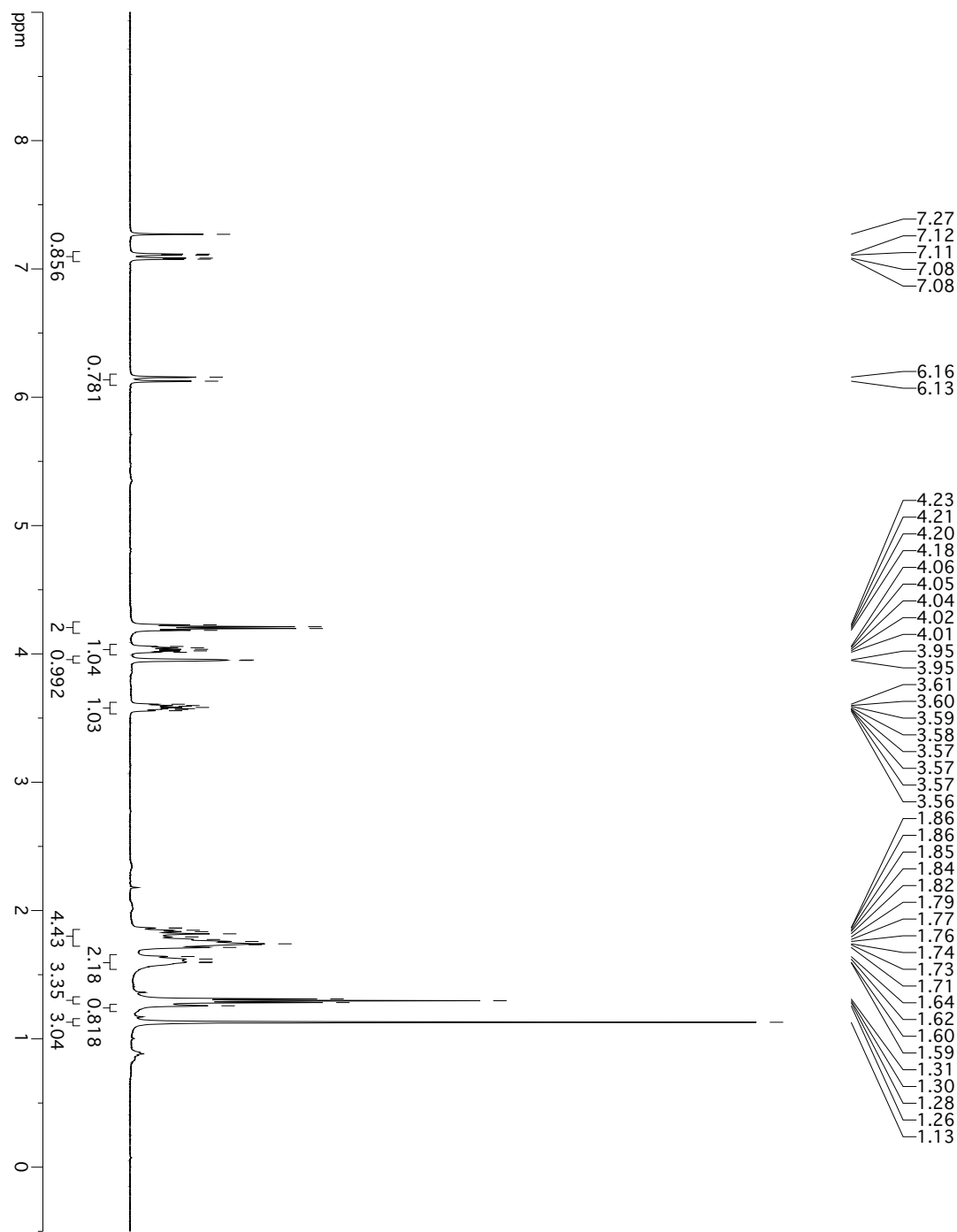
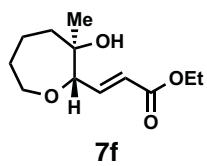


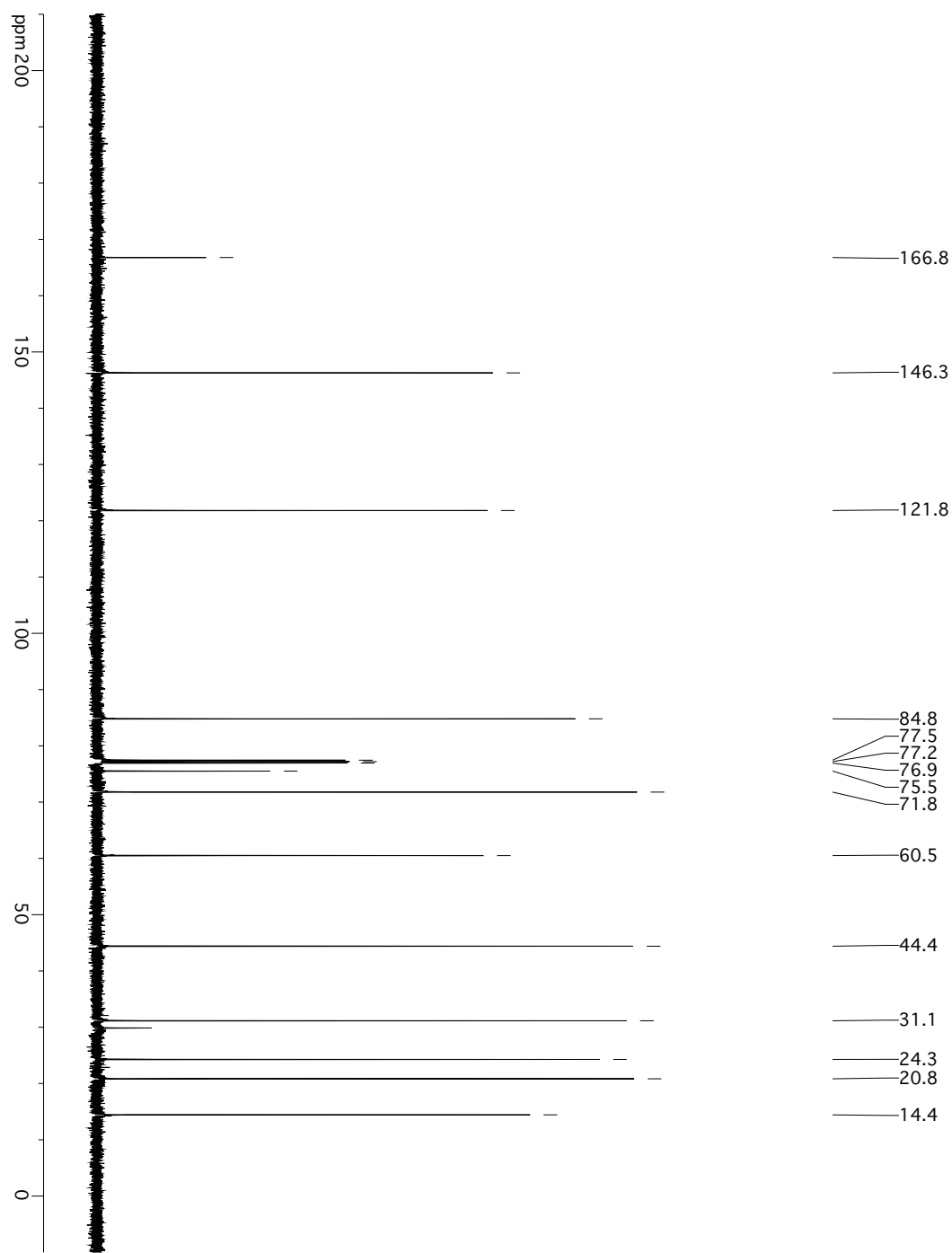
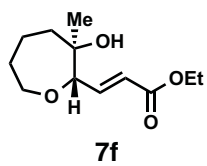


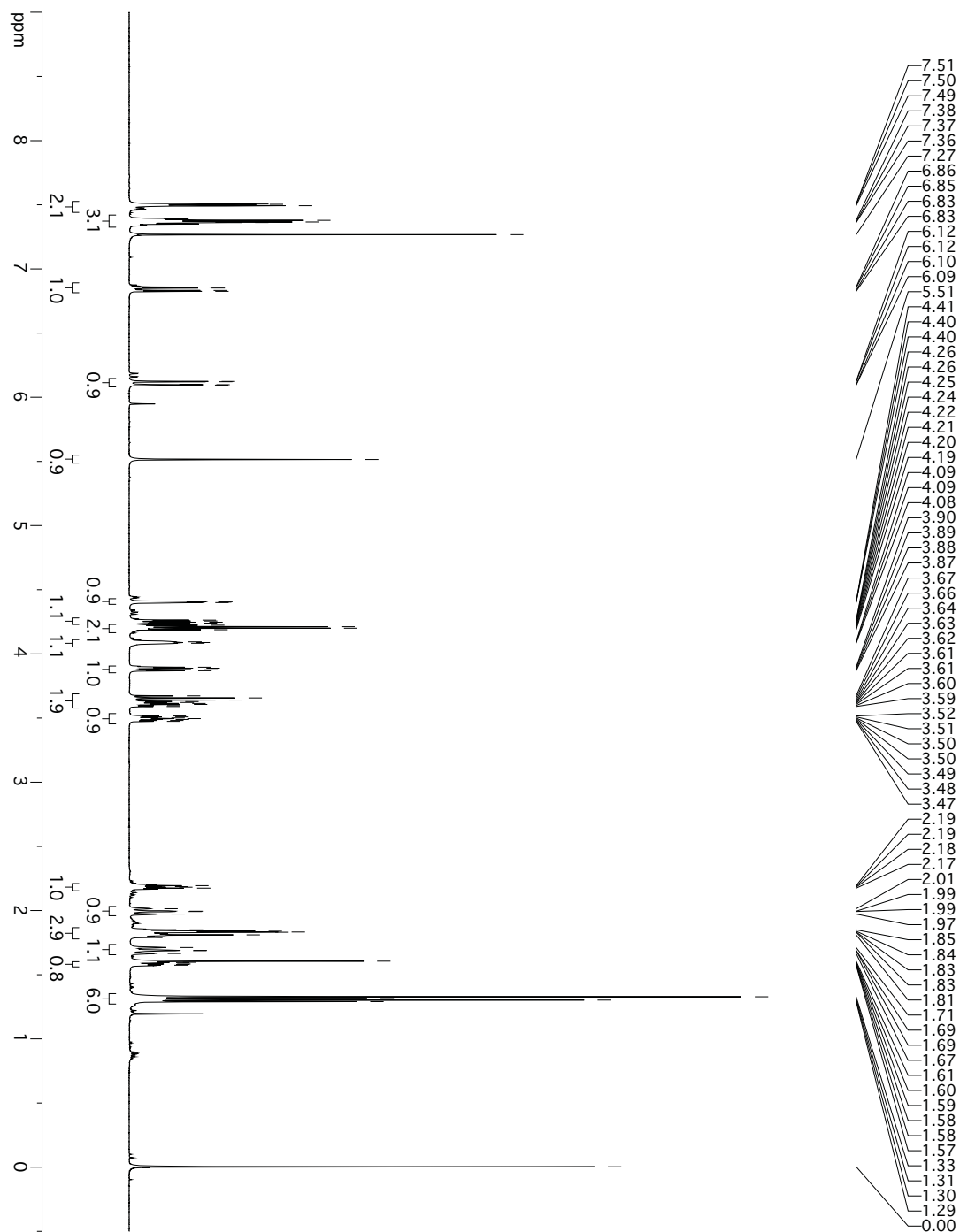
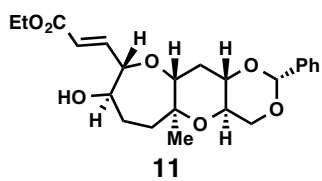


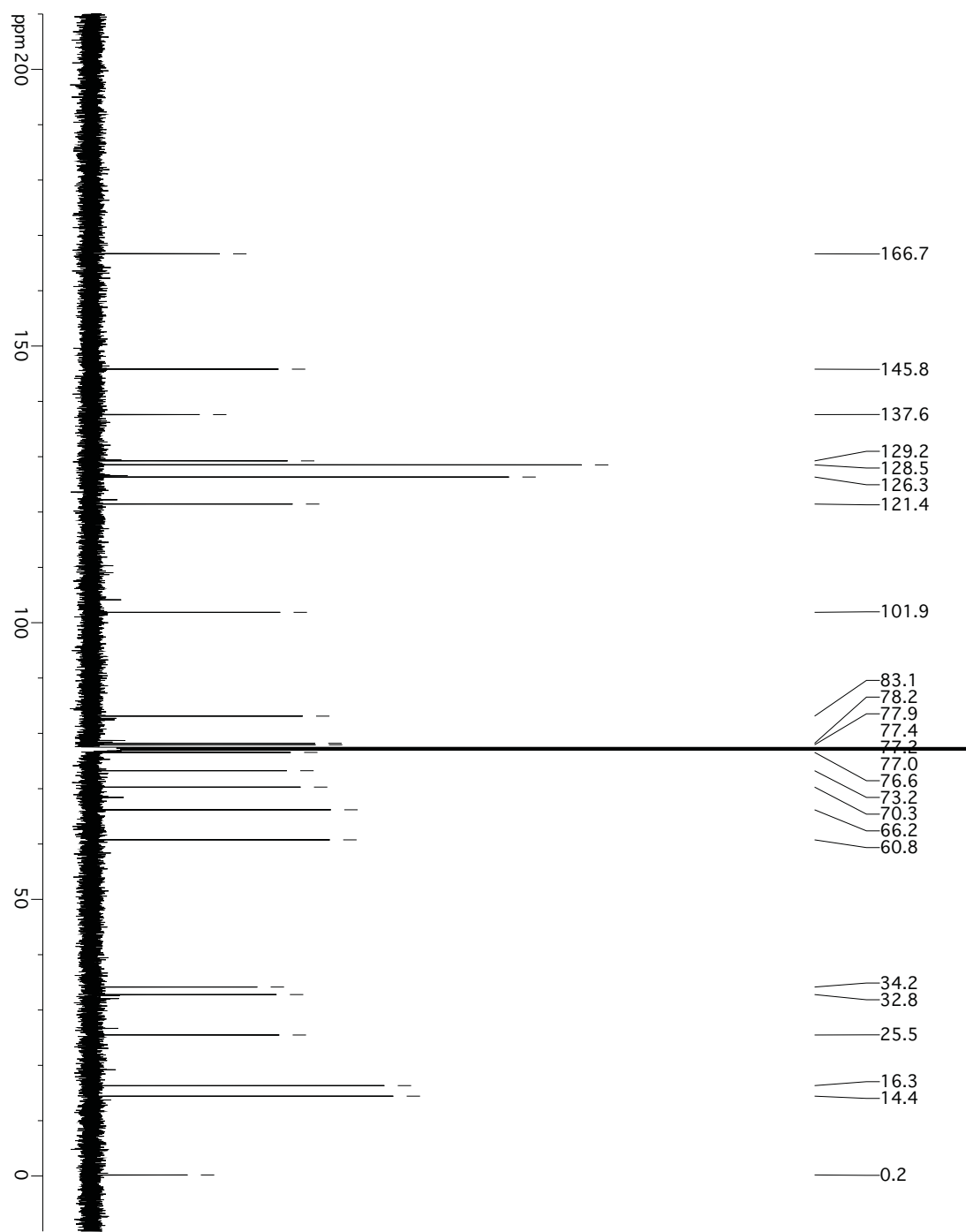
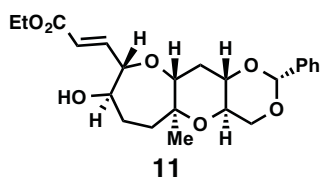


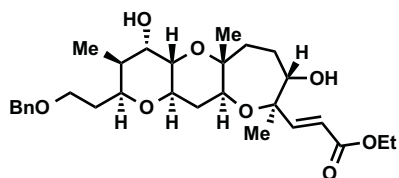




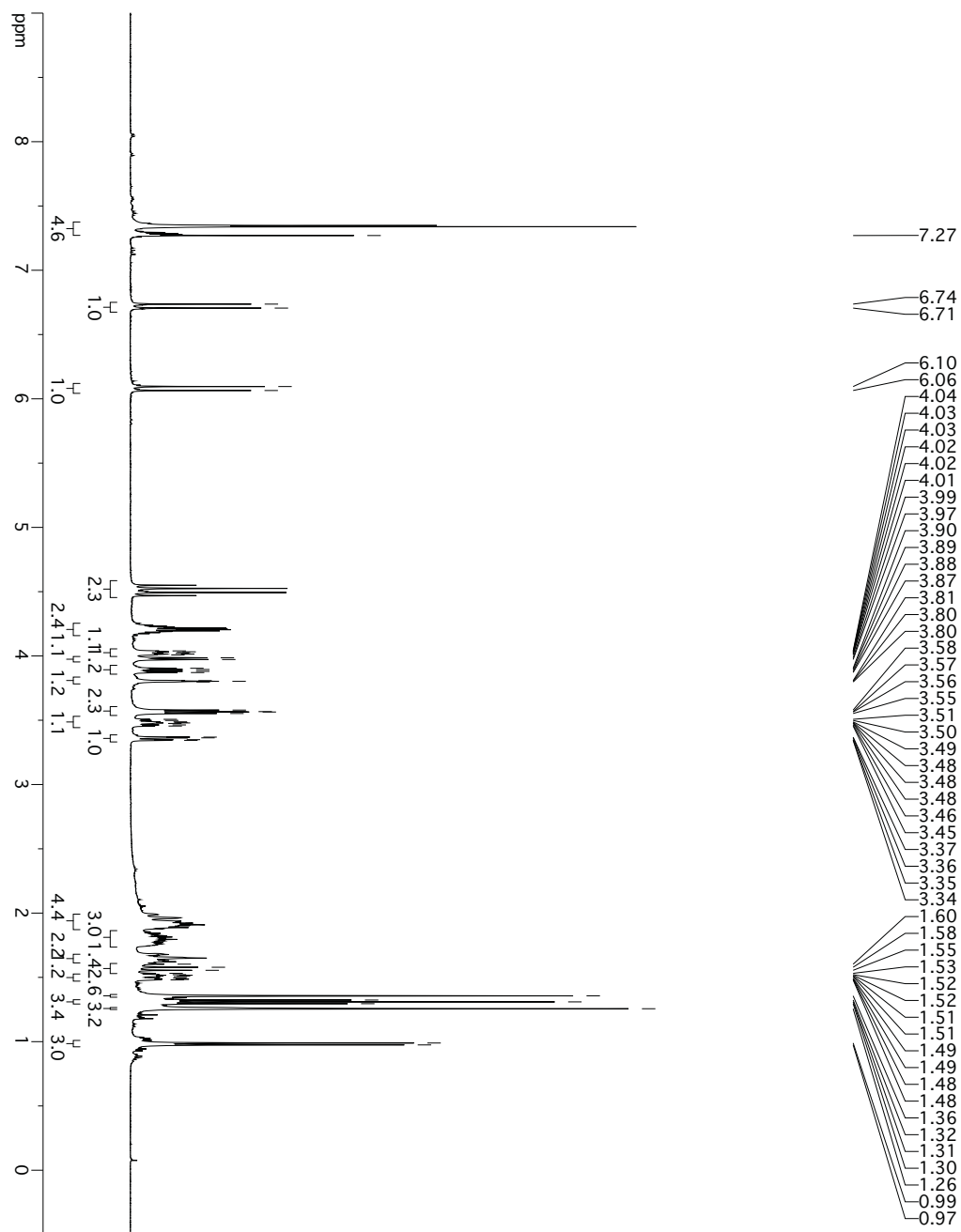




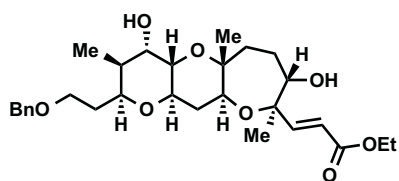




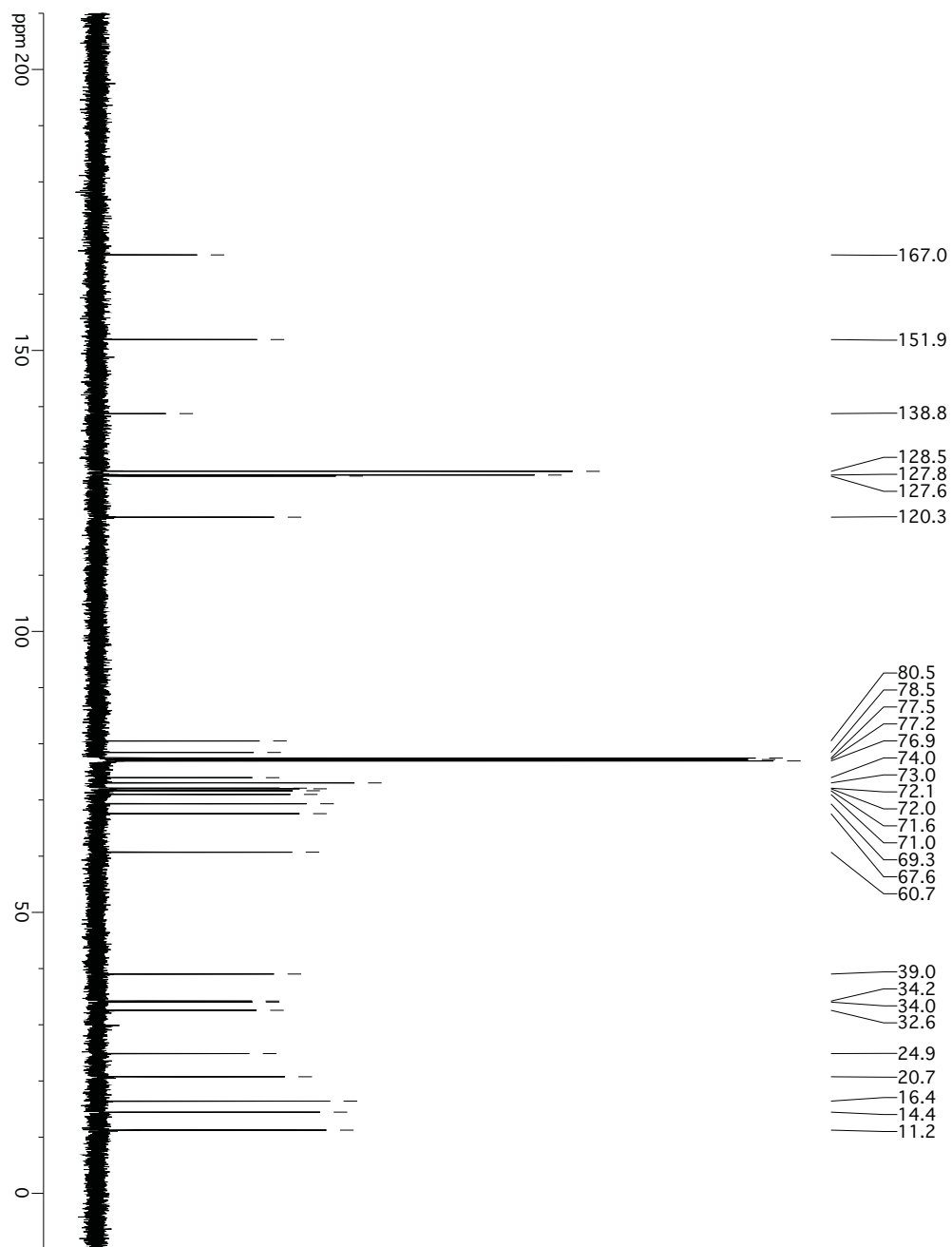
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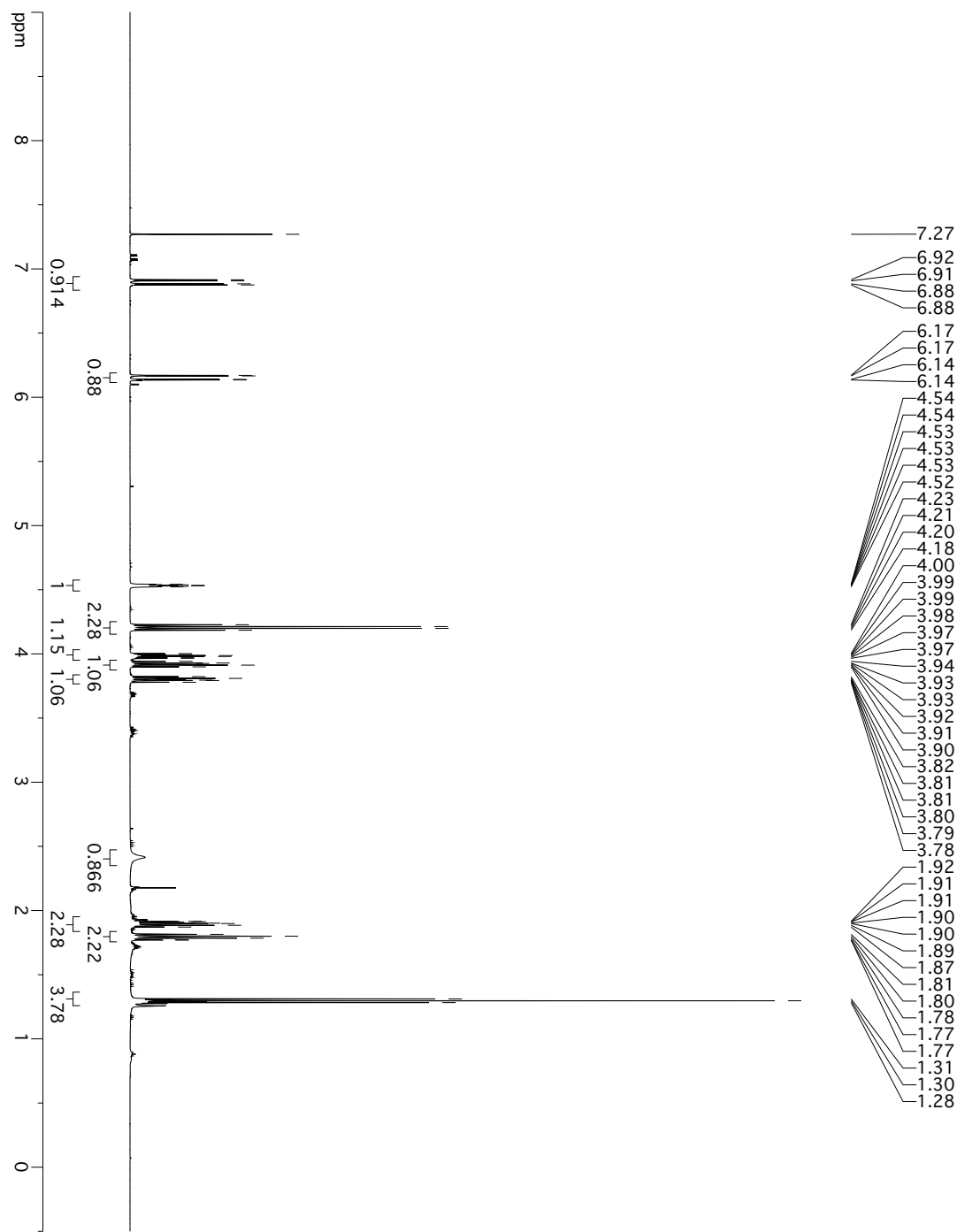
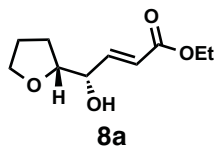


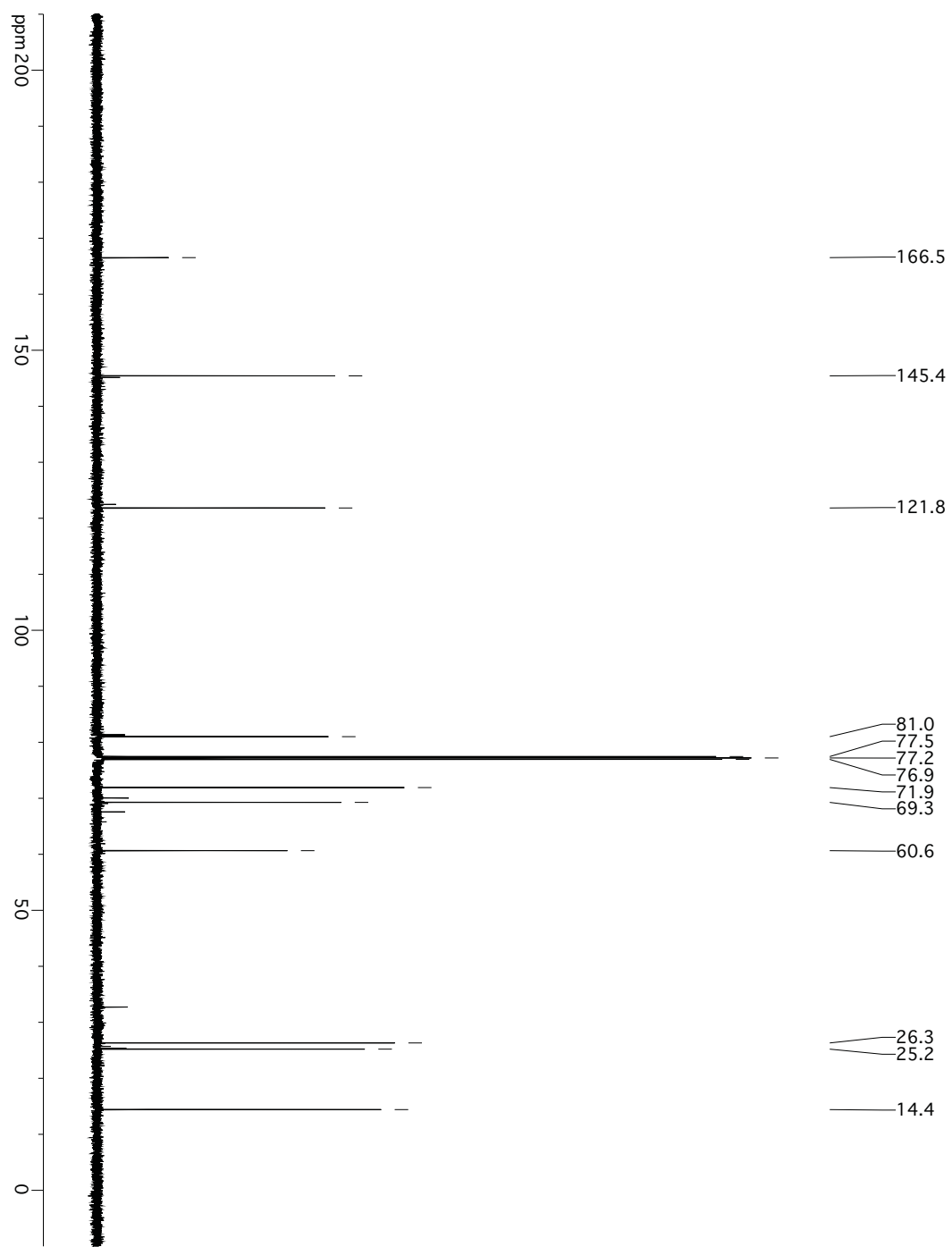
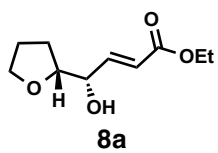


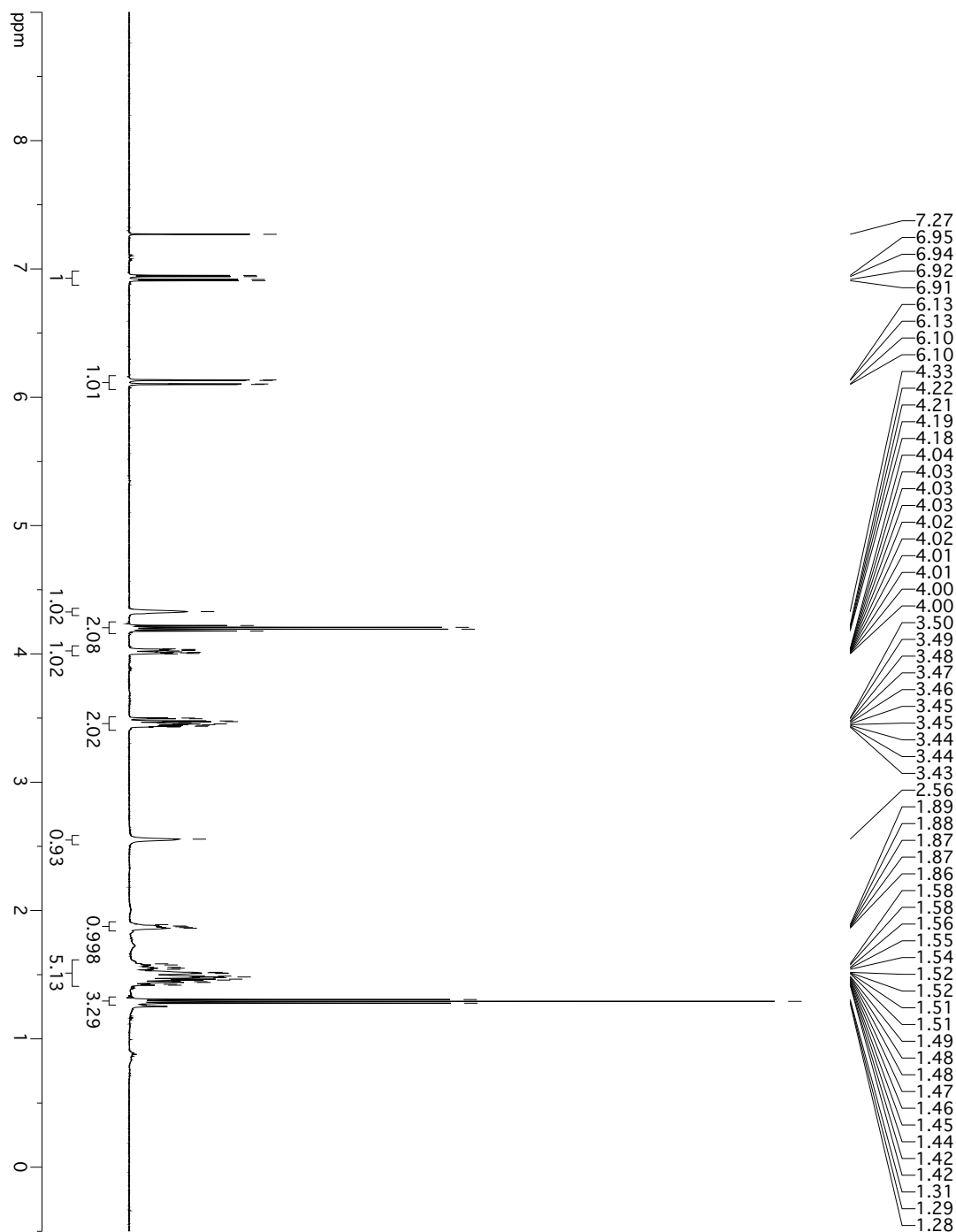
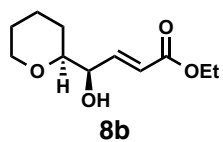


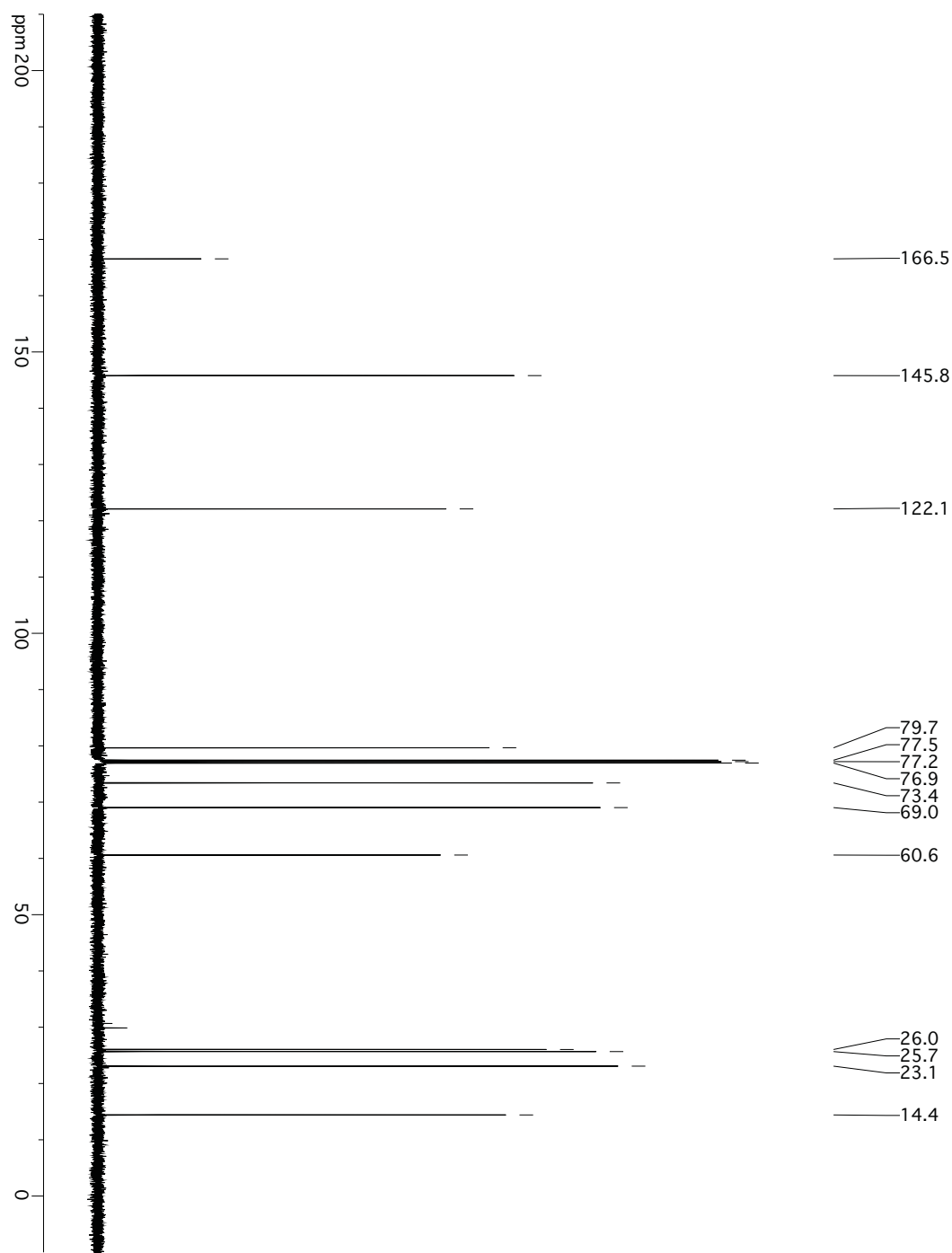
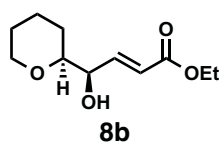
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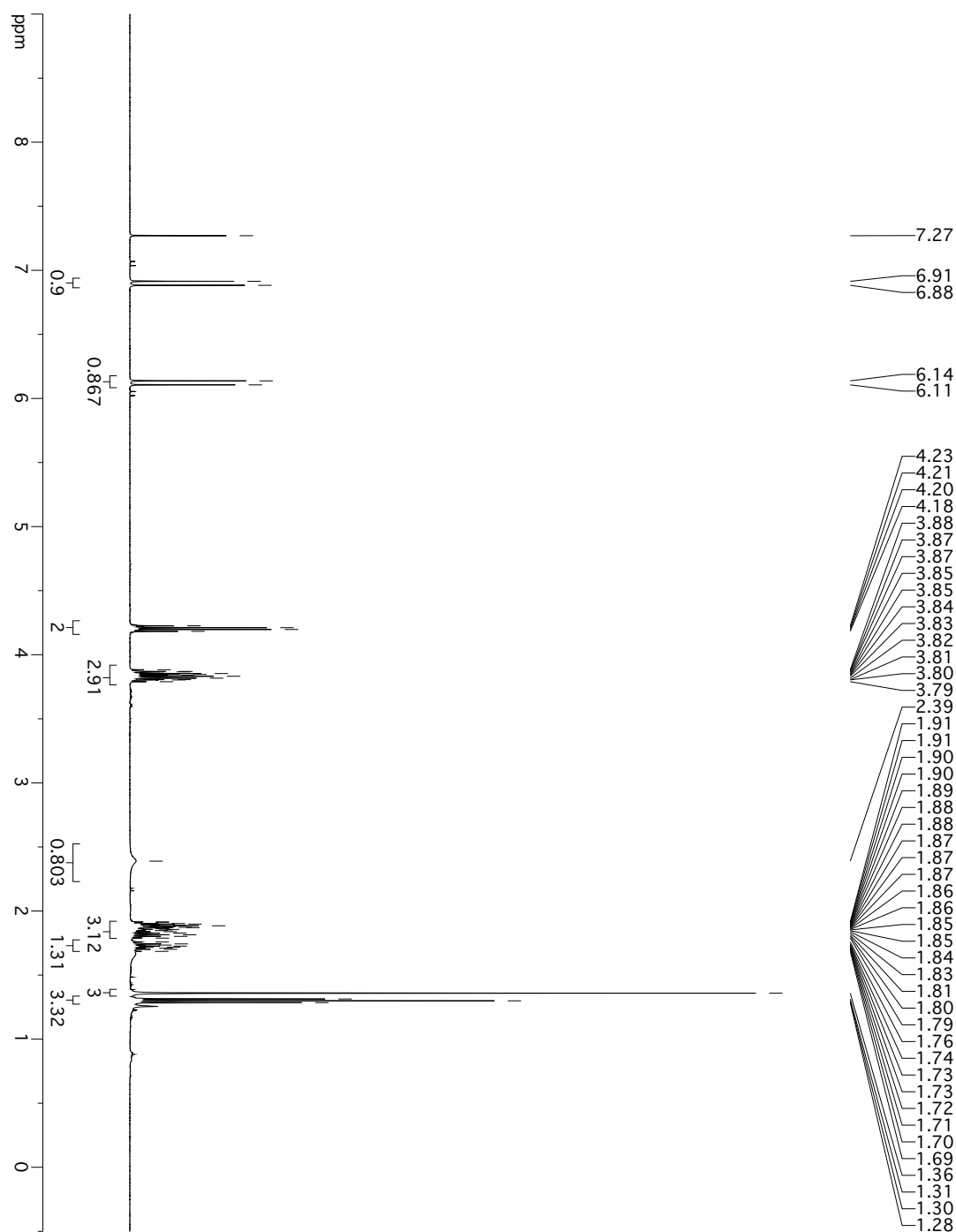
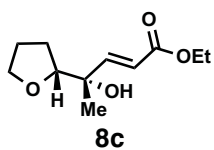


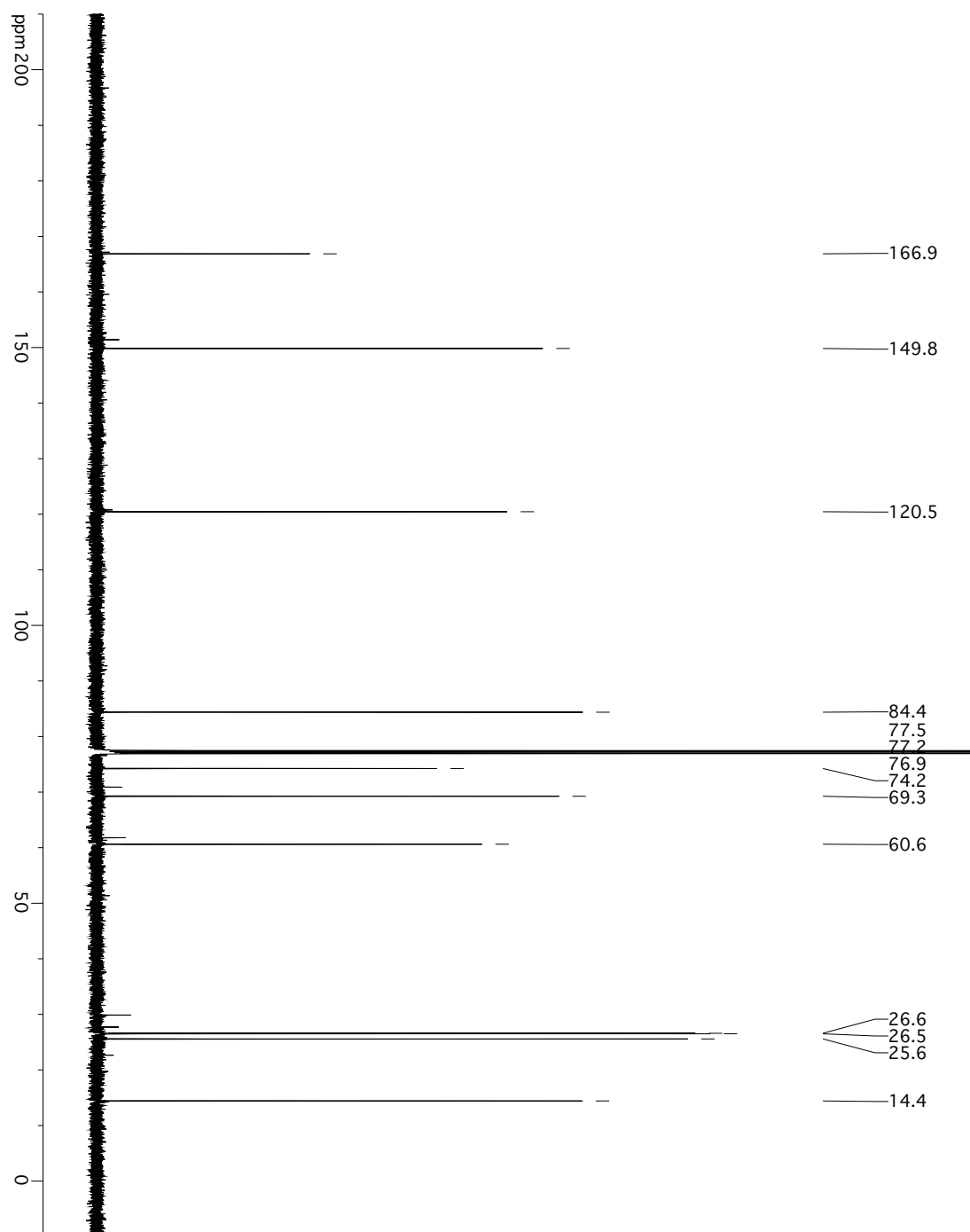
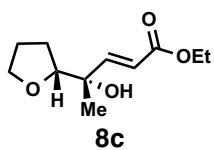


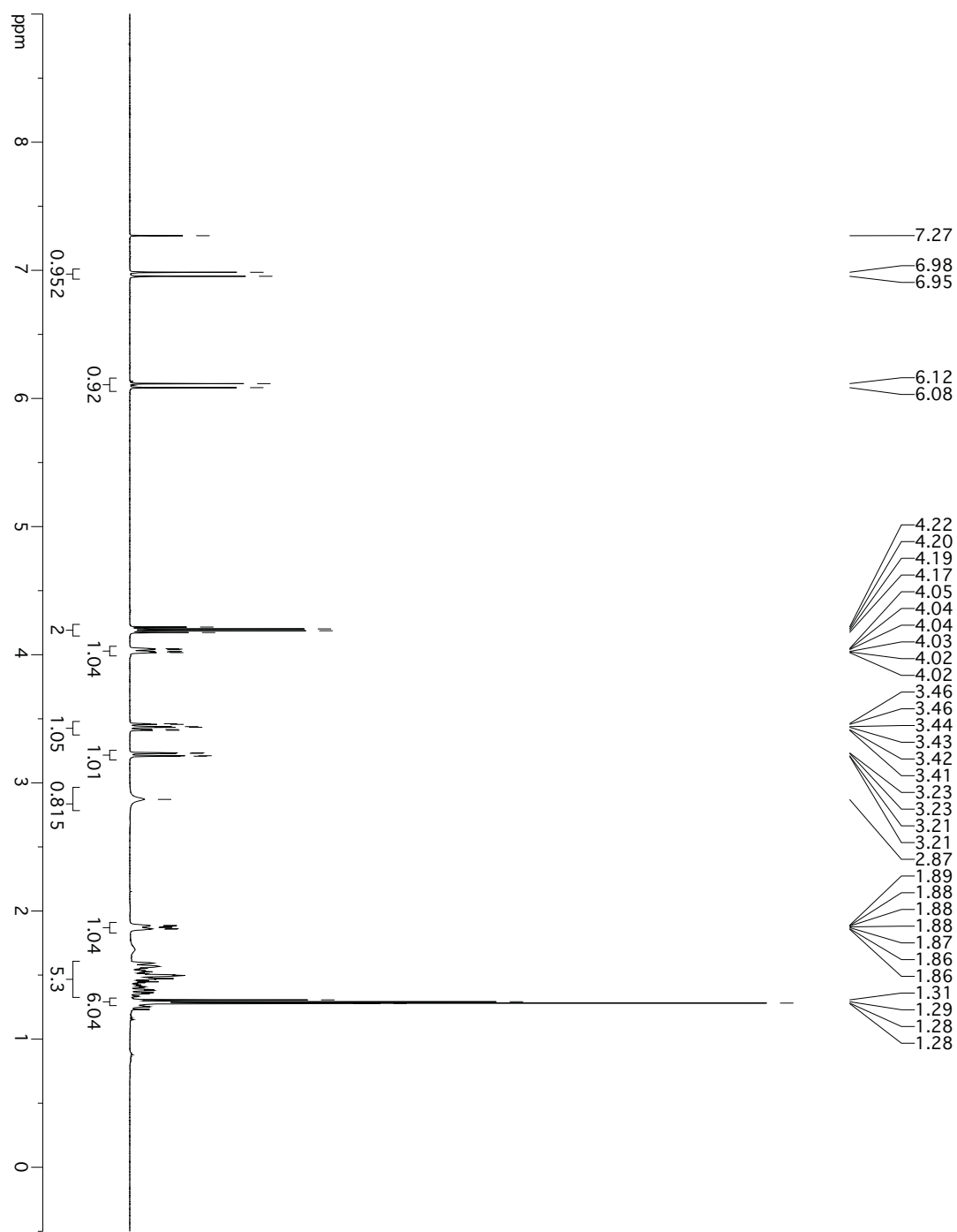
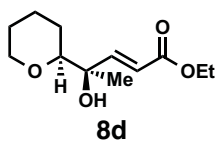




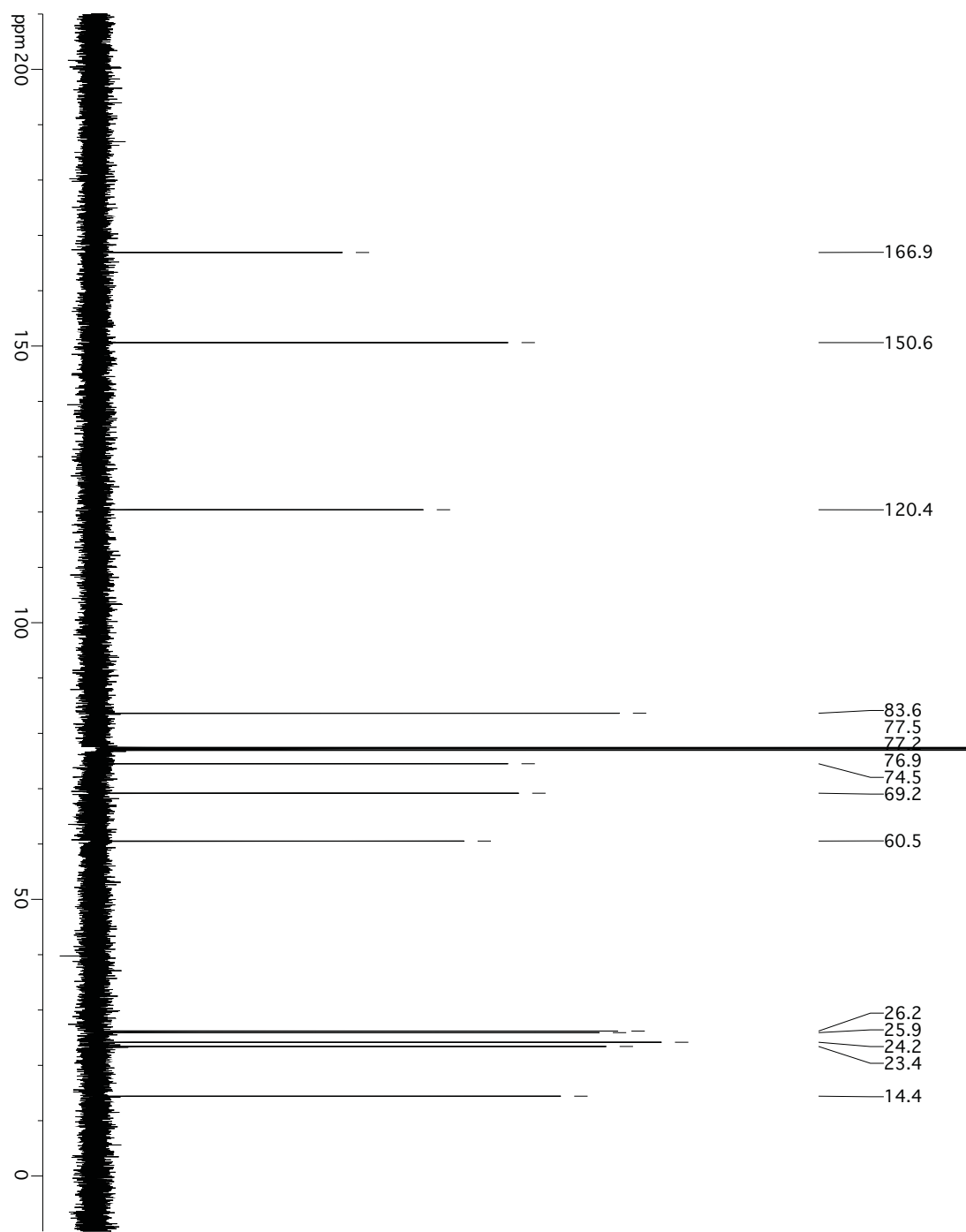
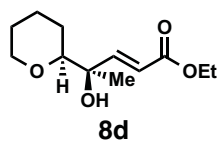


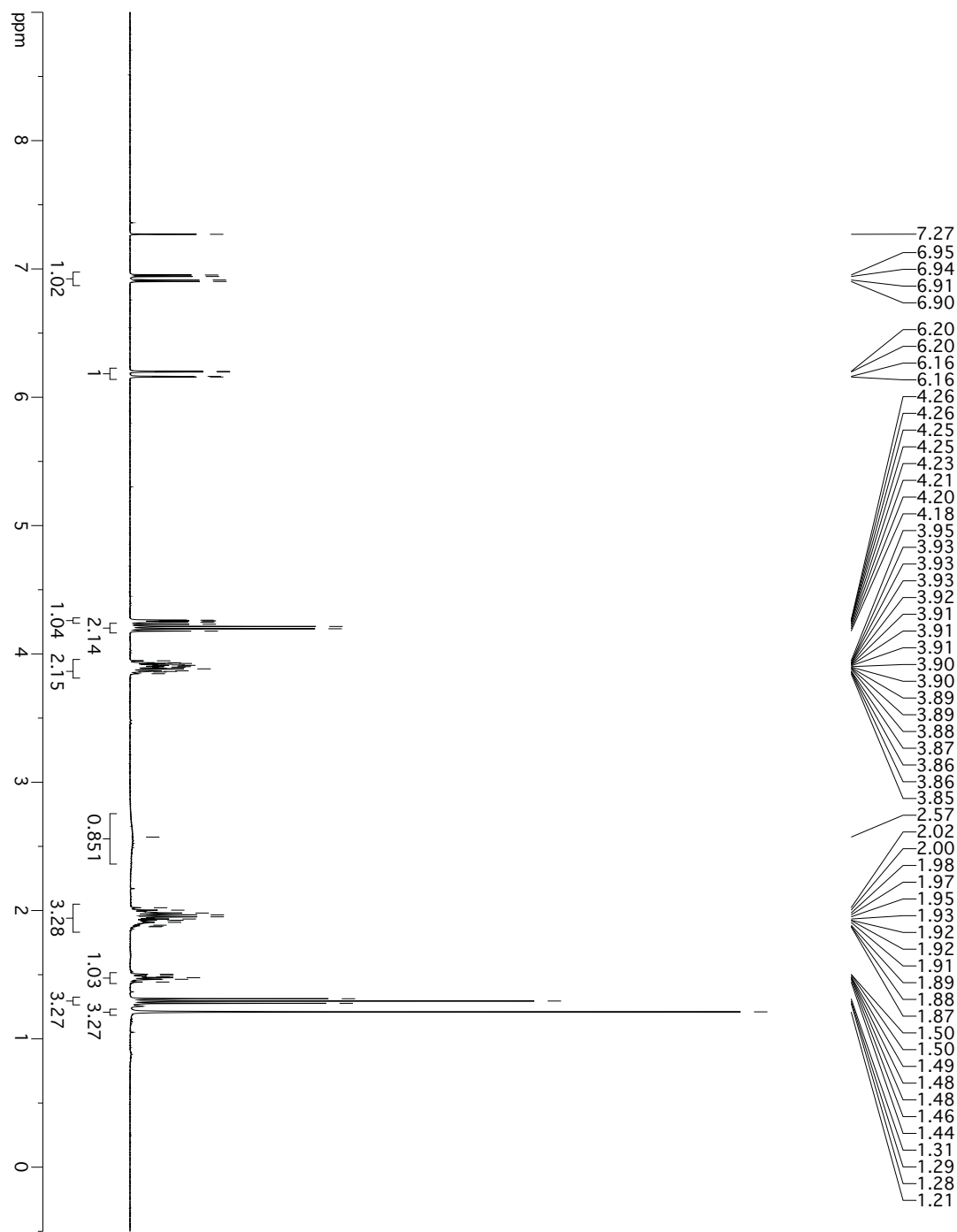
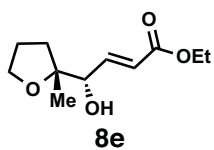


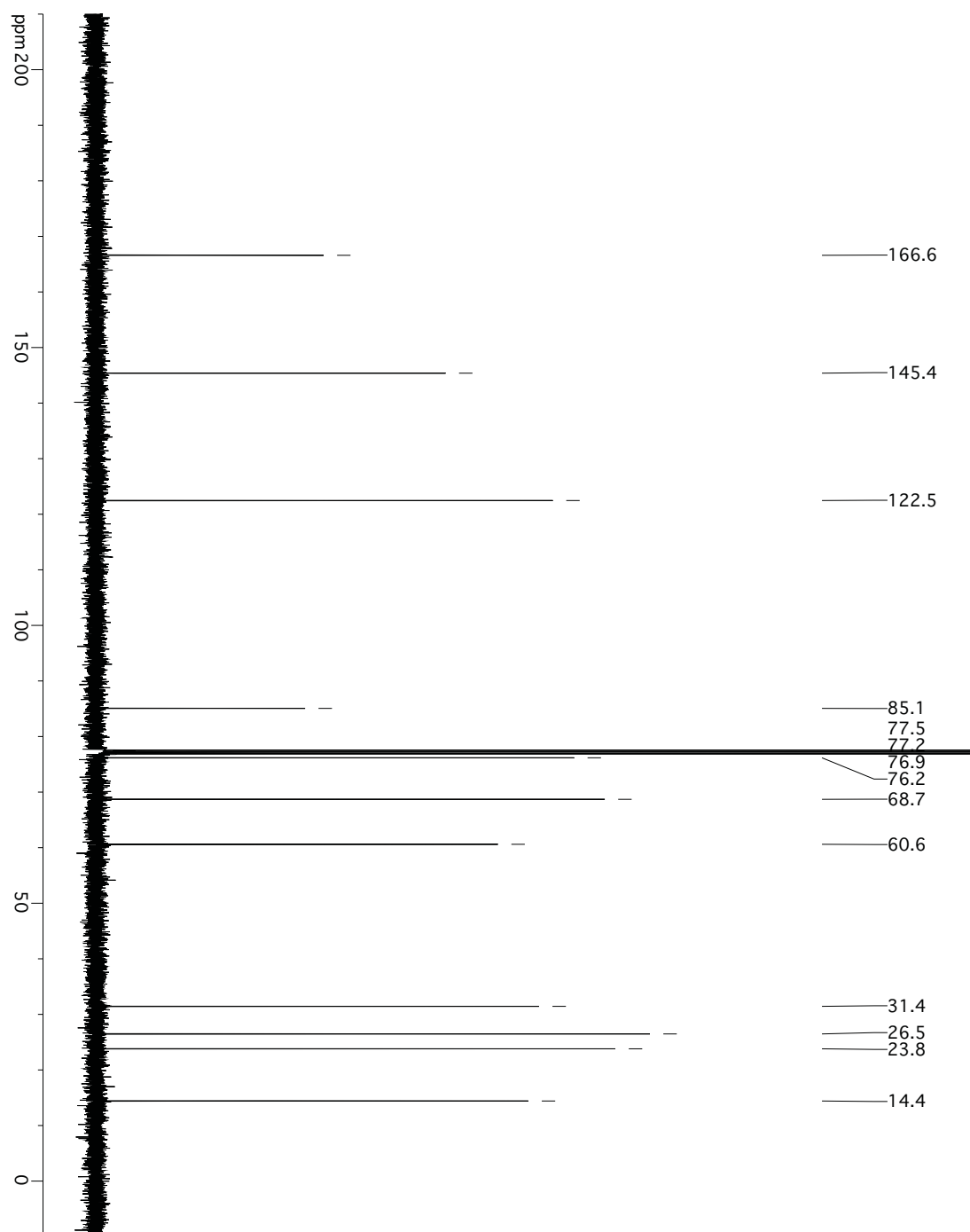
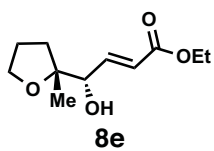


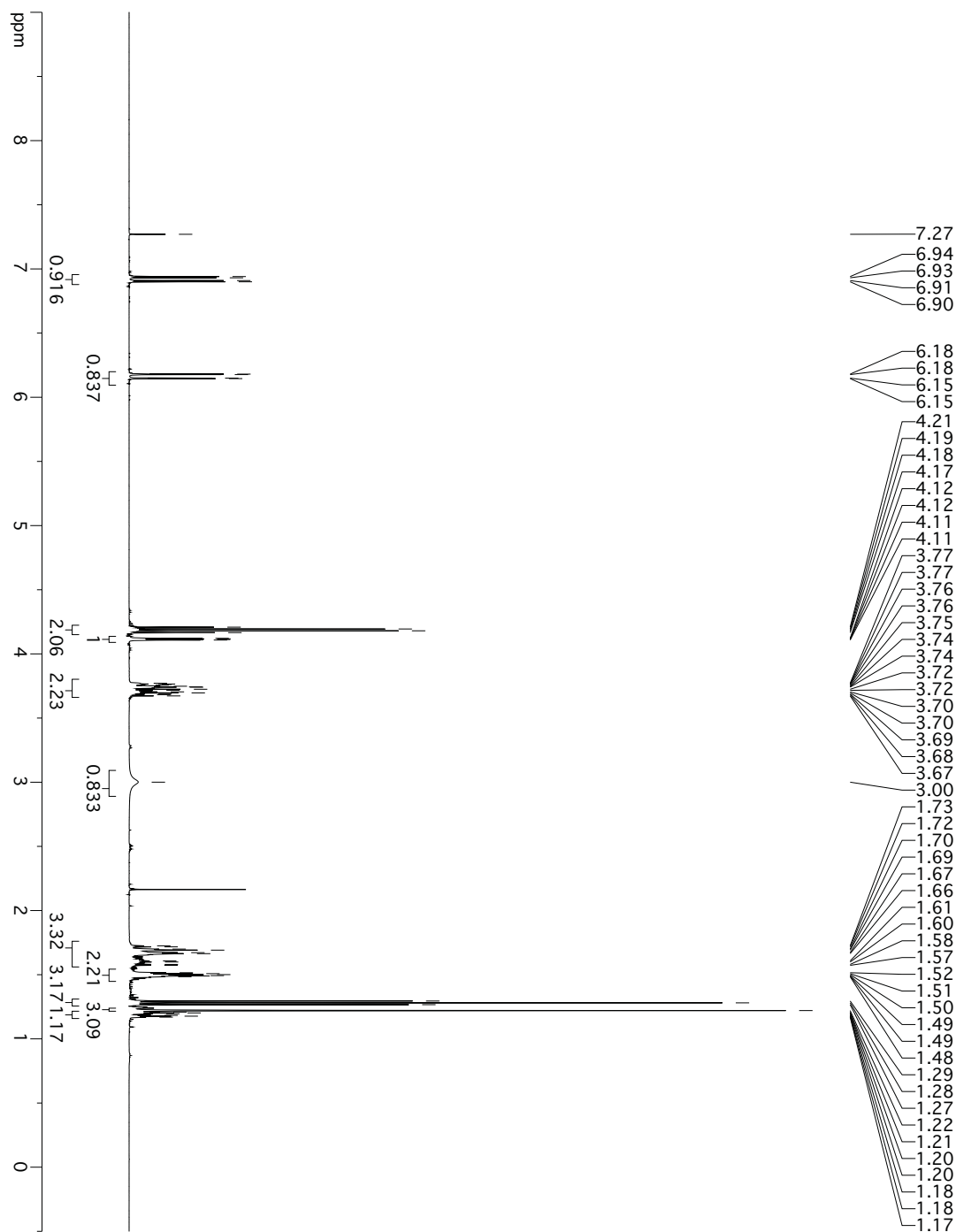
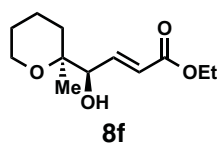


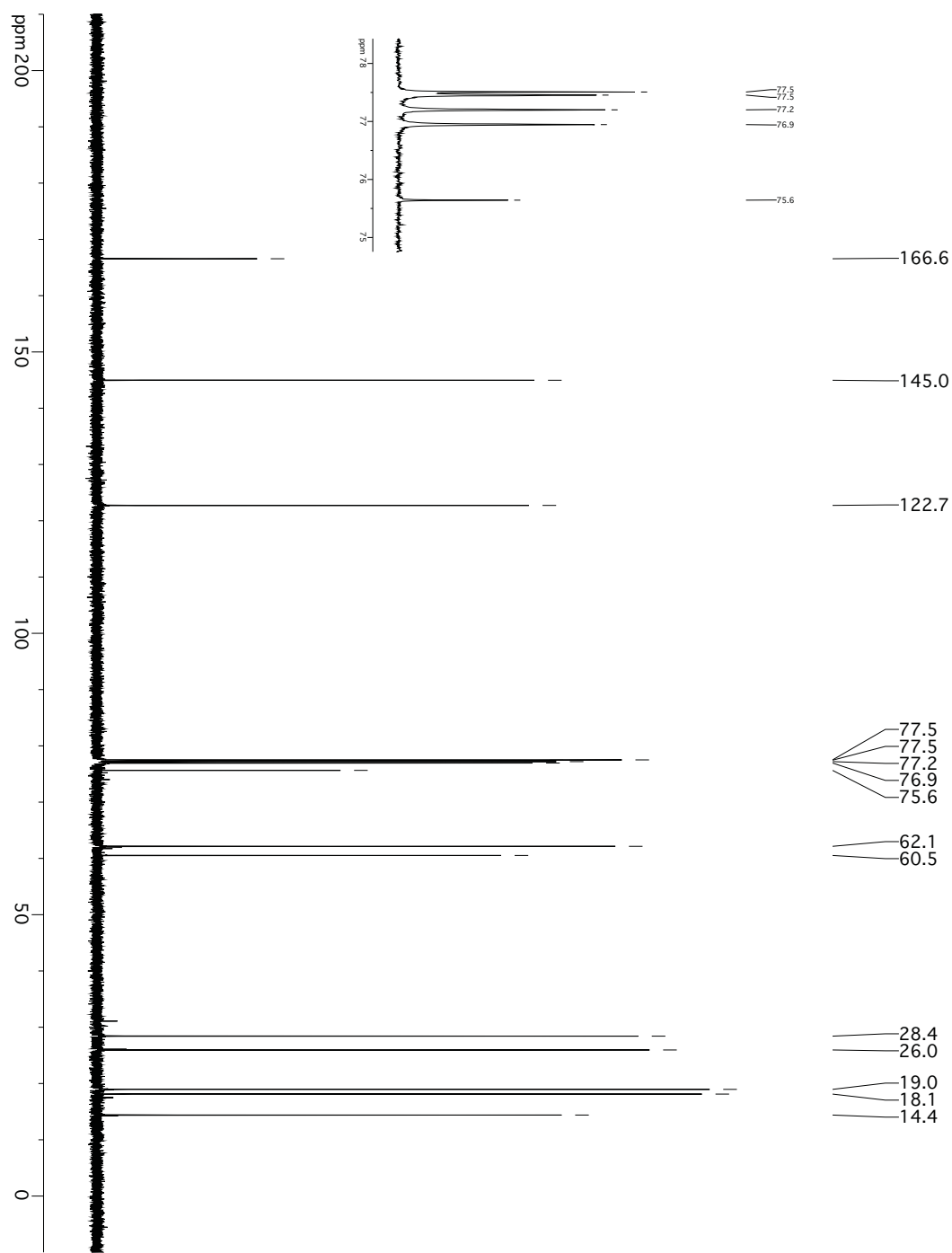
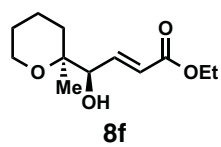


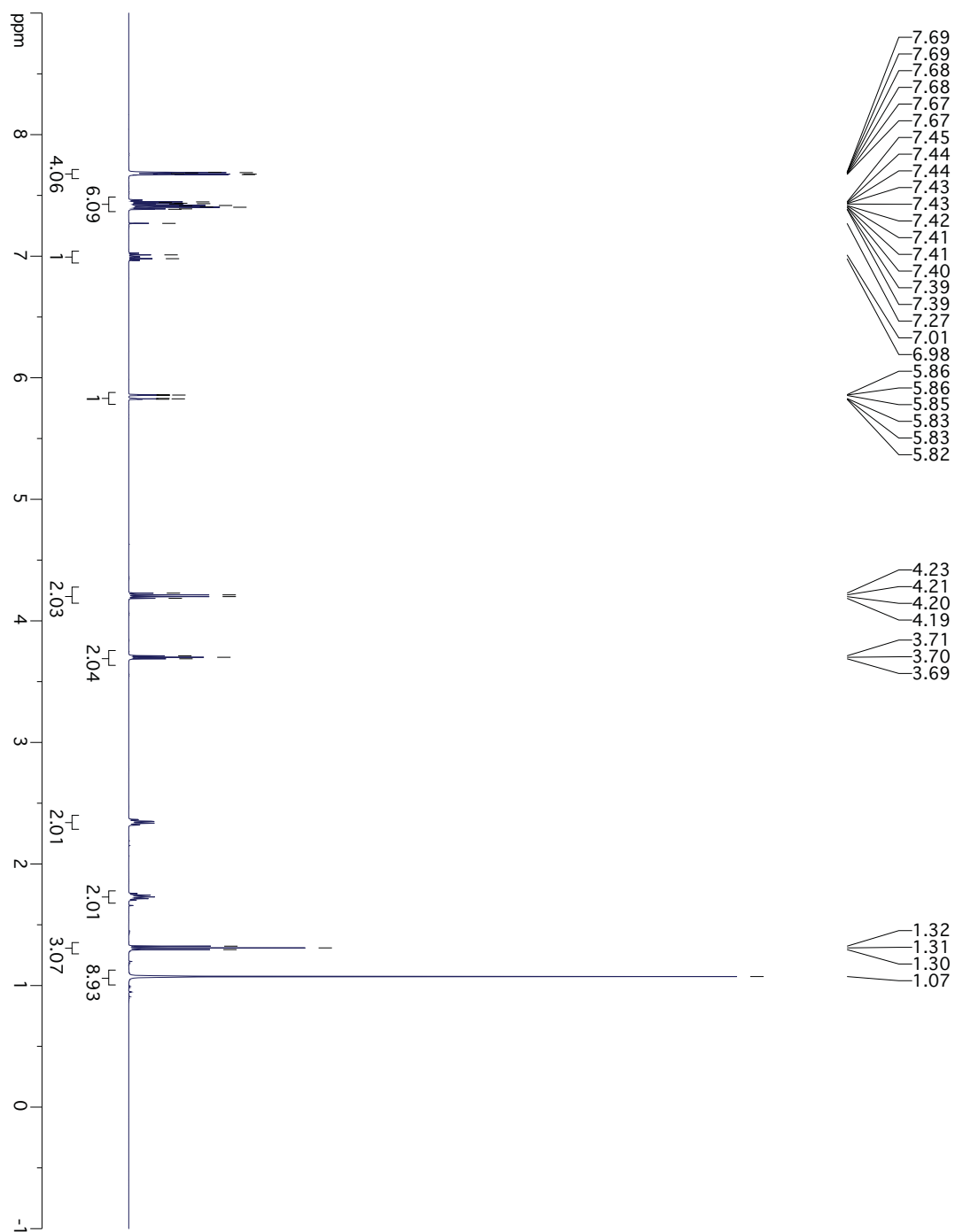
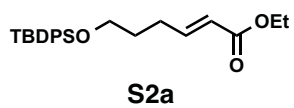


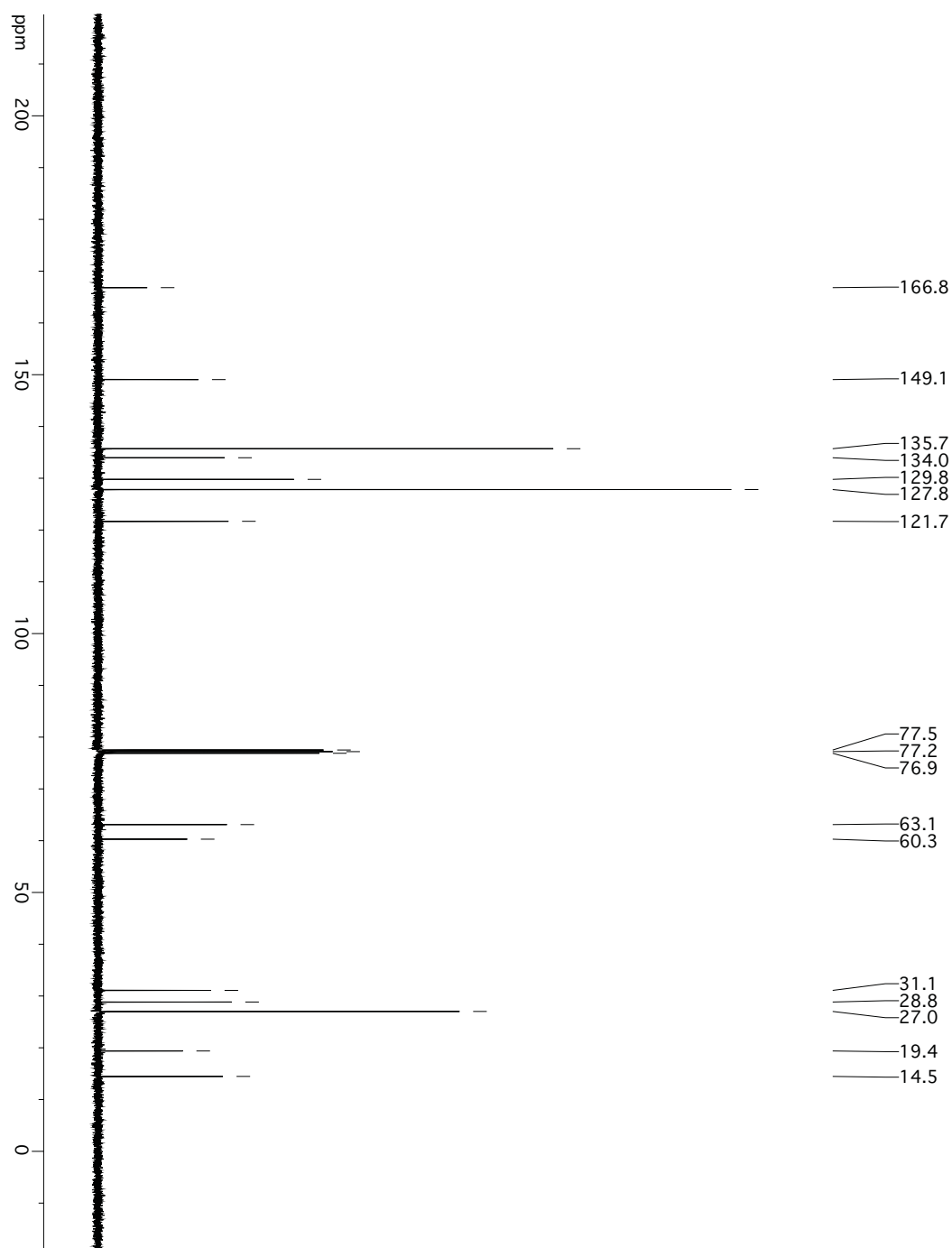
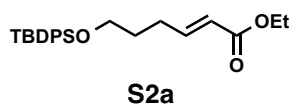


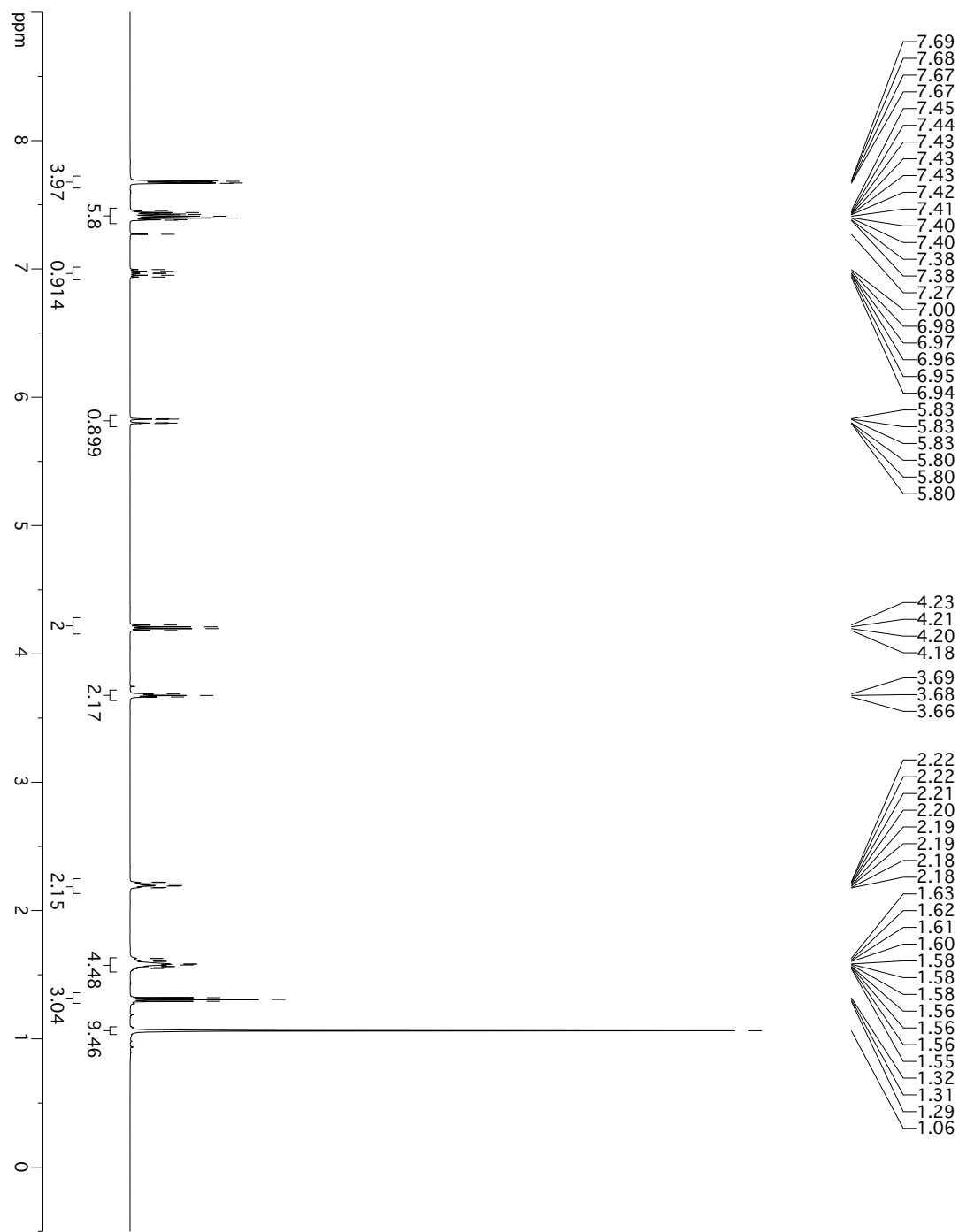
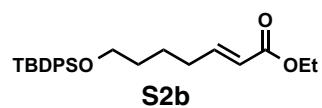




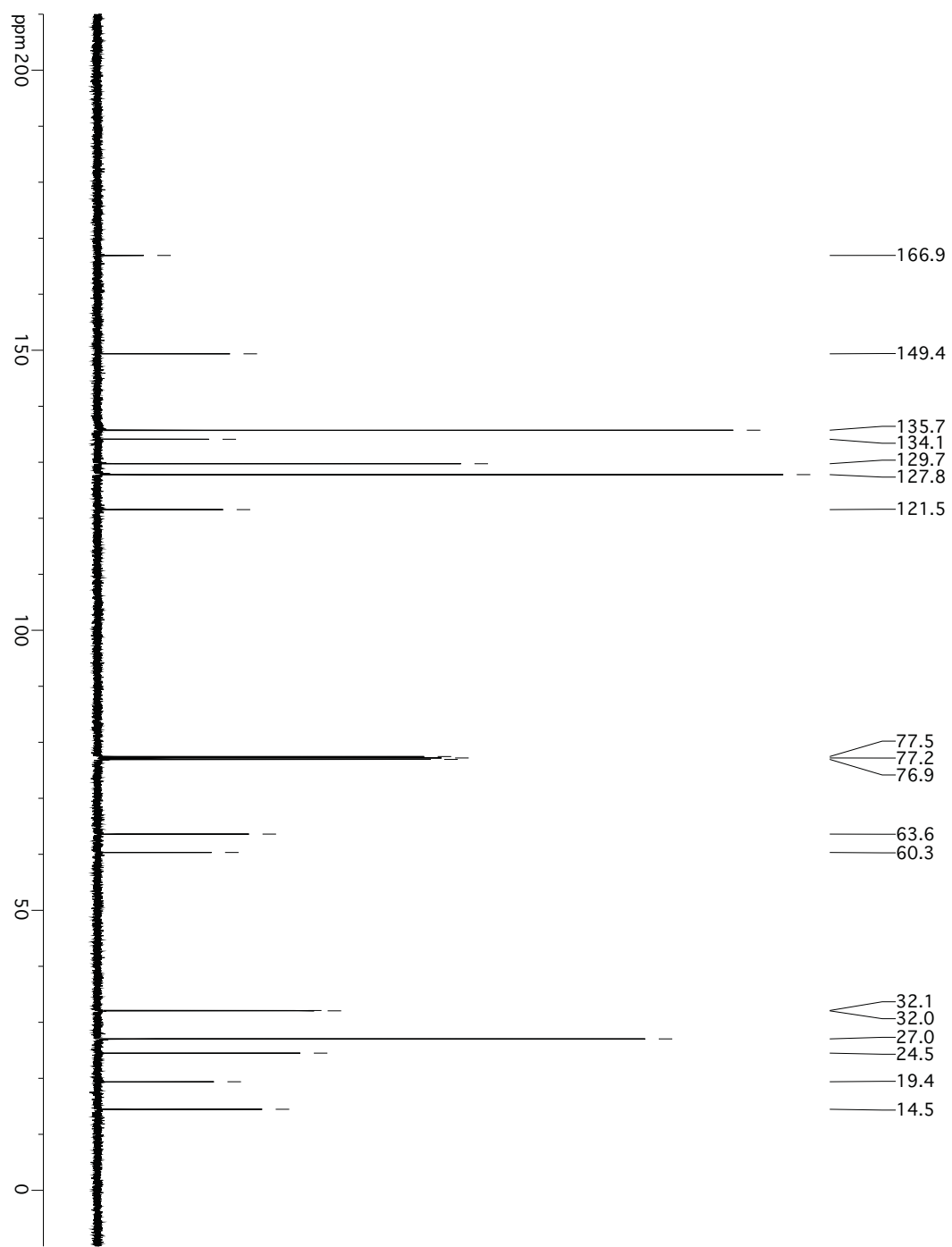
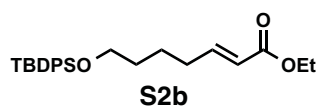


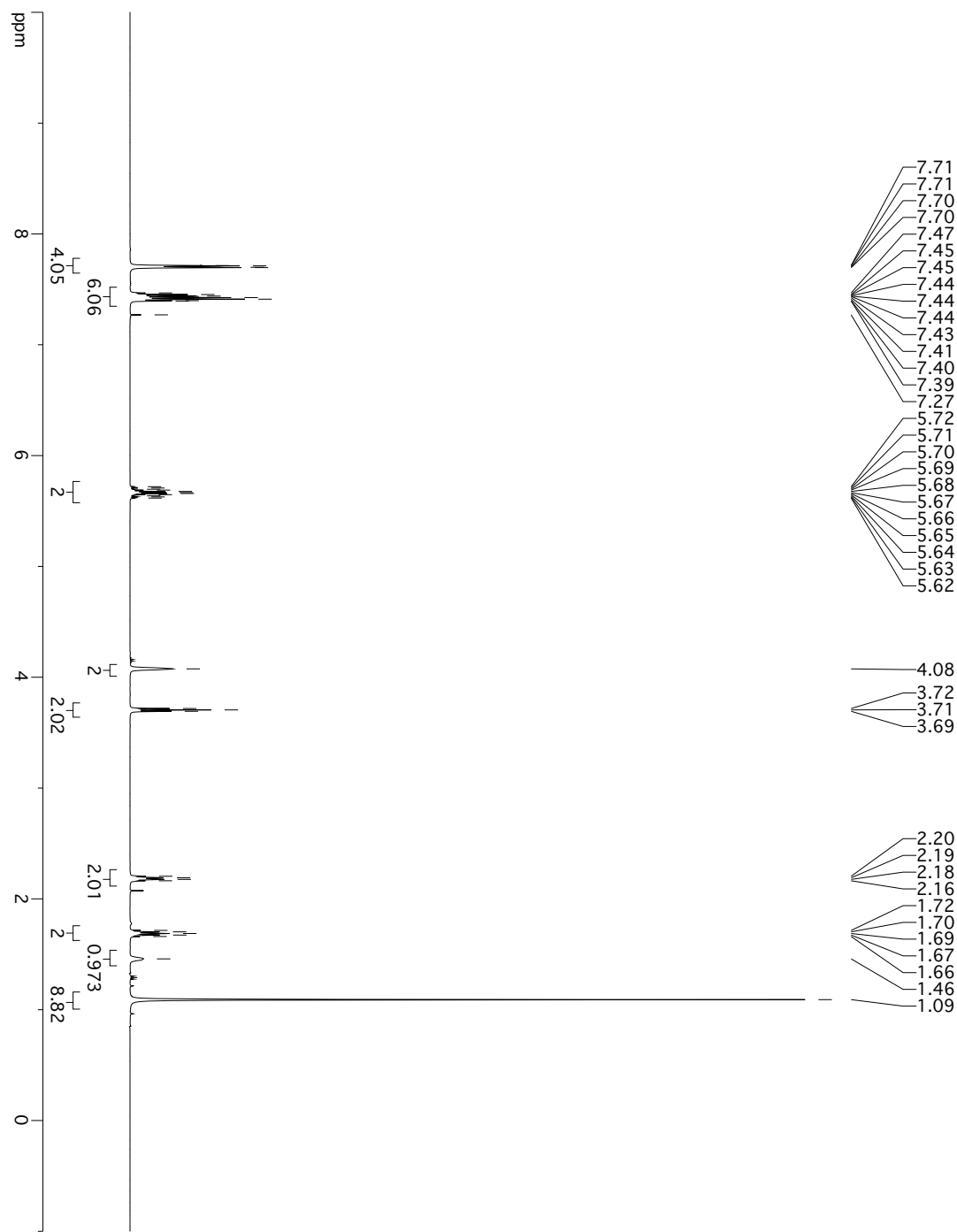
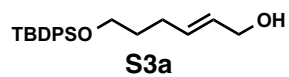


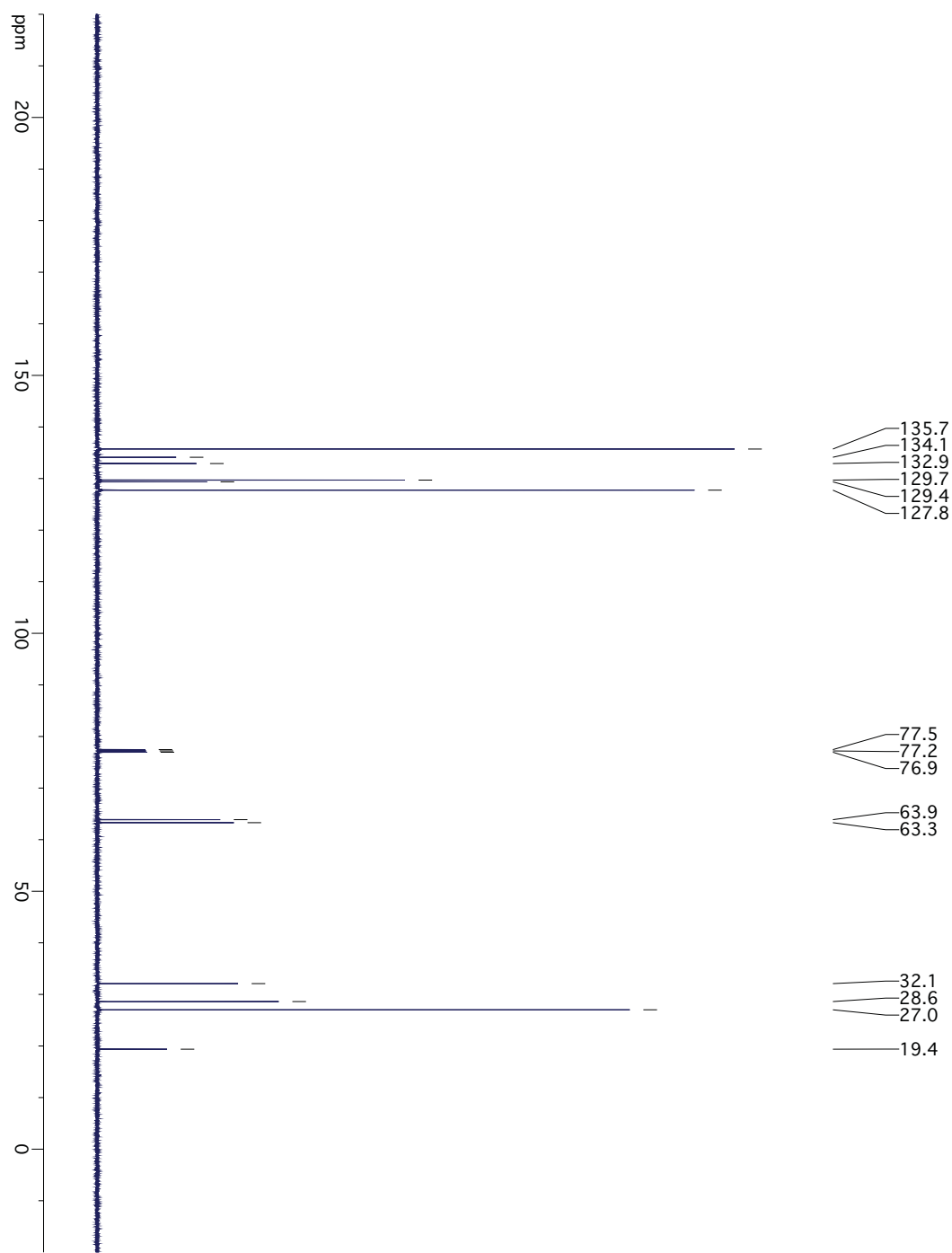
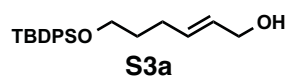


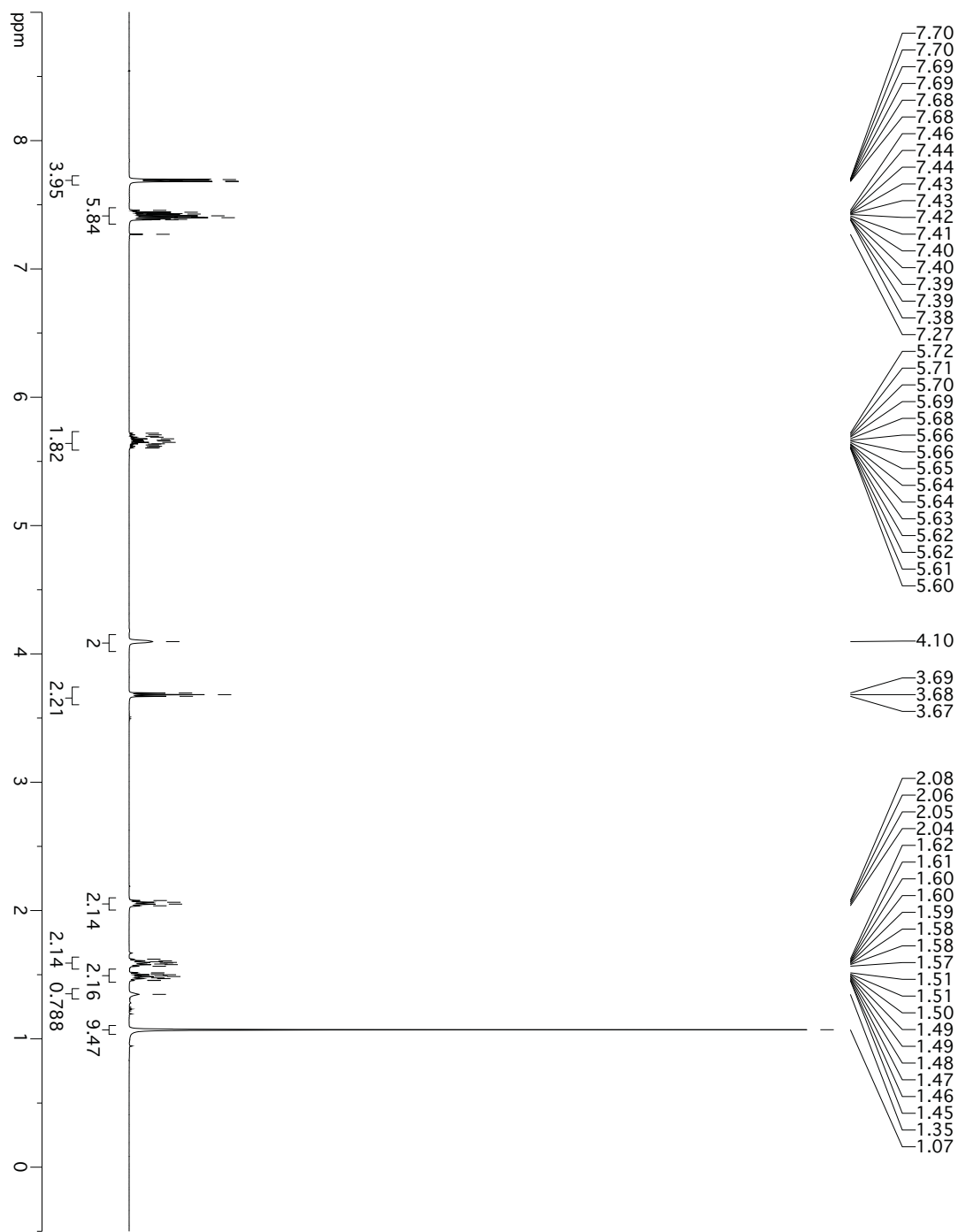
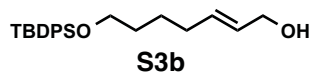


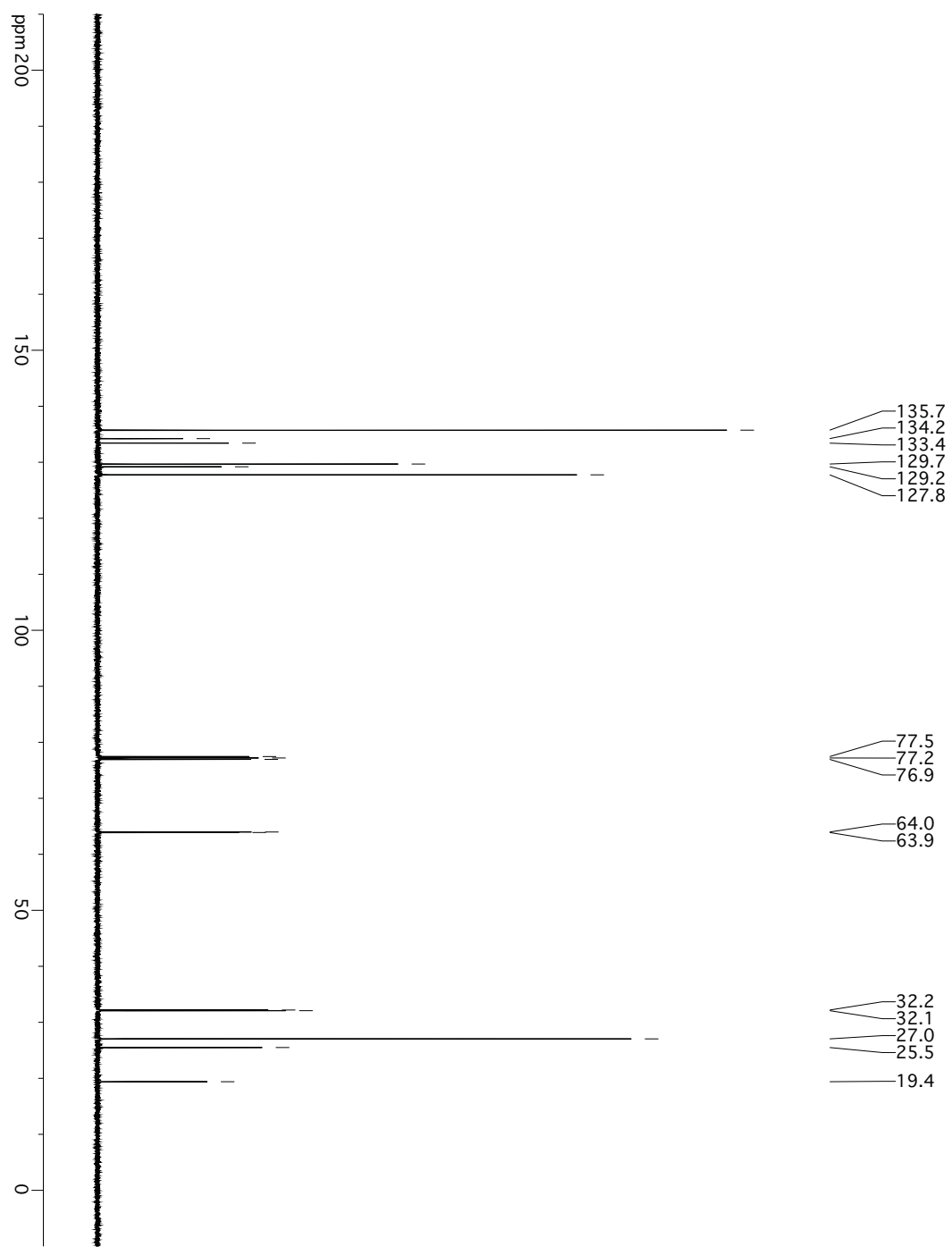
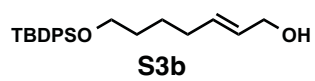


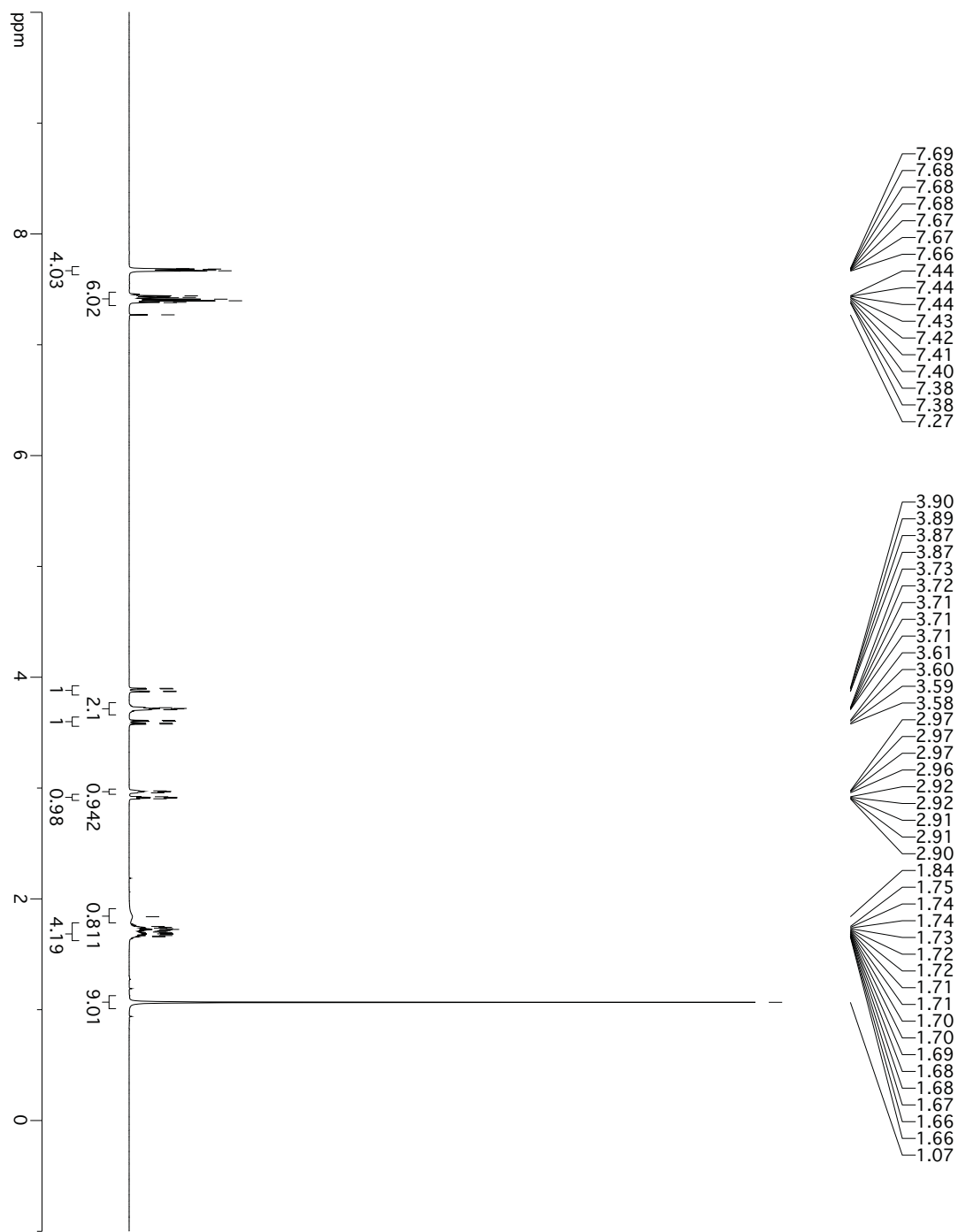
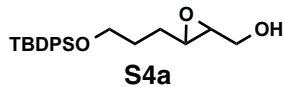


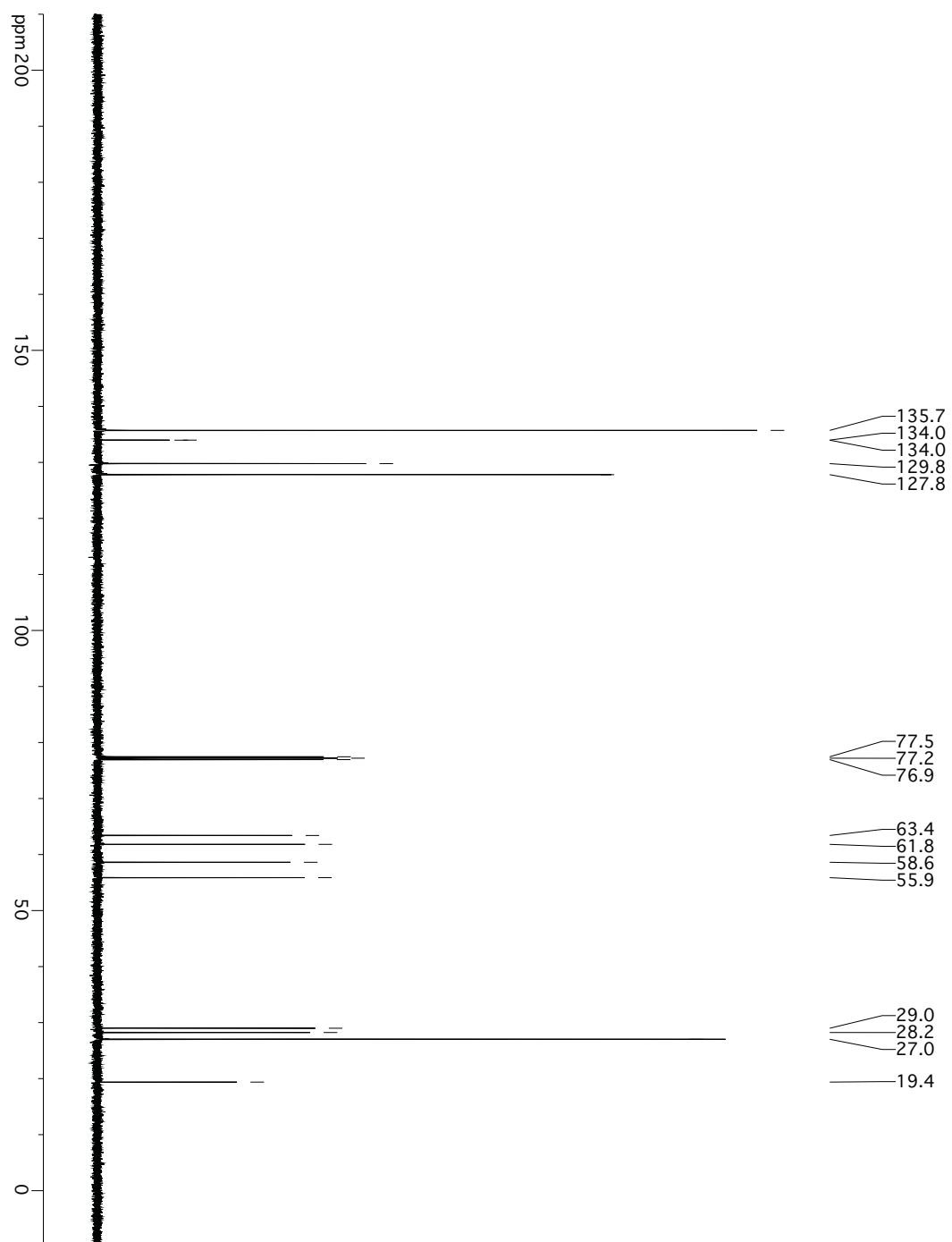




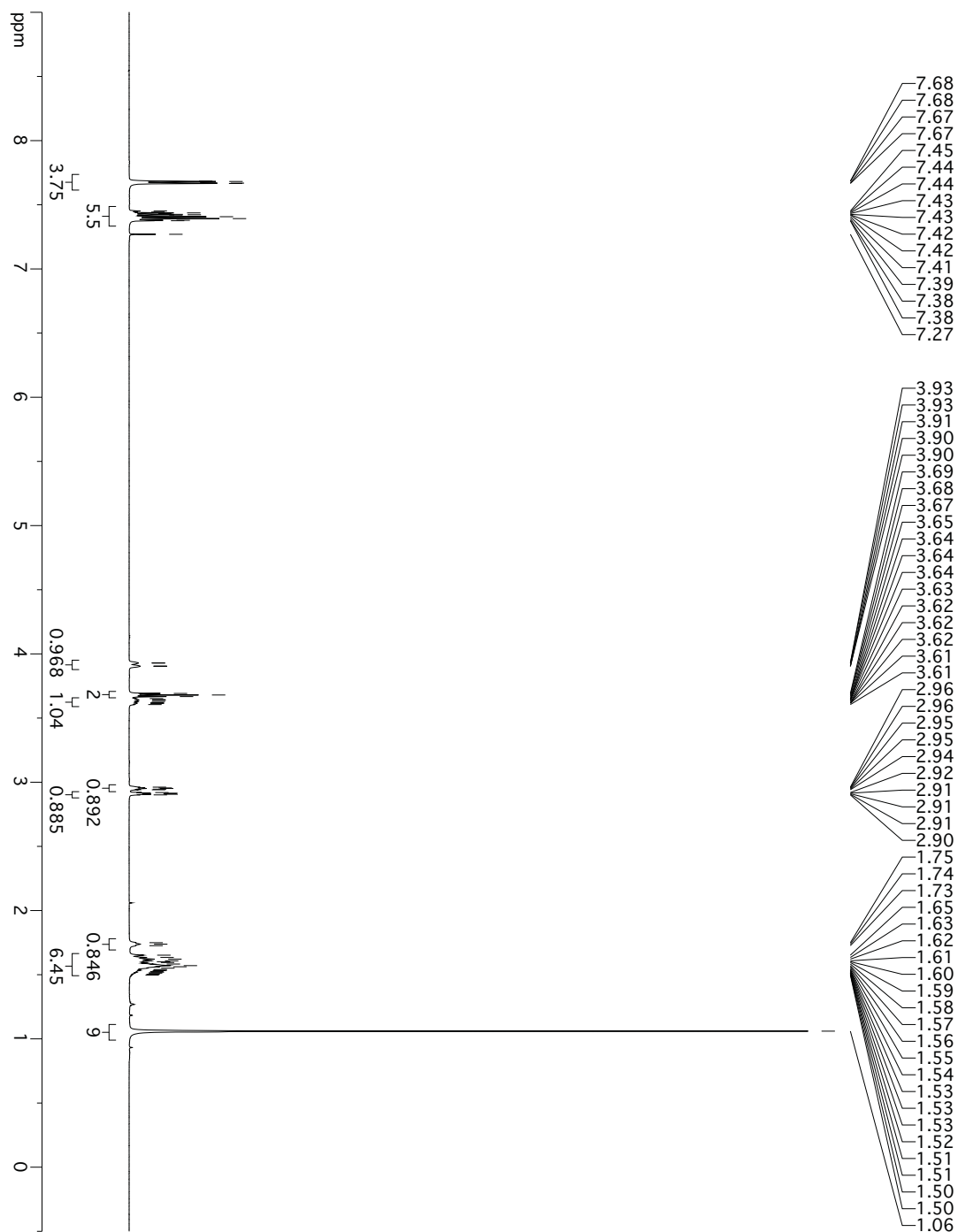




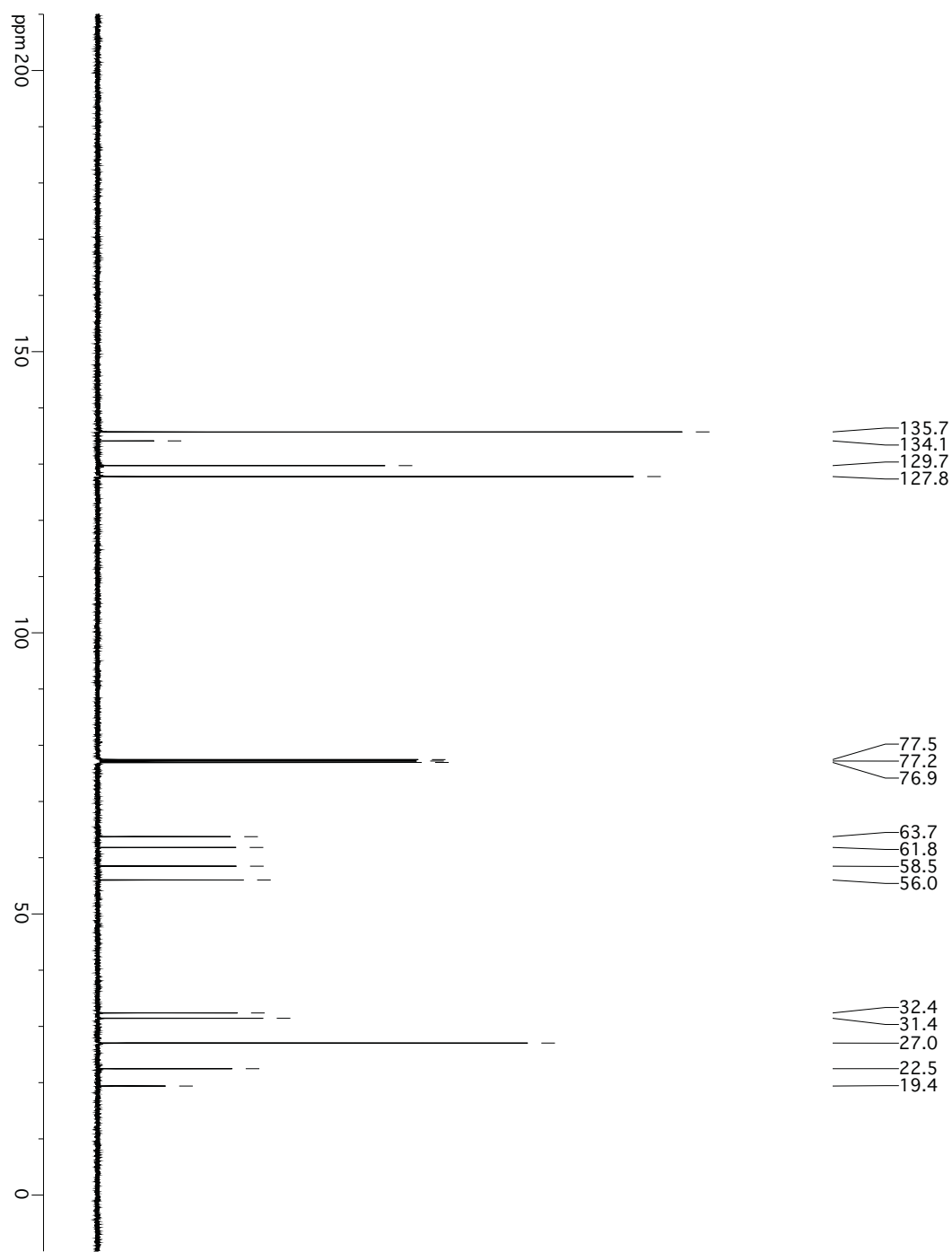


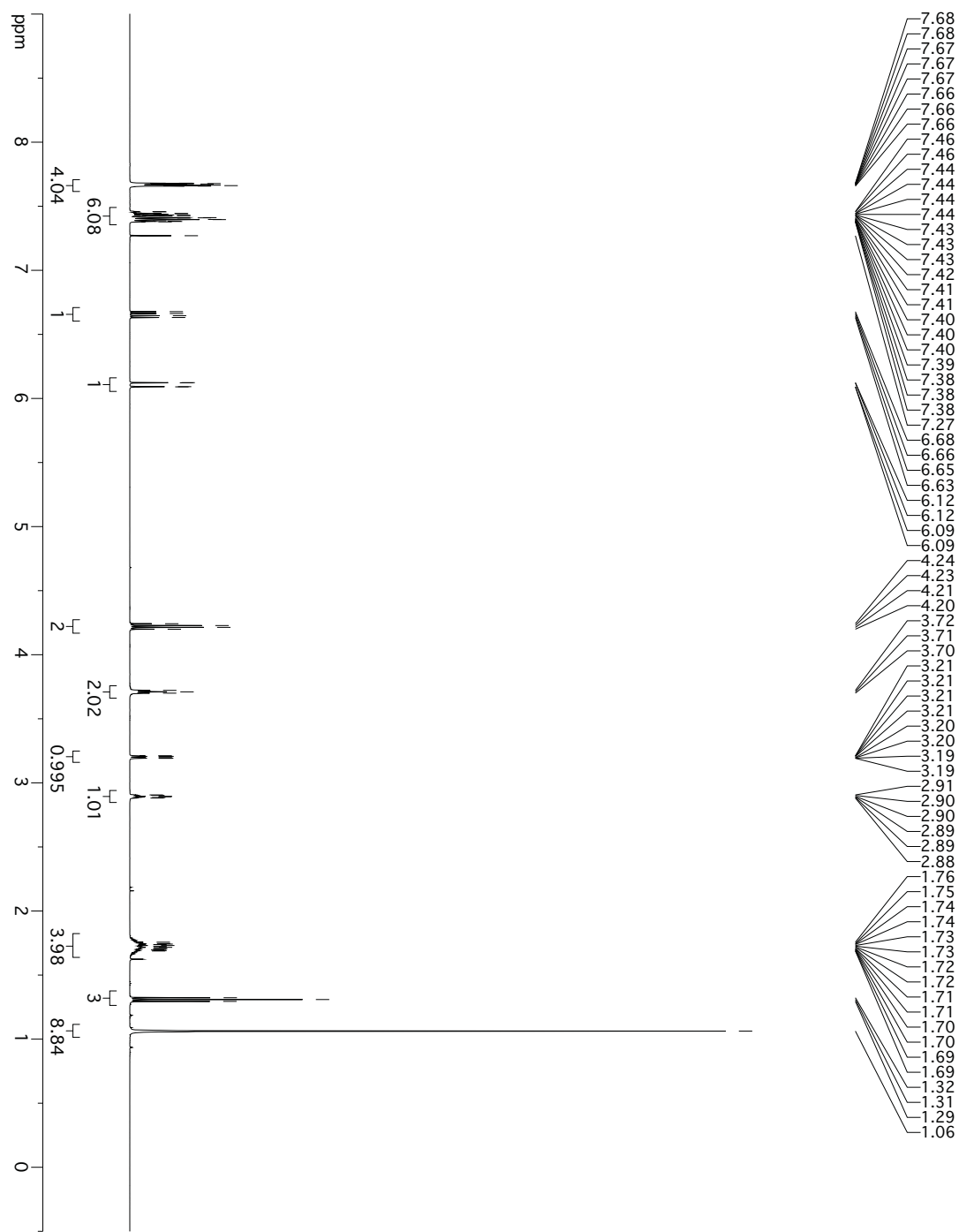
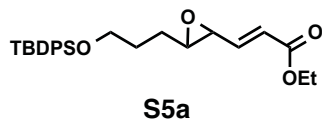


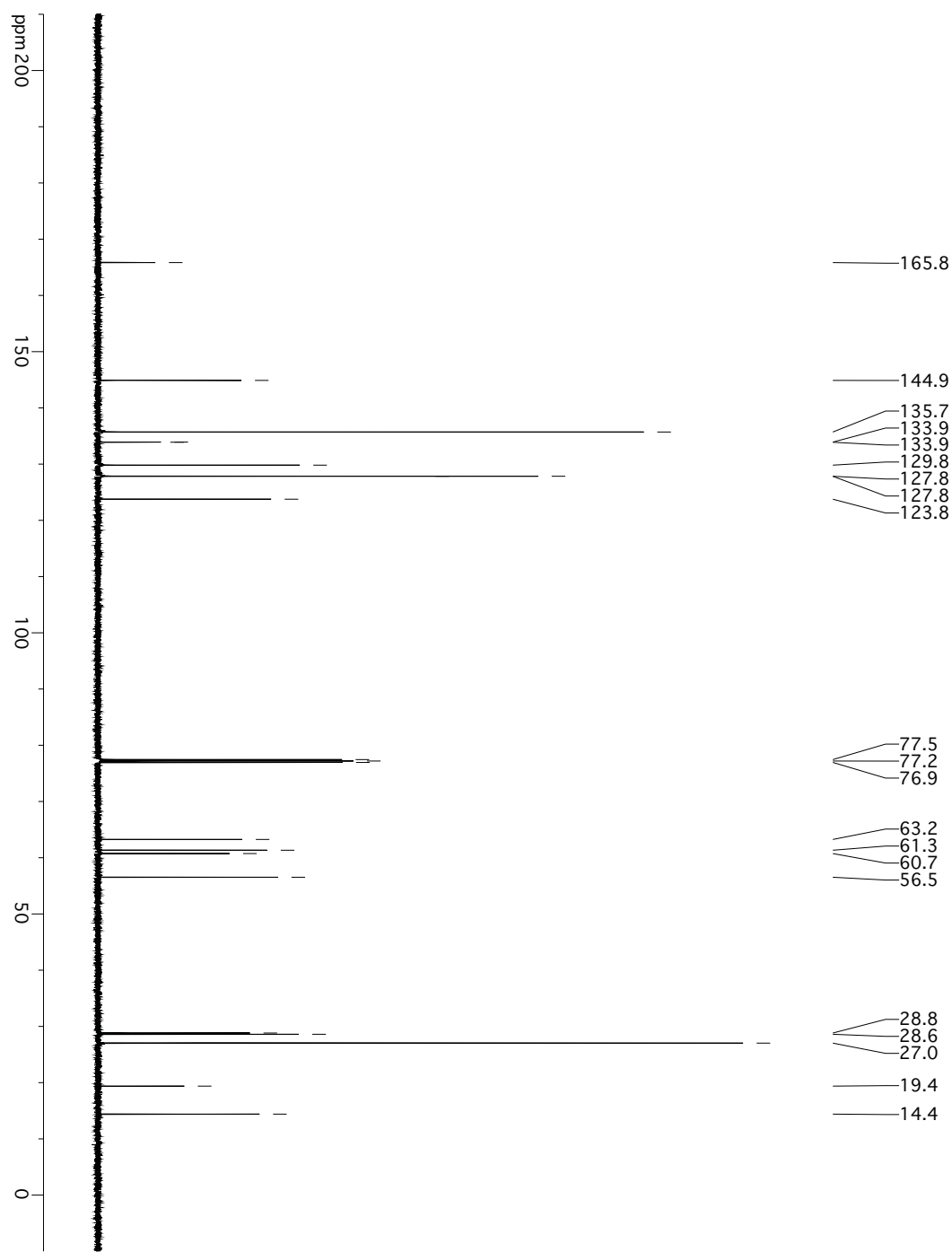
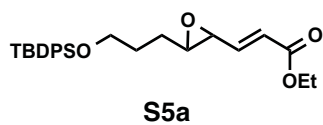
**S4b**

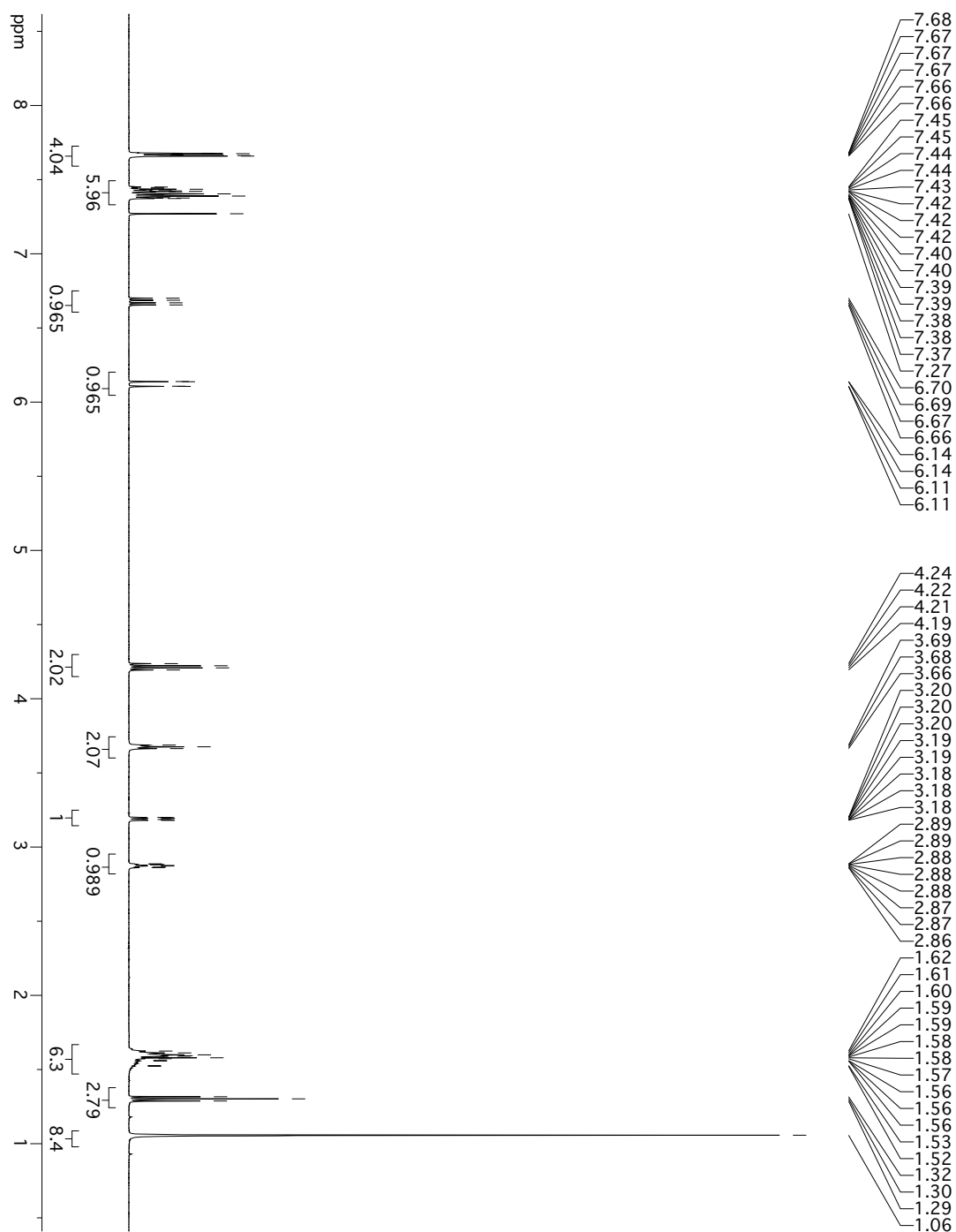
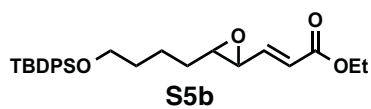


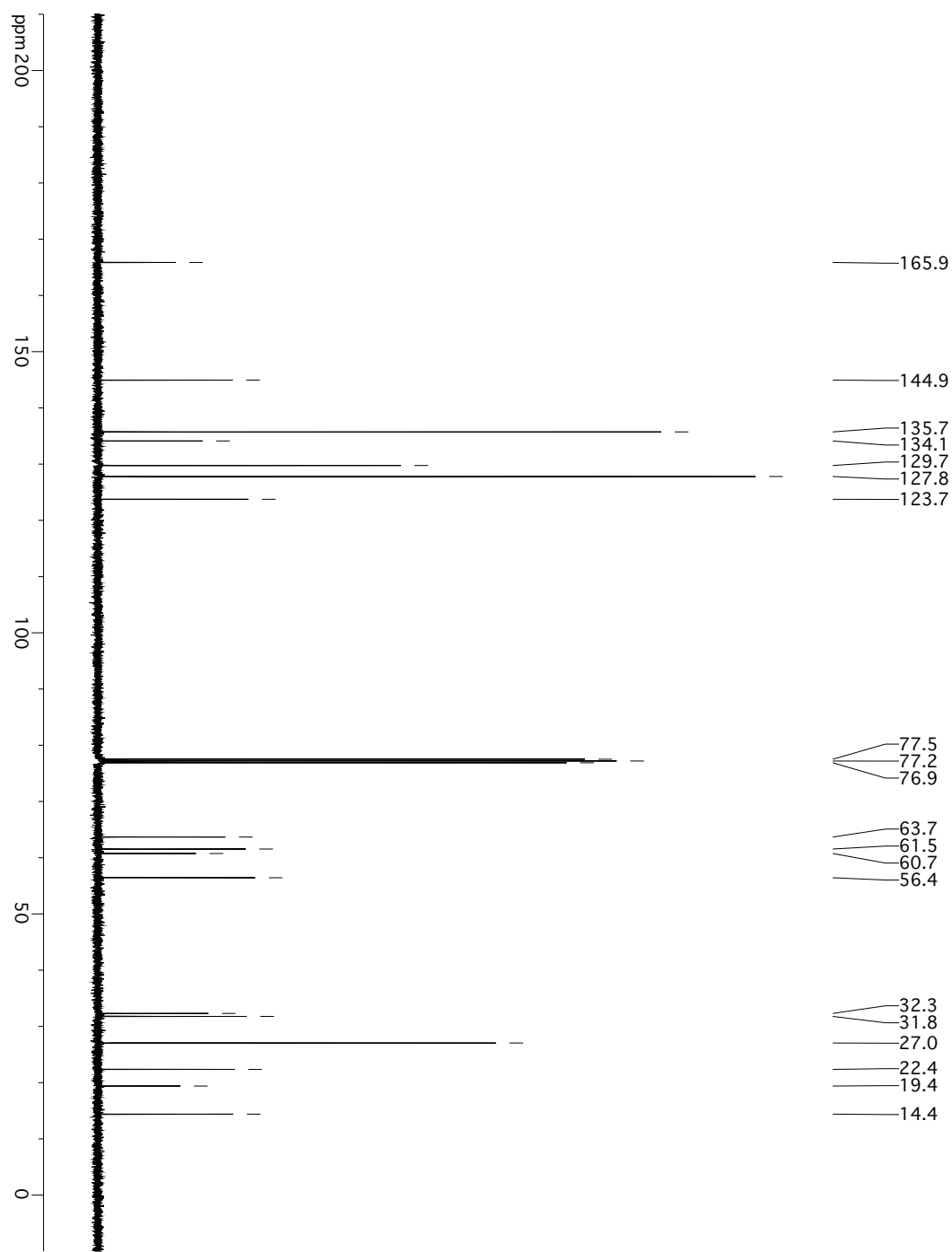
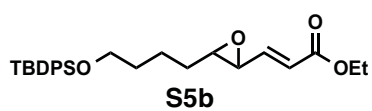


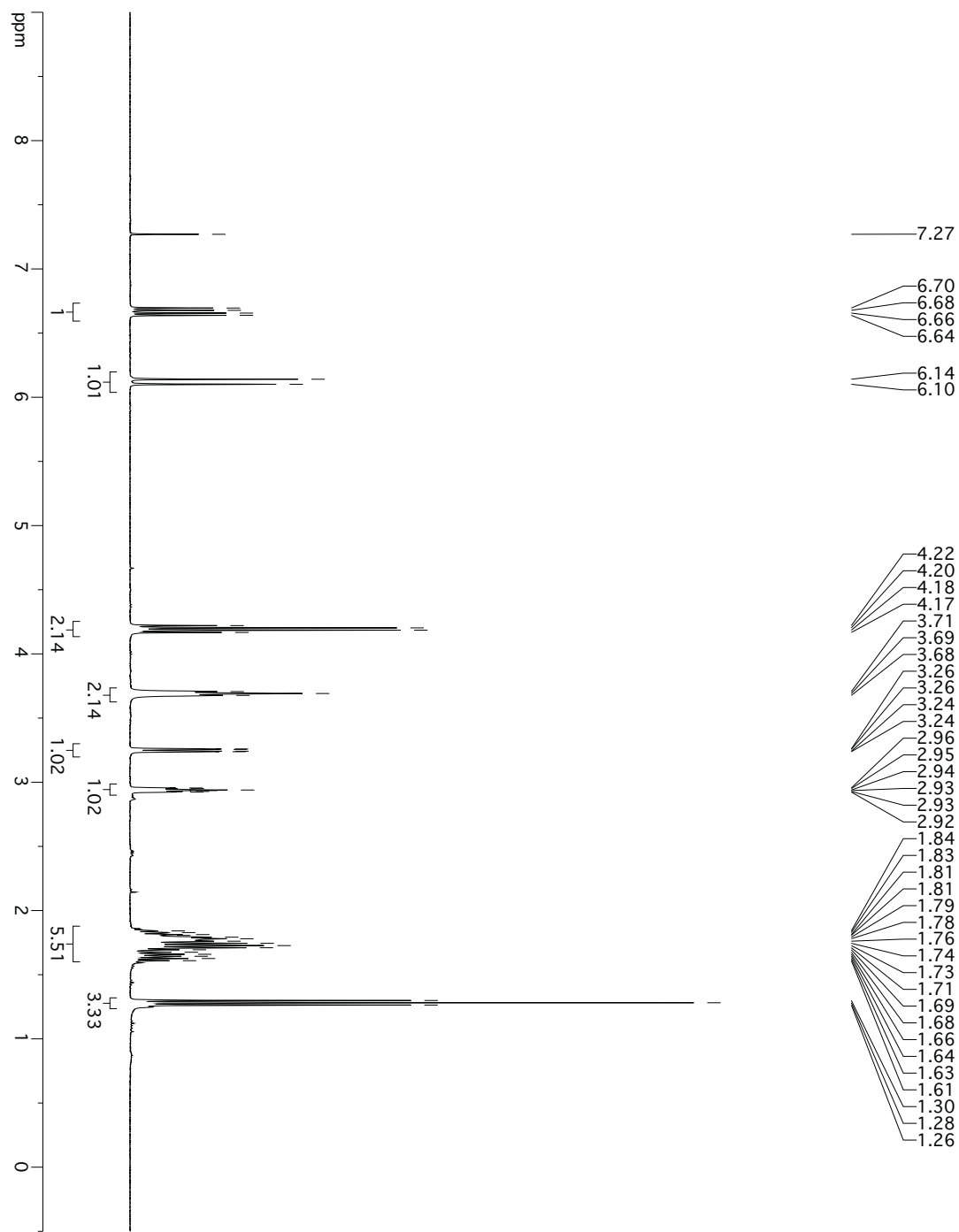
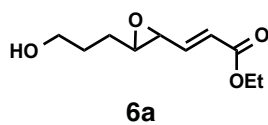


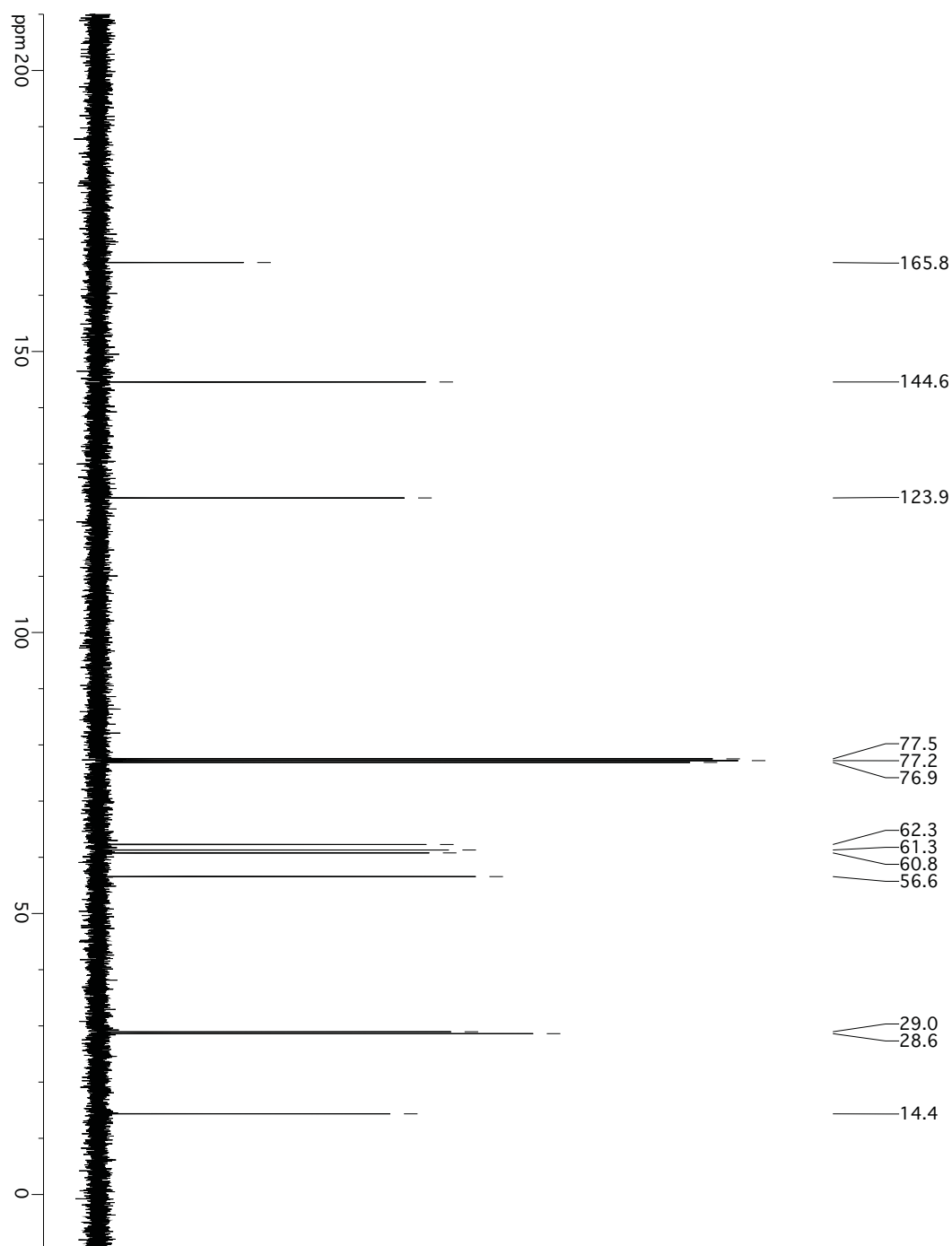
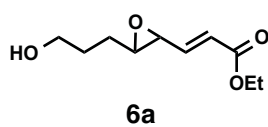


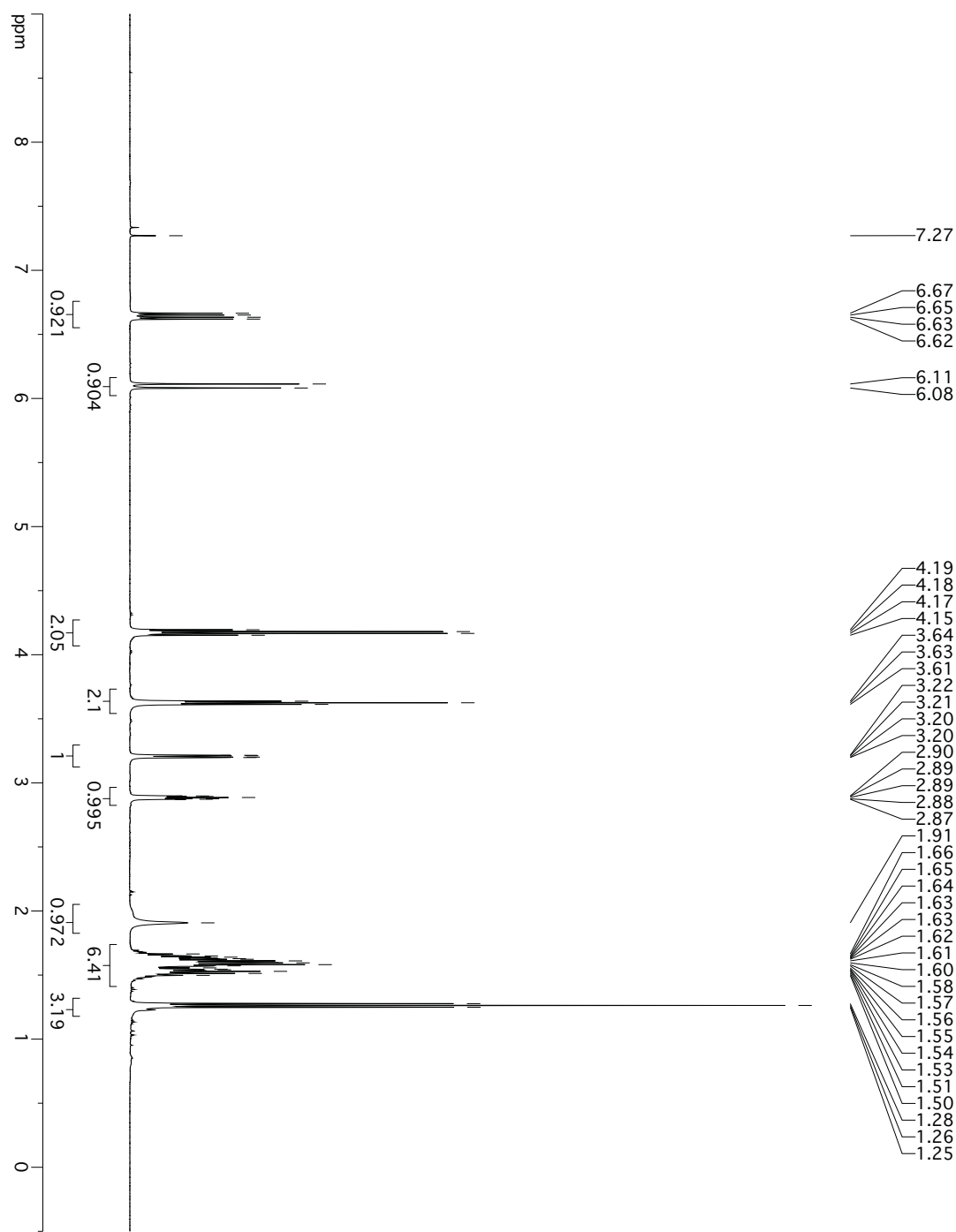
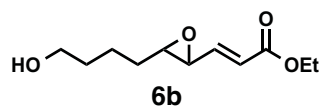




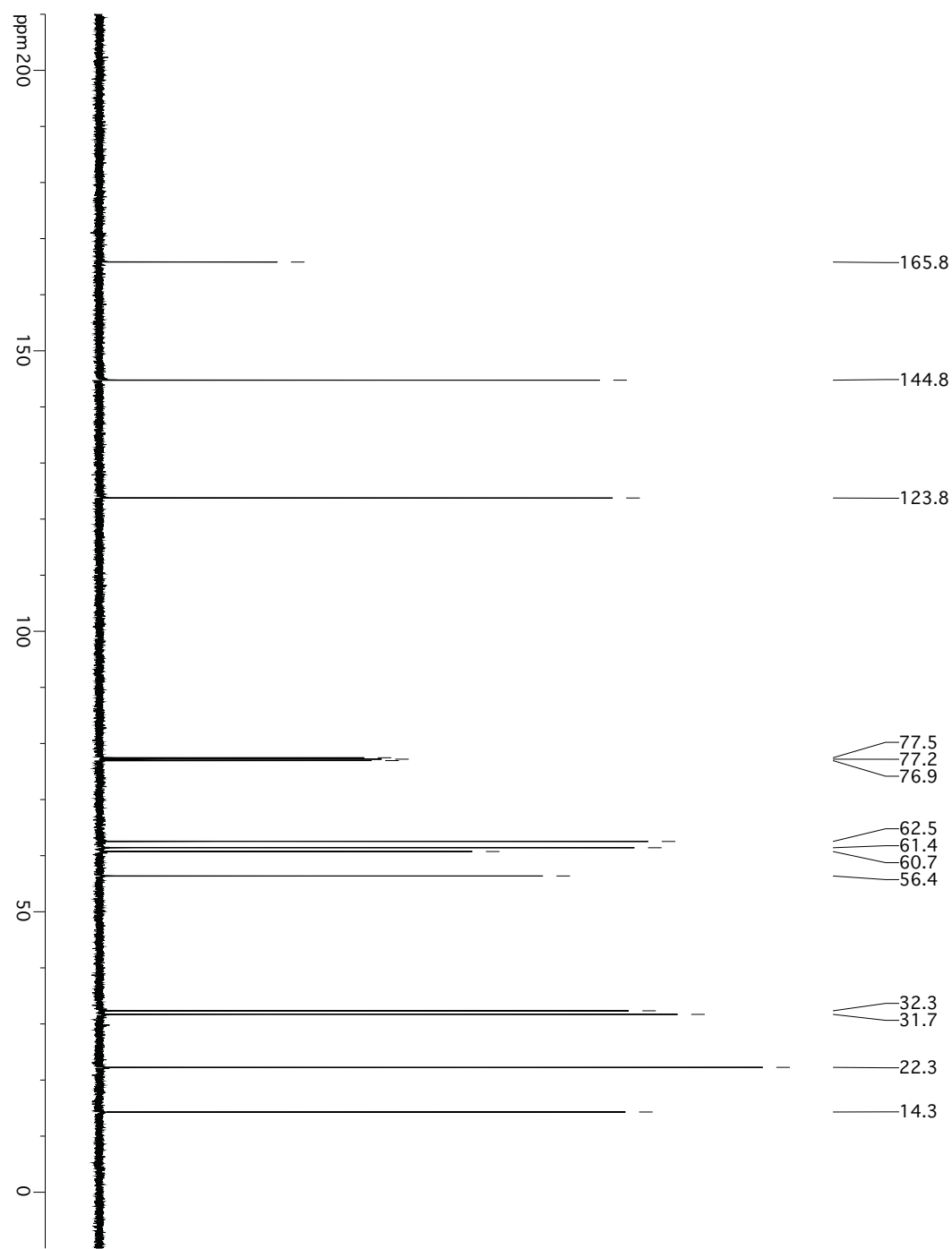
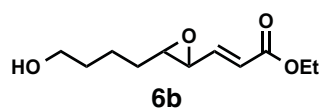


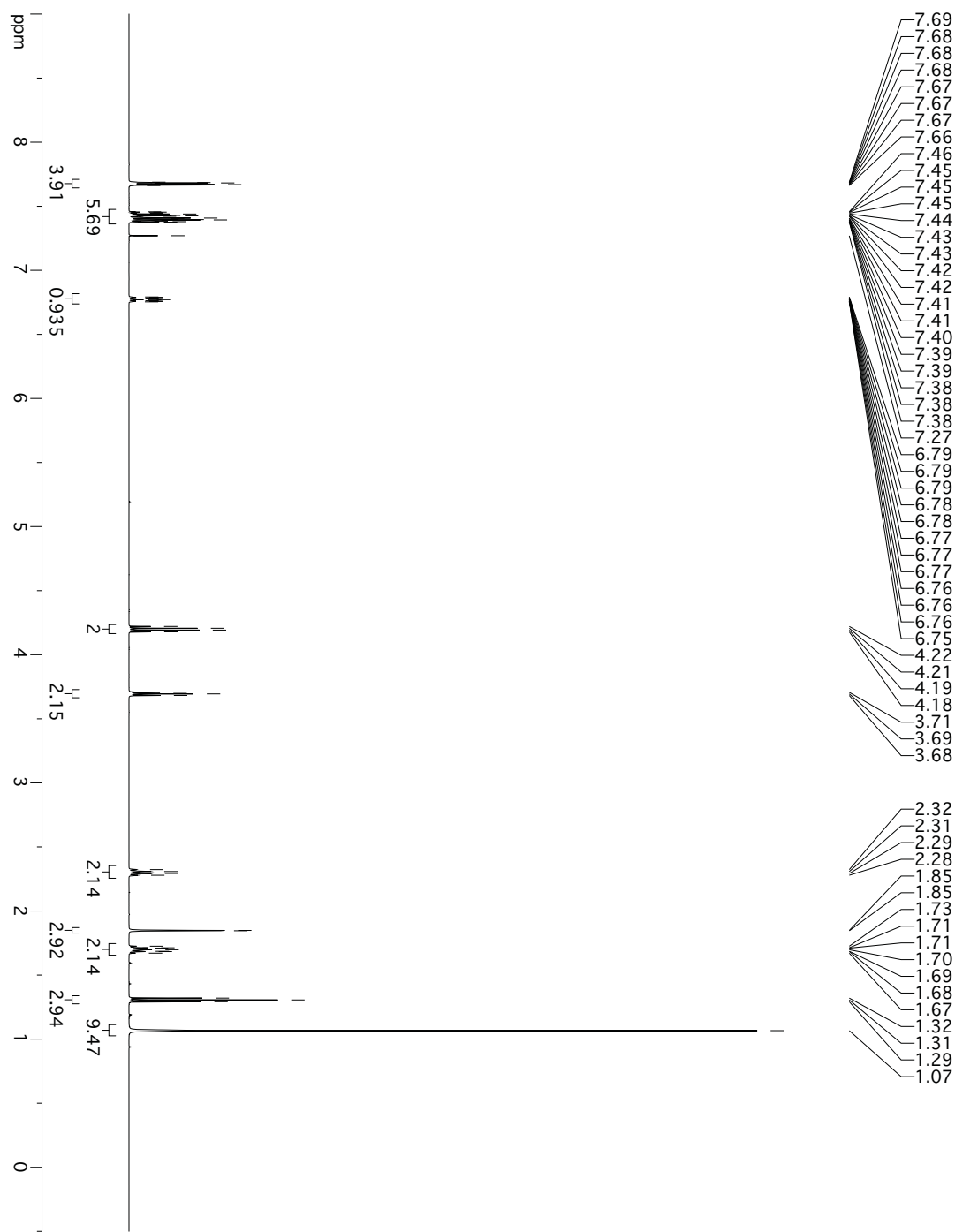


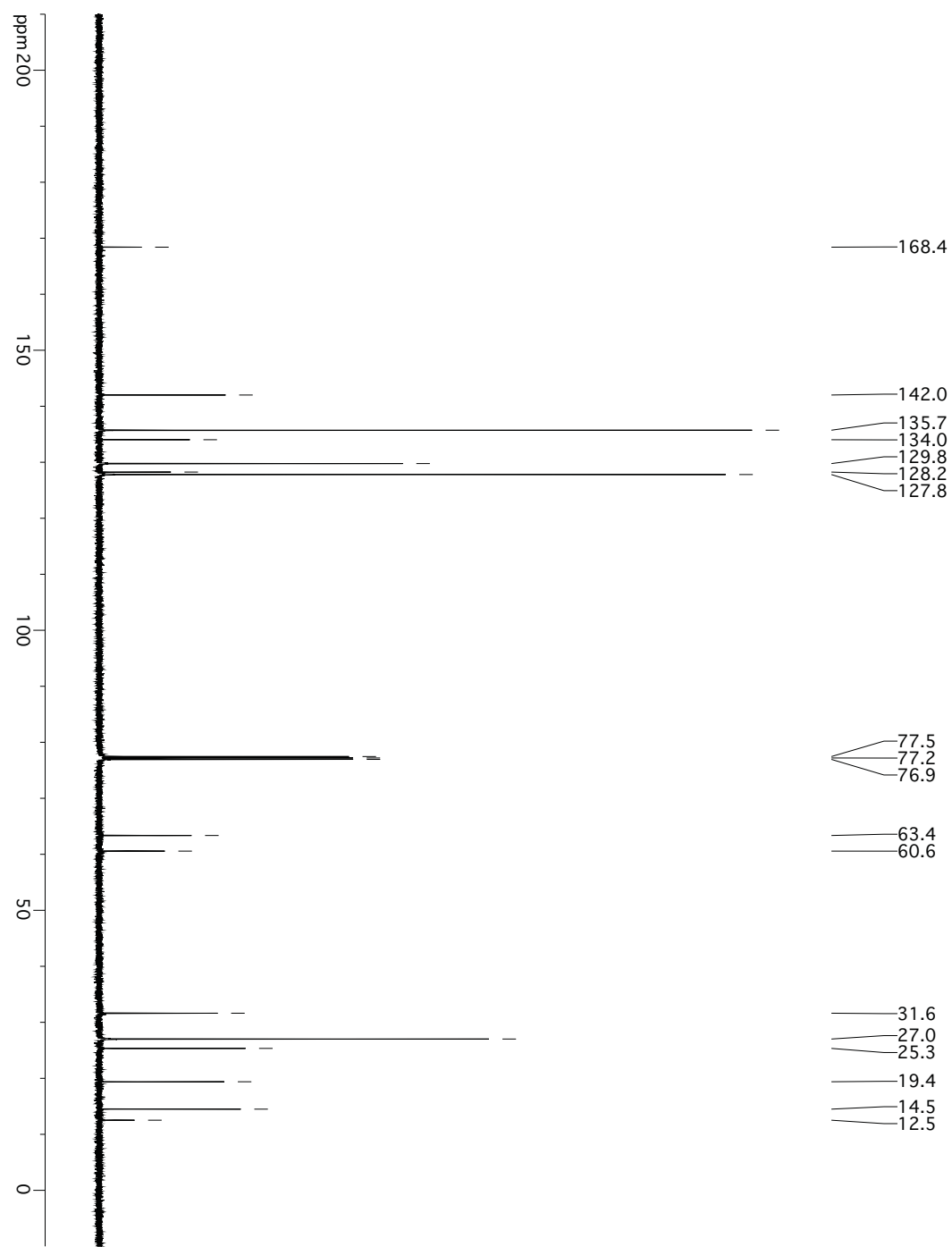


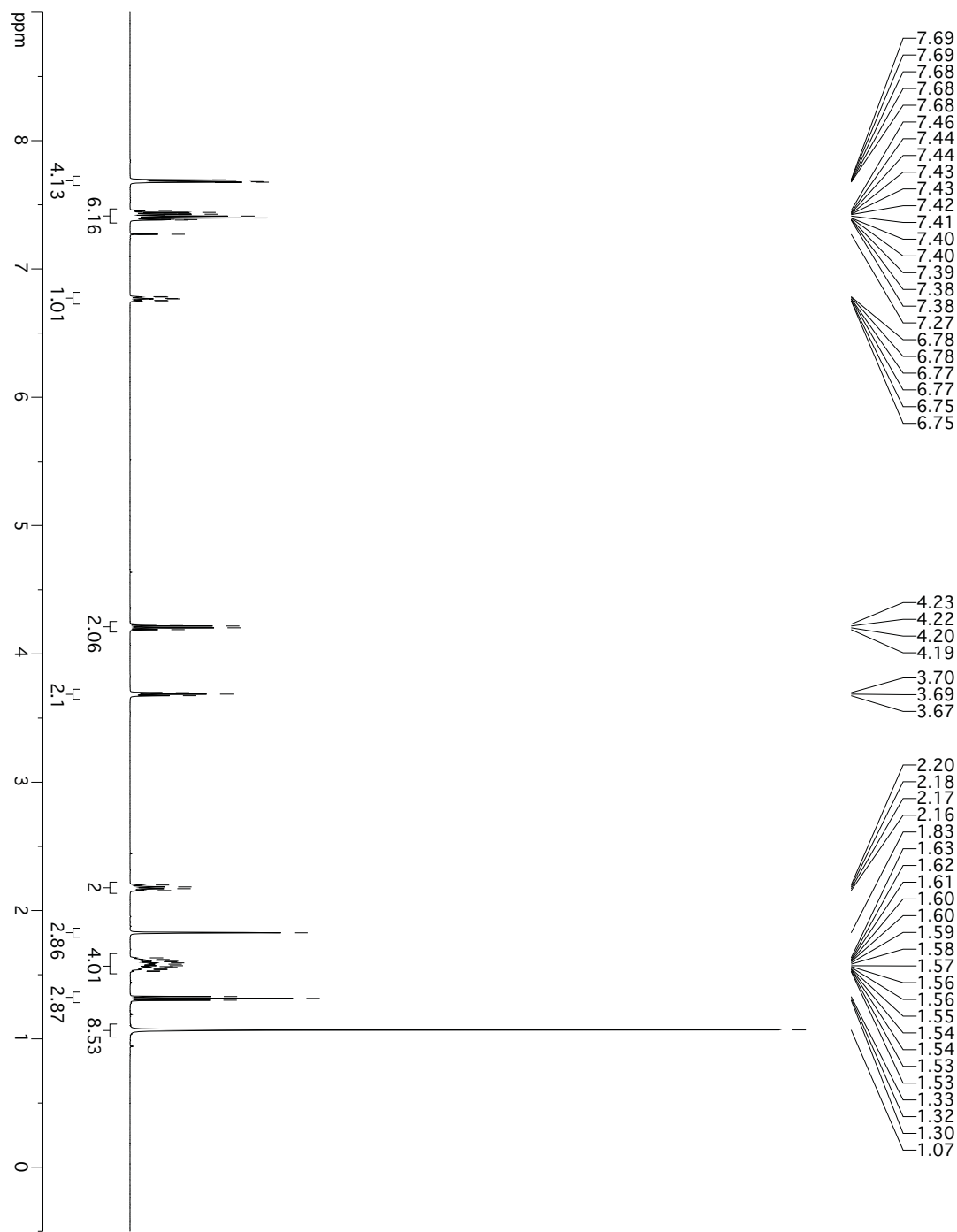
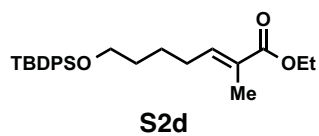


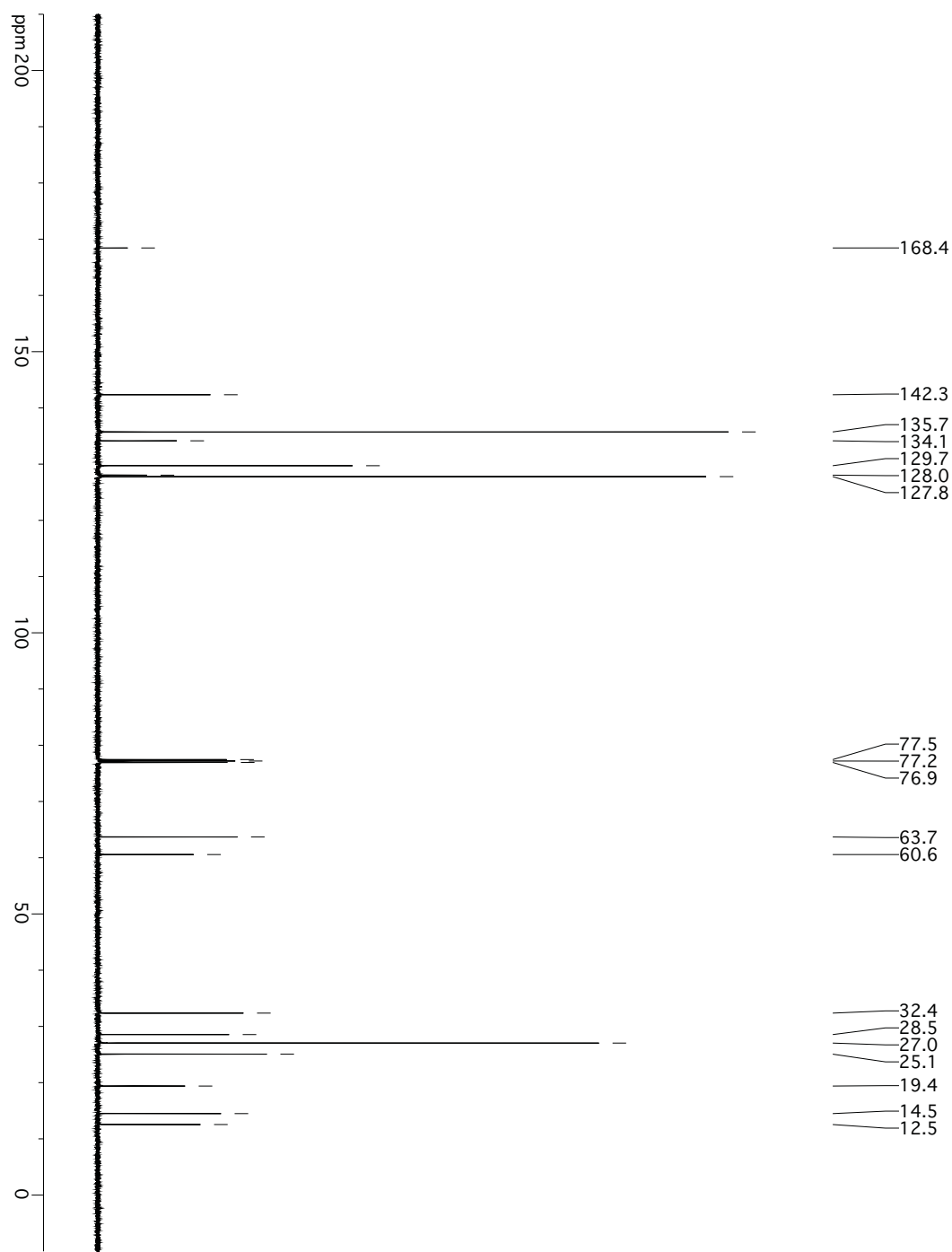
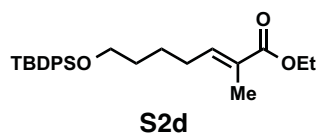


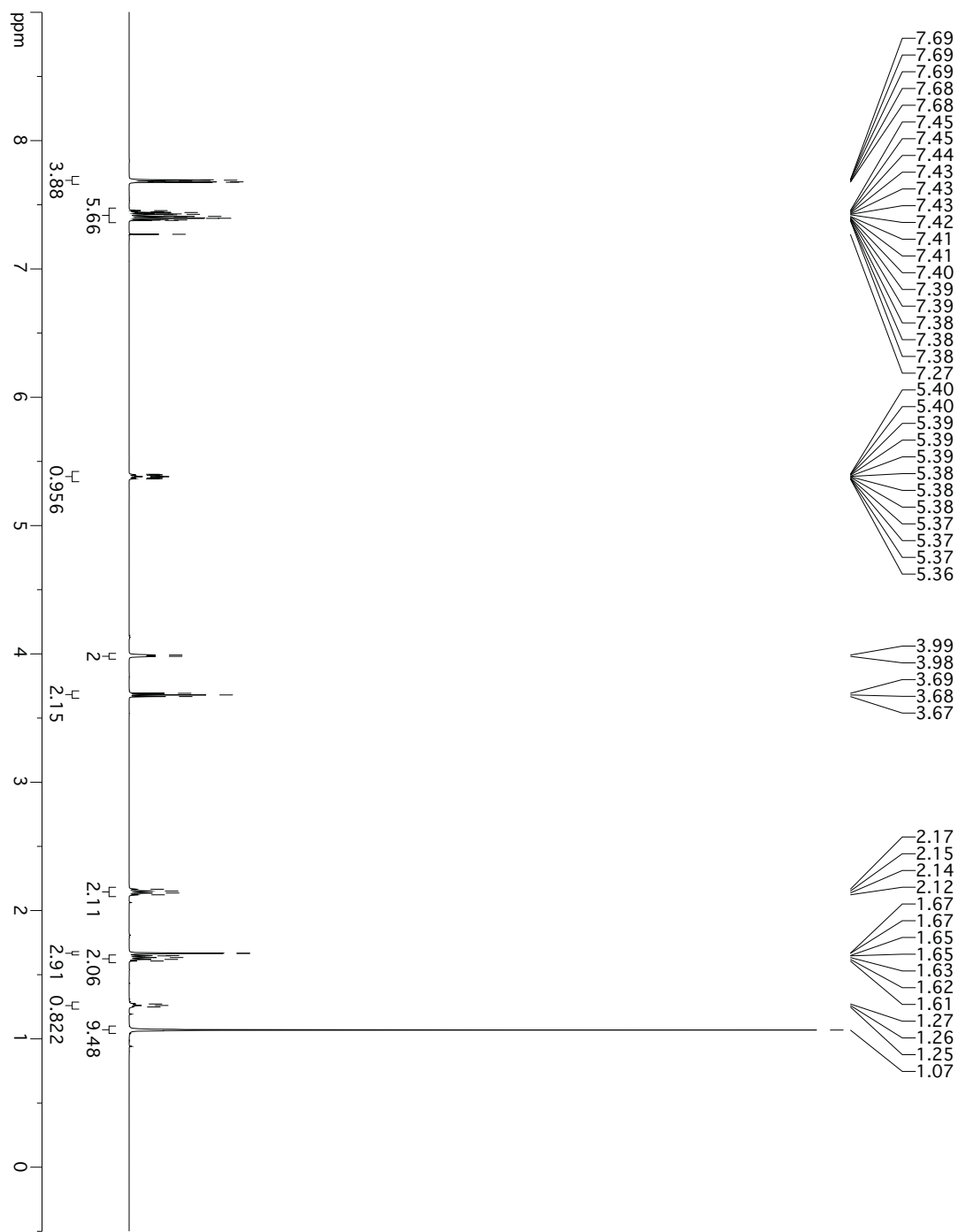


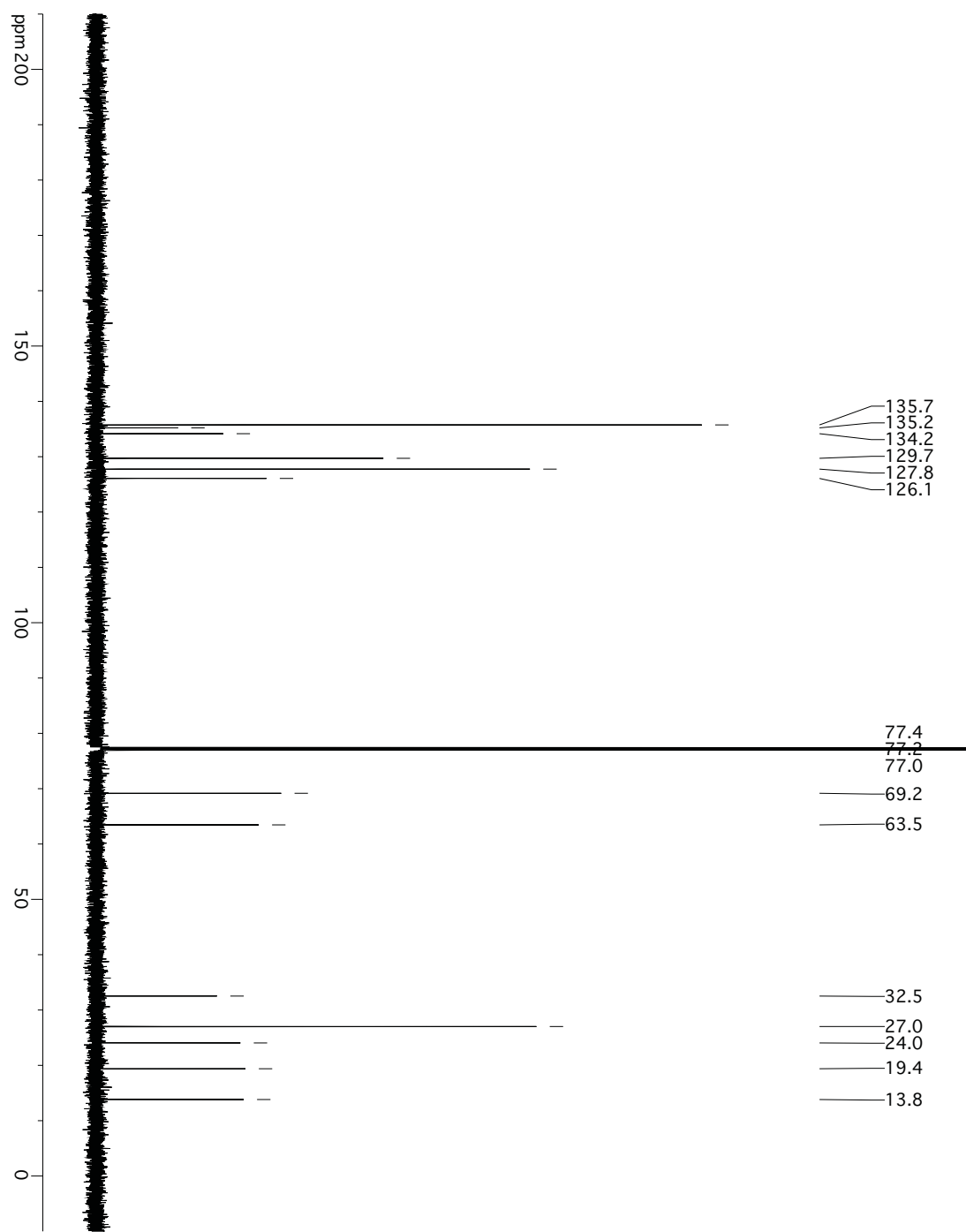
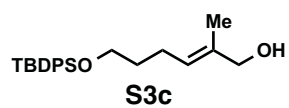


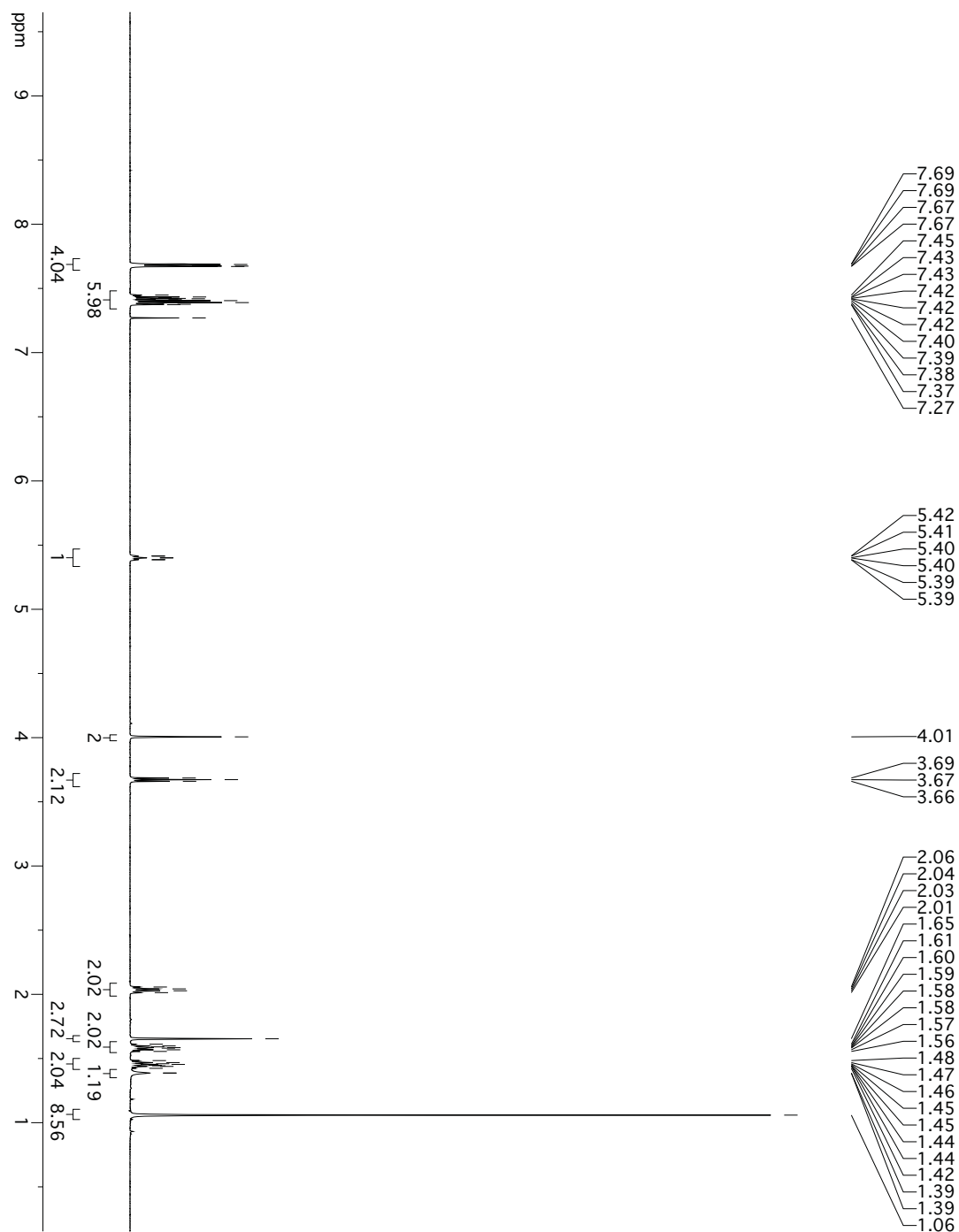
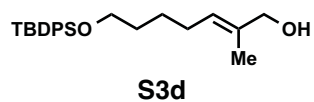




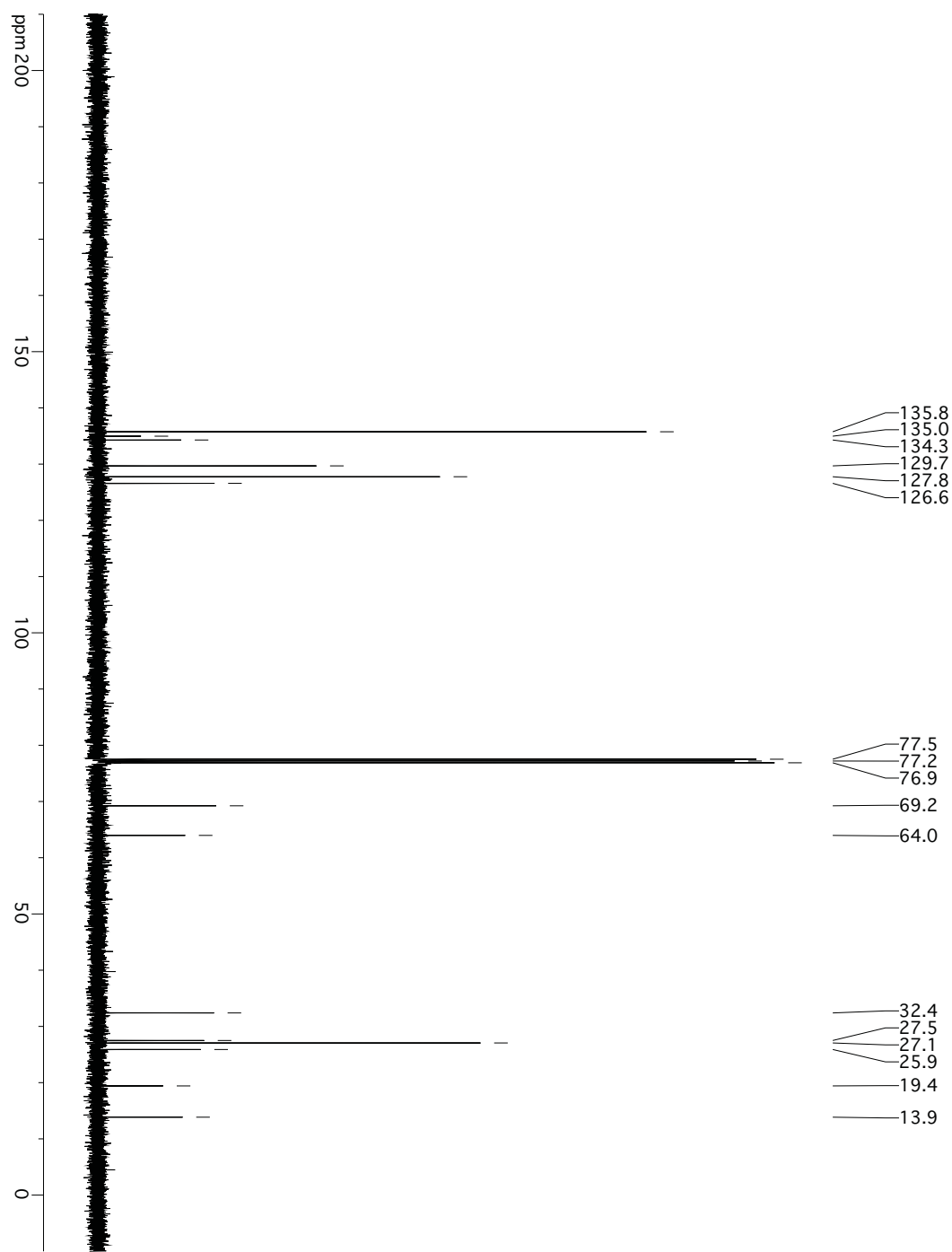
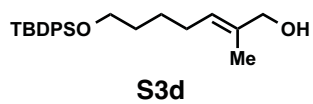


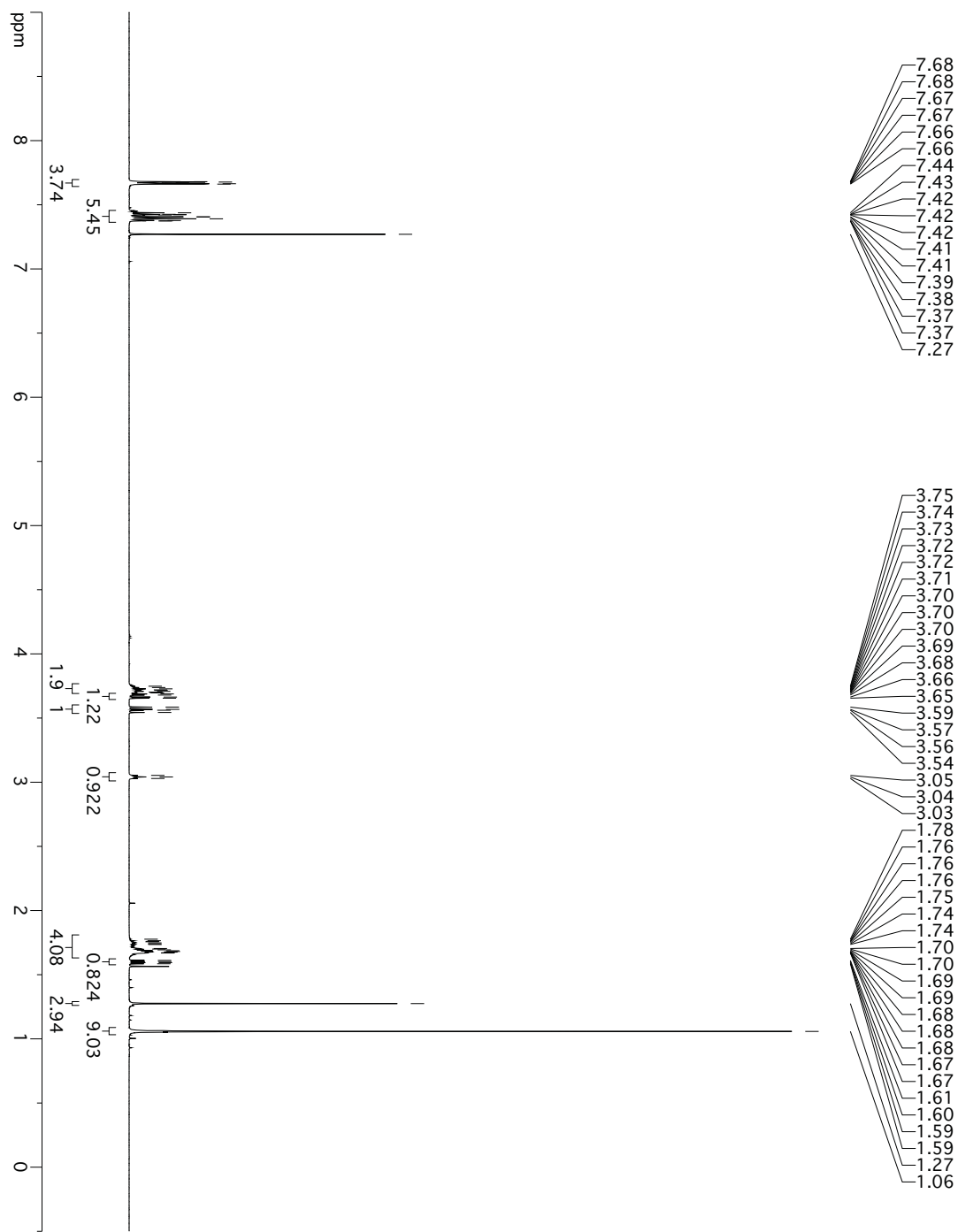
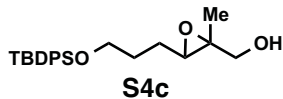


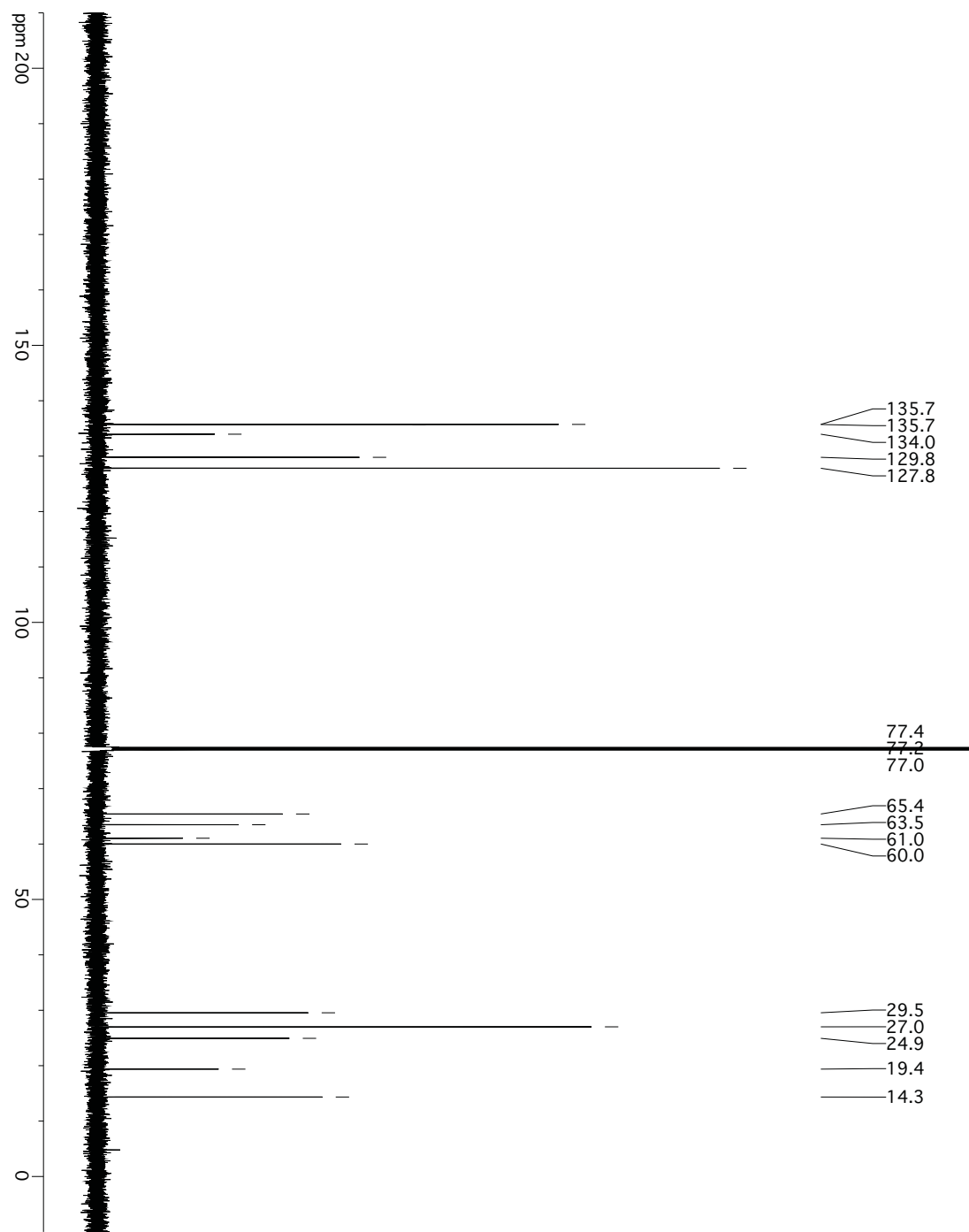


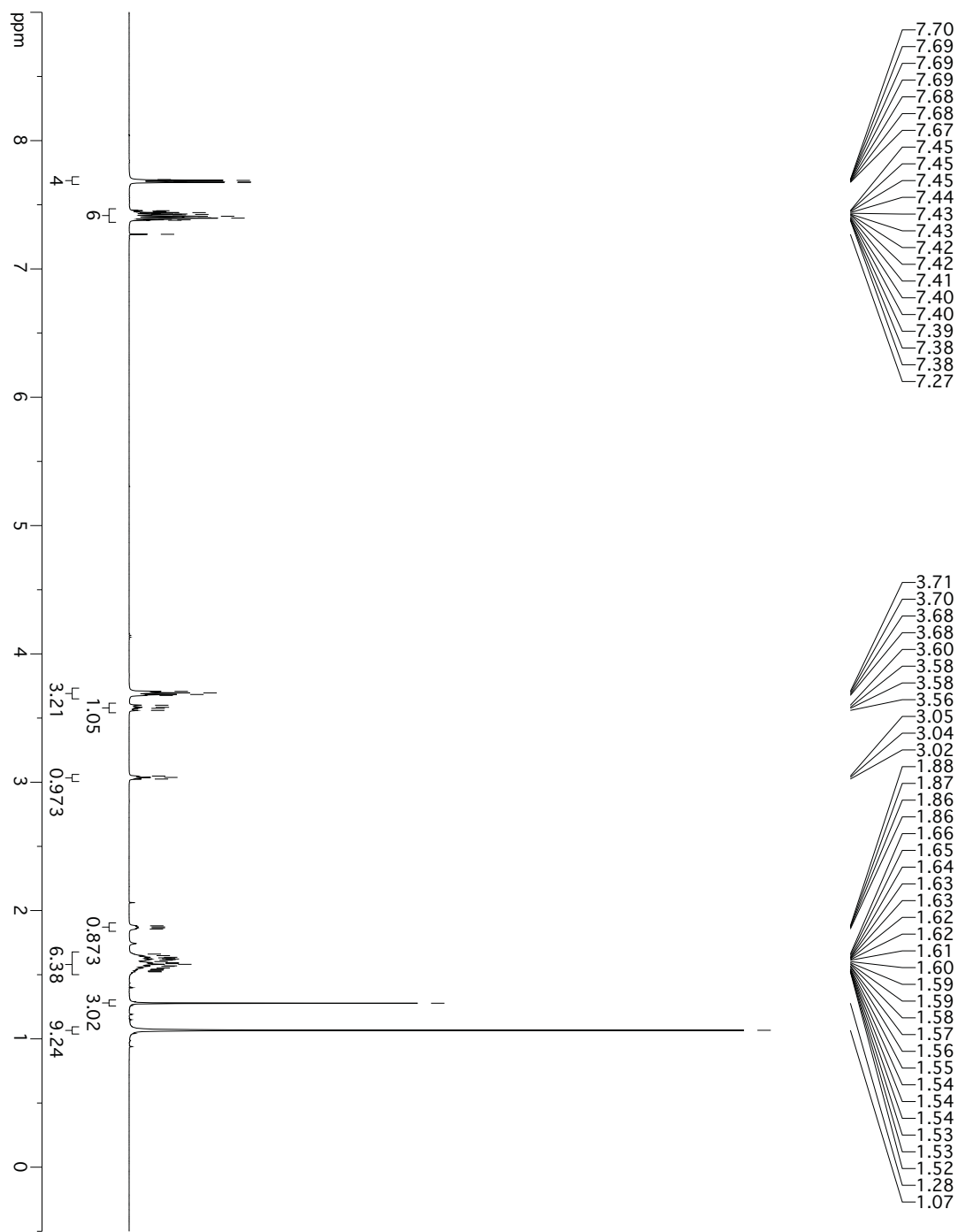
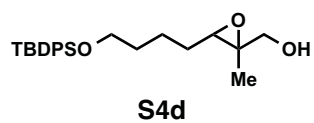


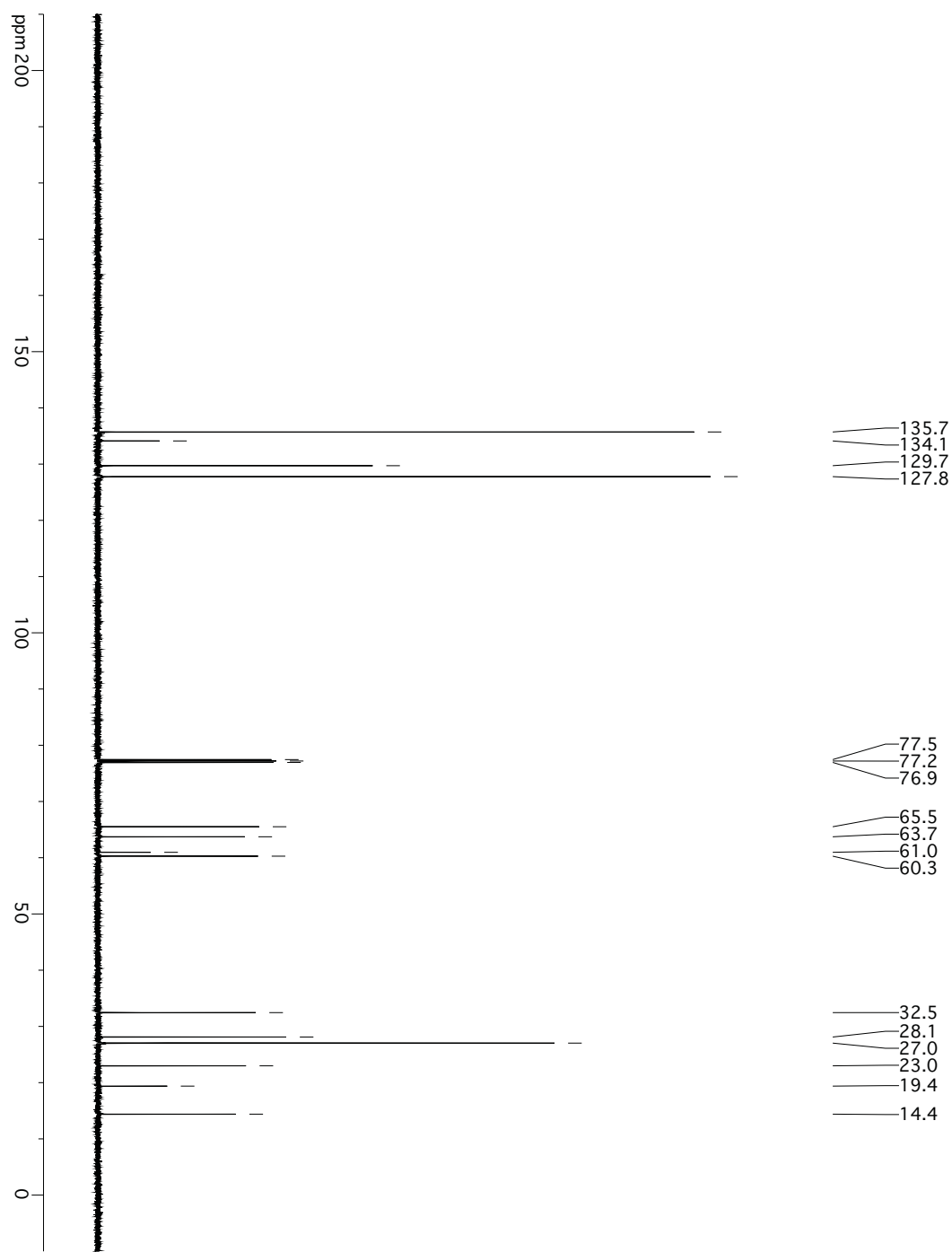
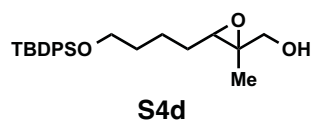


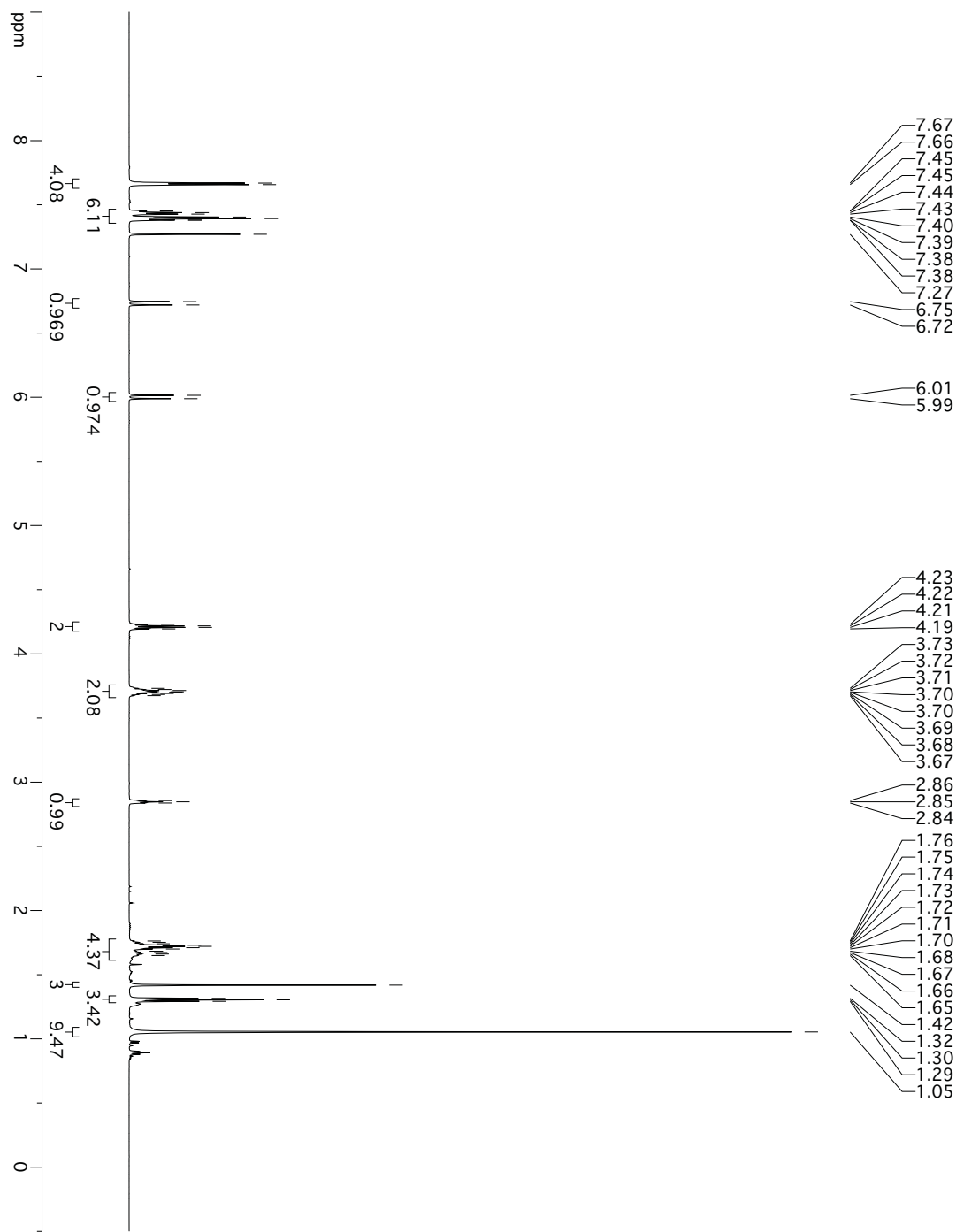
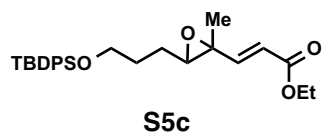


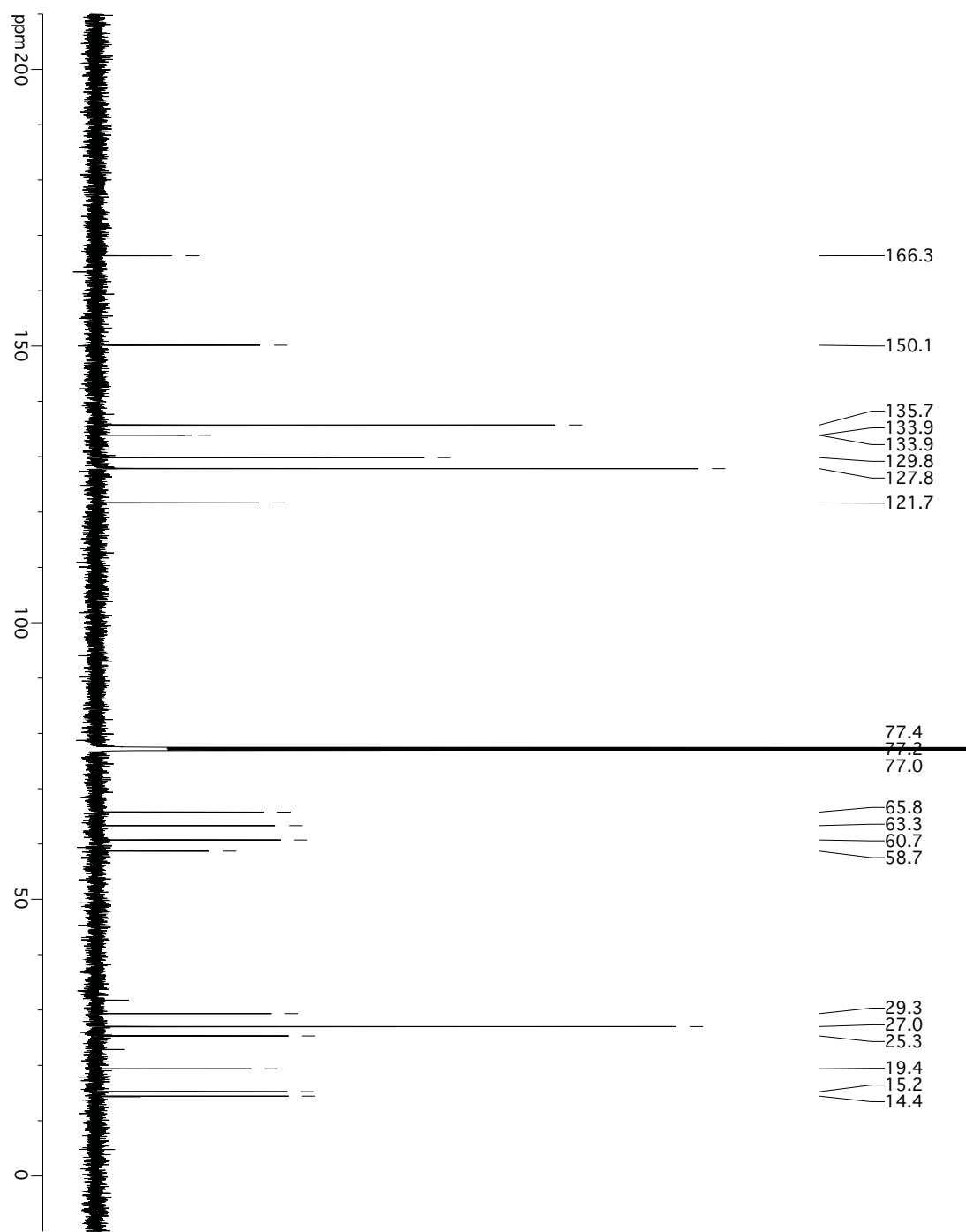
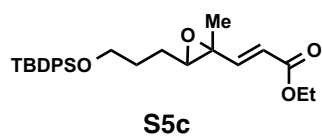


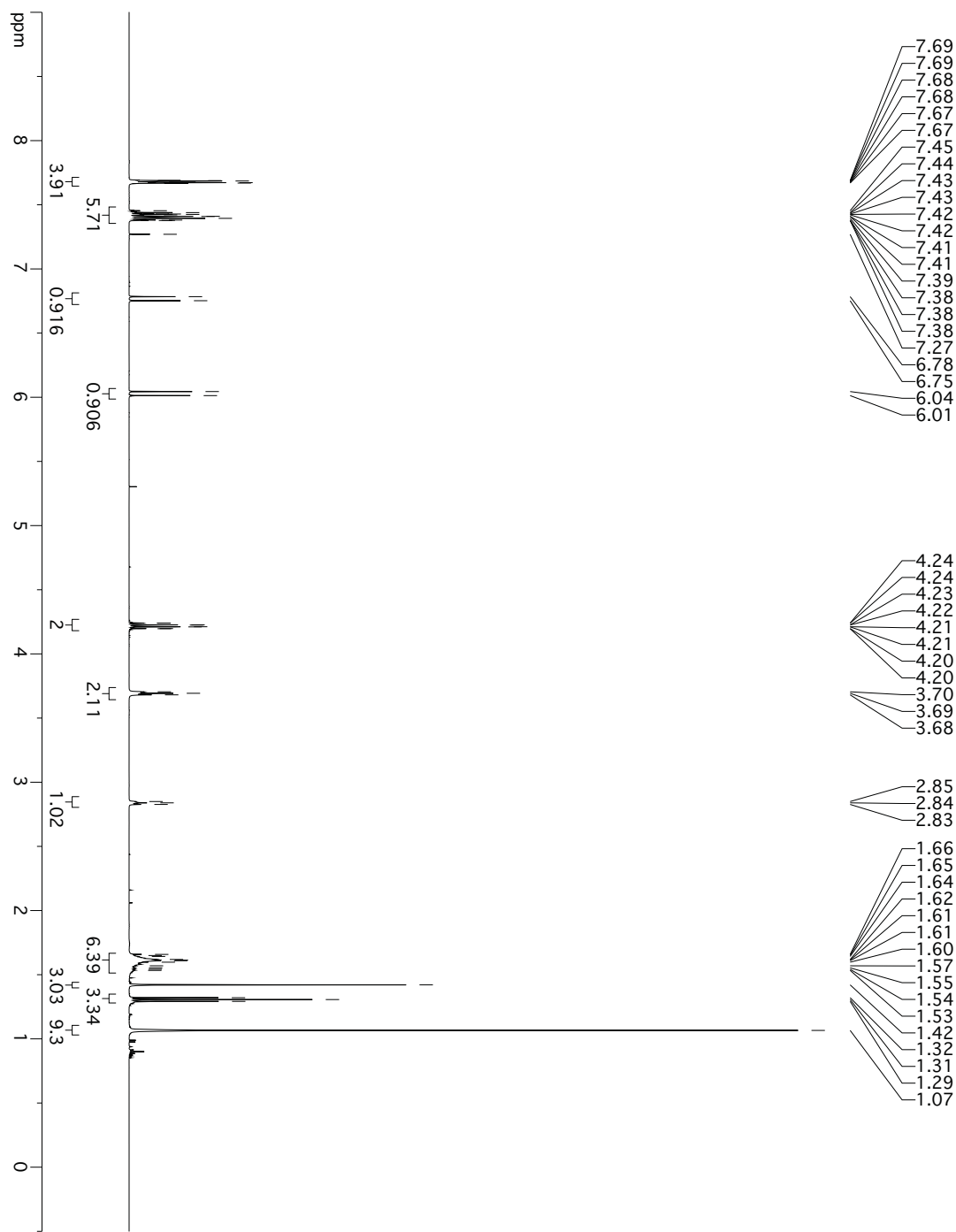
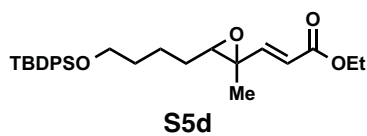




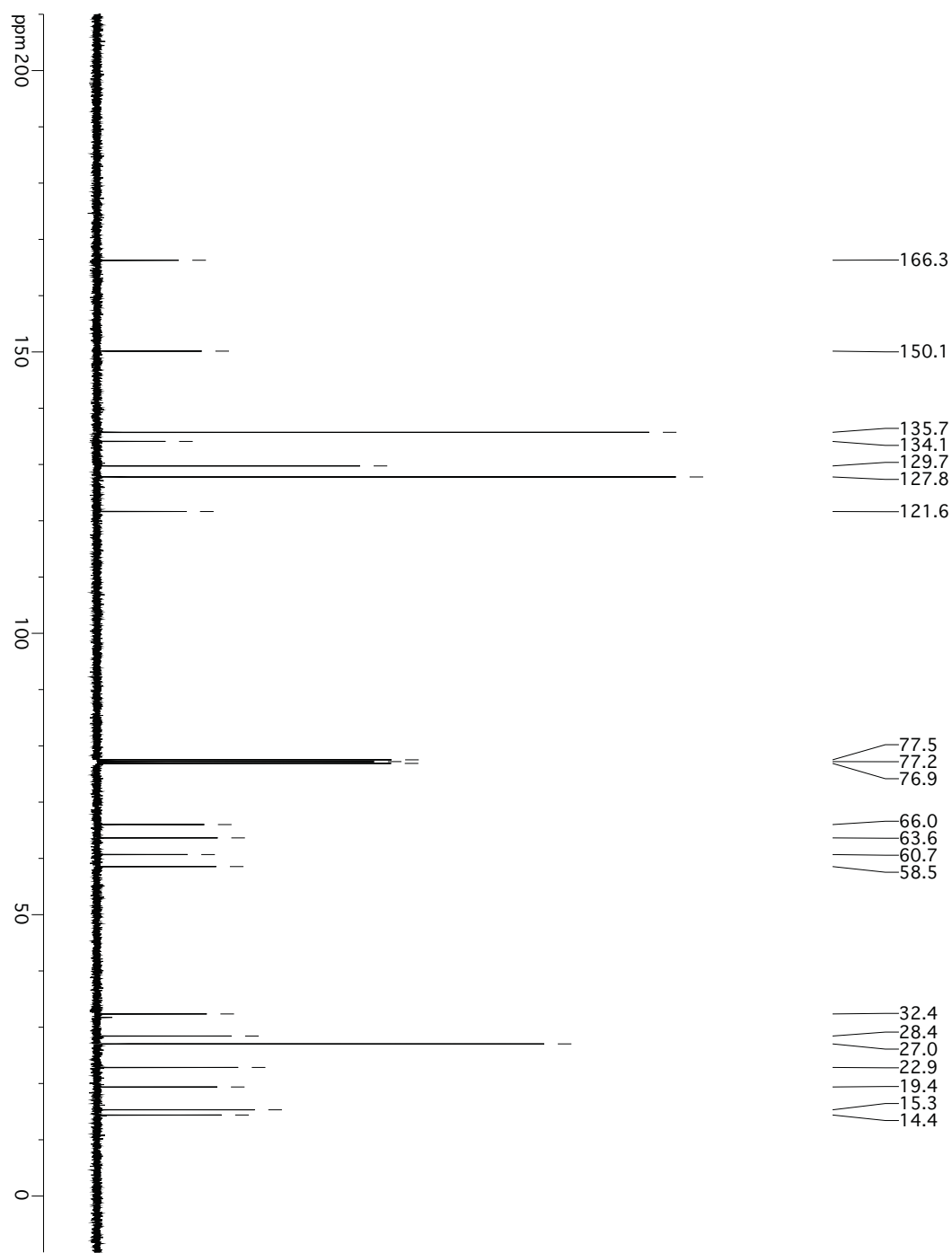
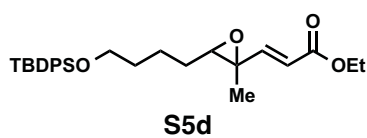


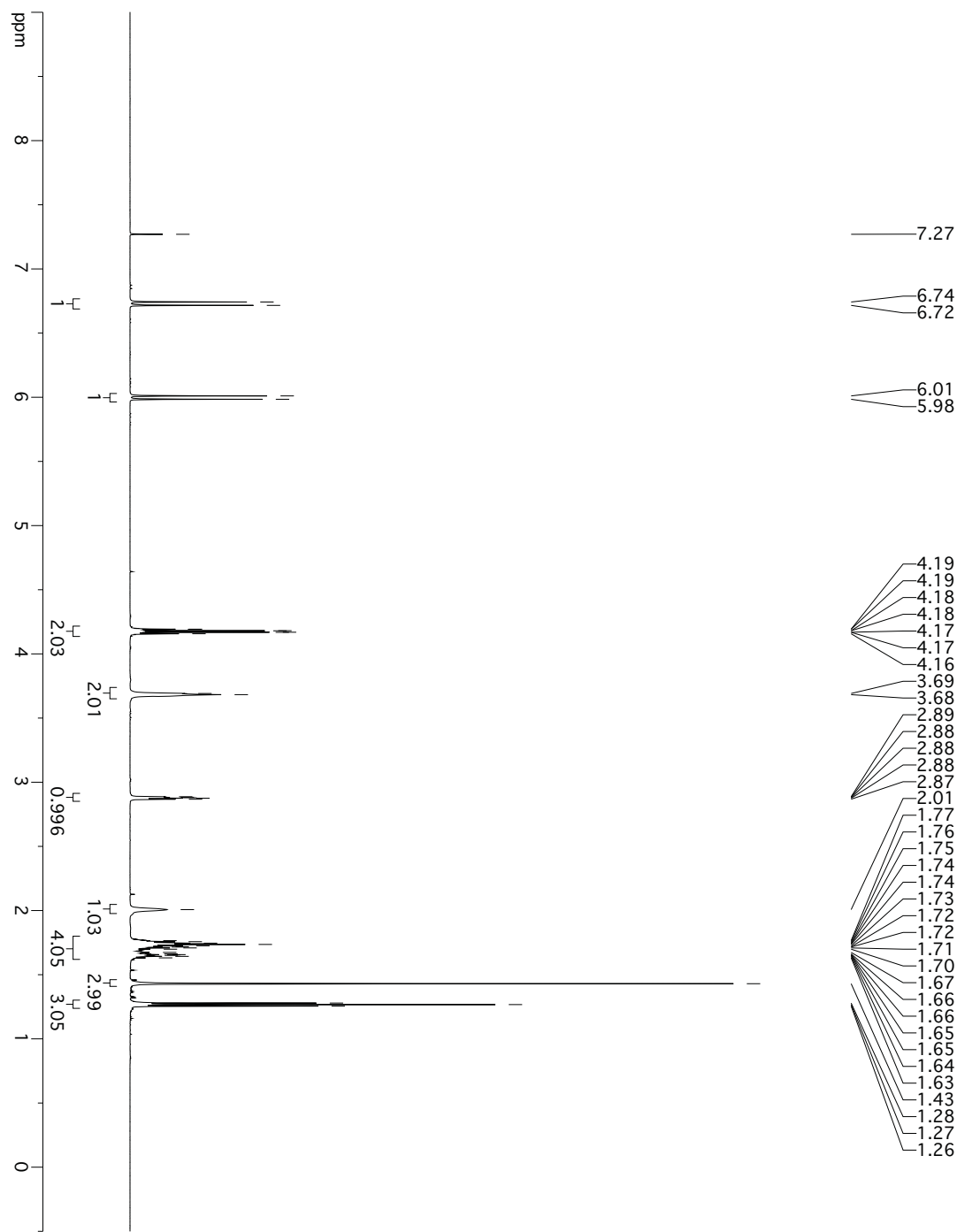
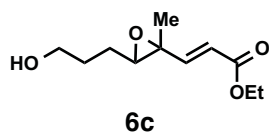


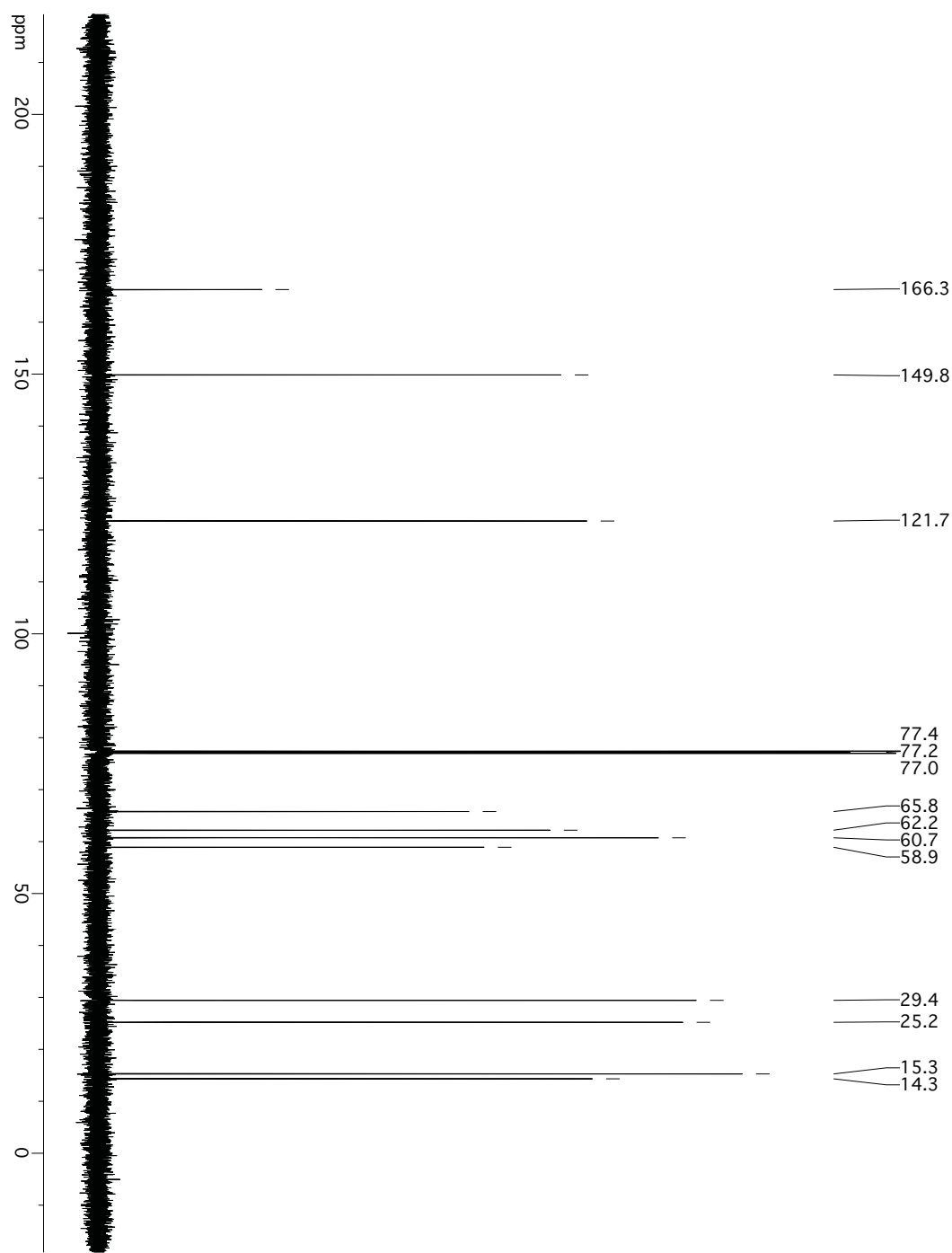
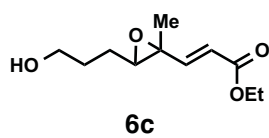


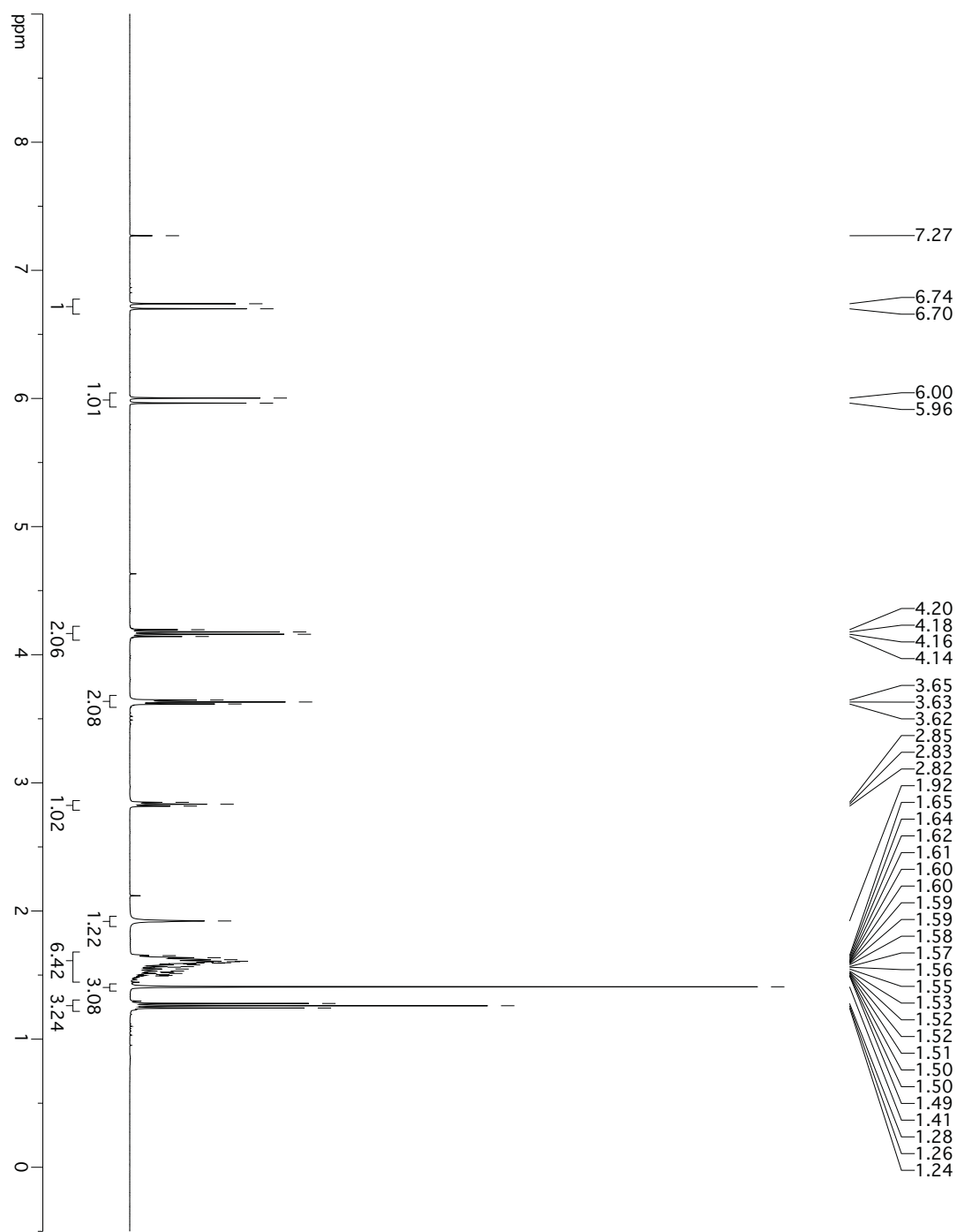
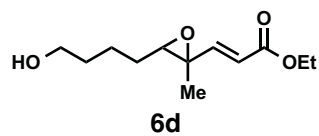


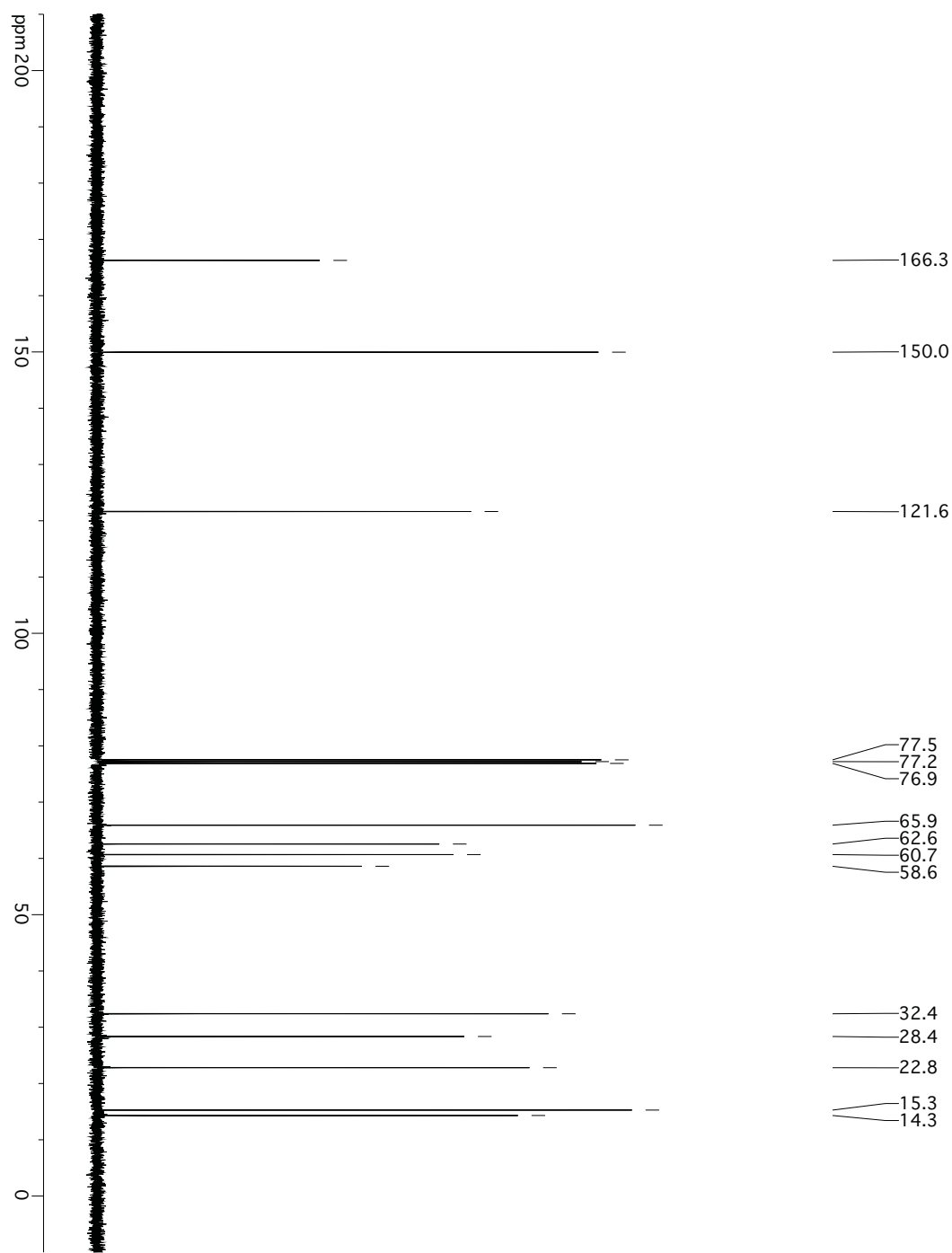
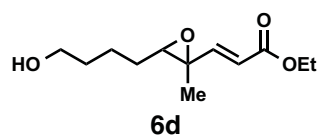


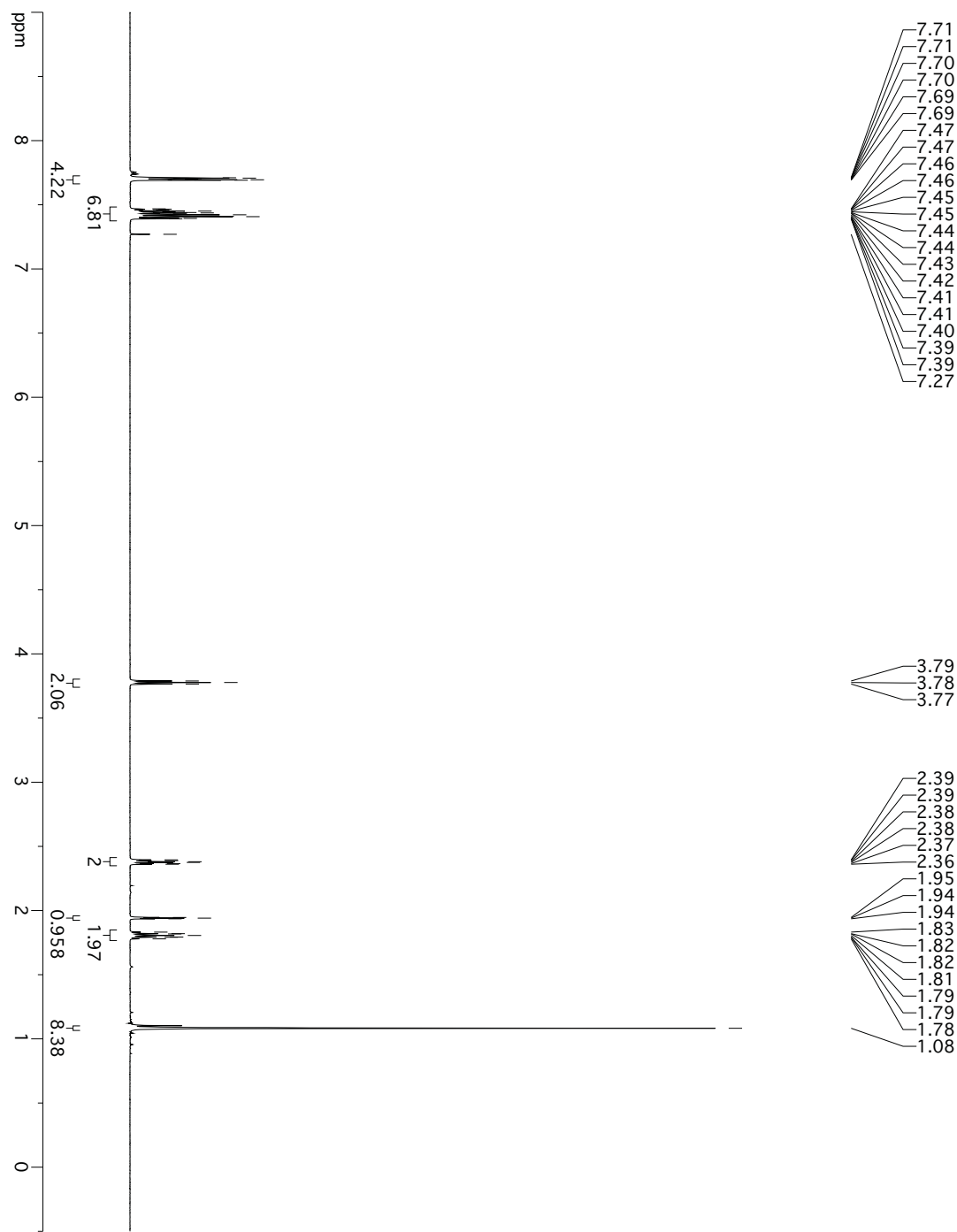
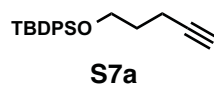


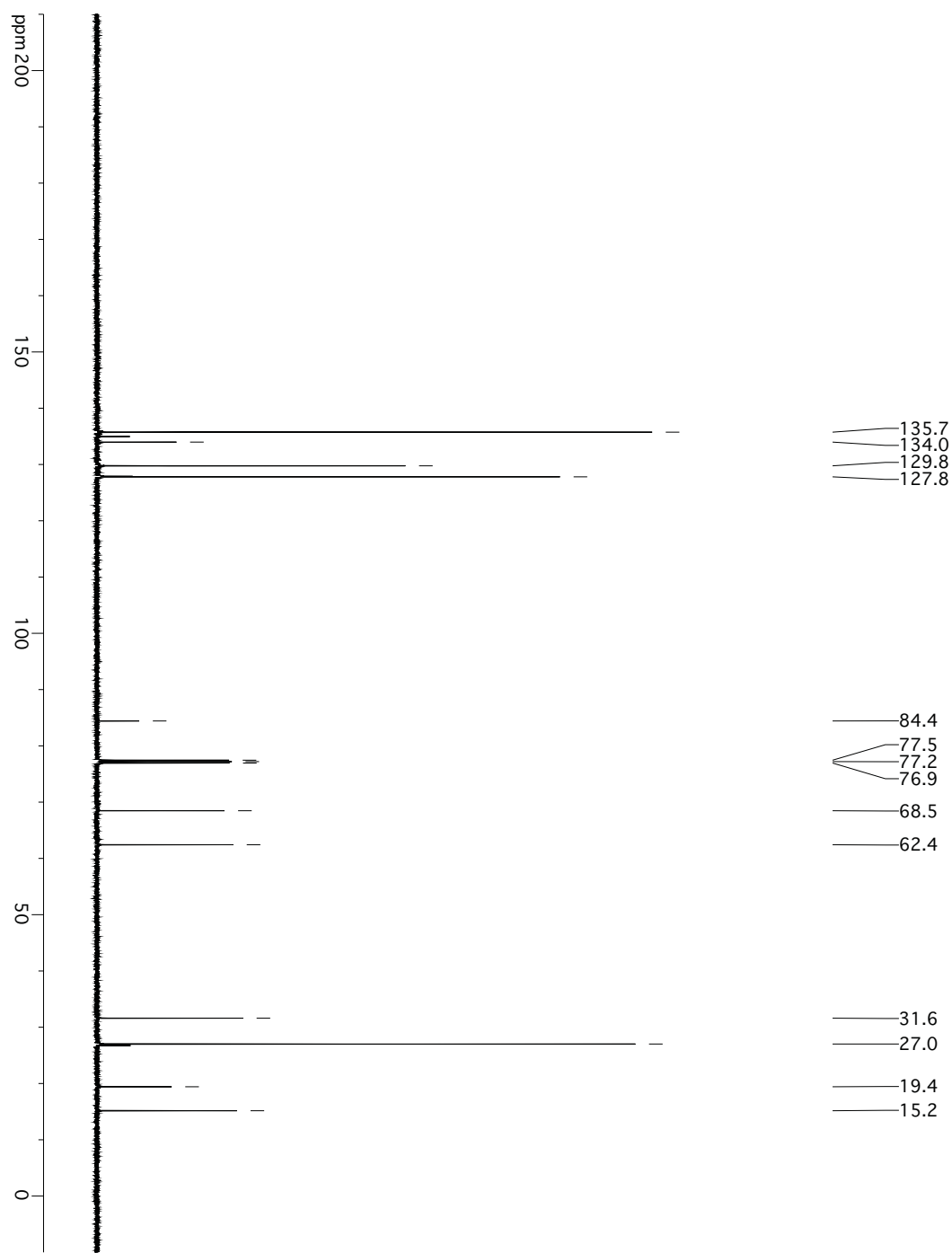
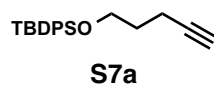


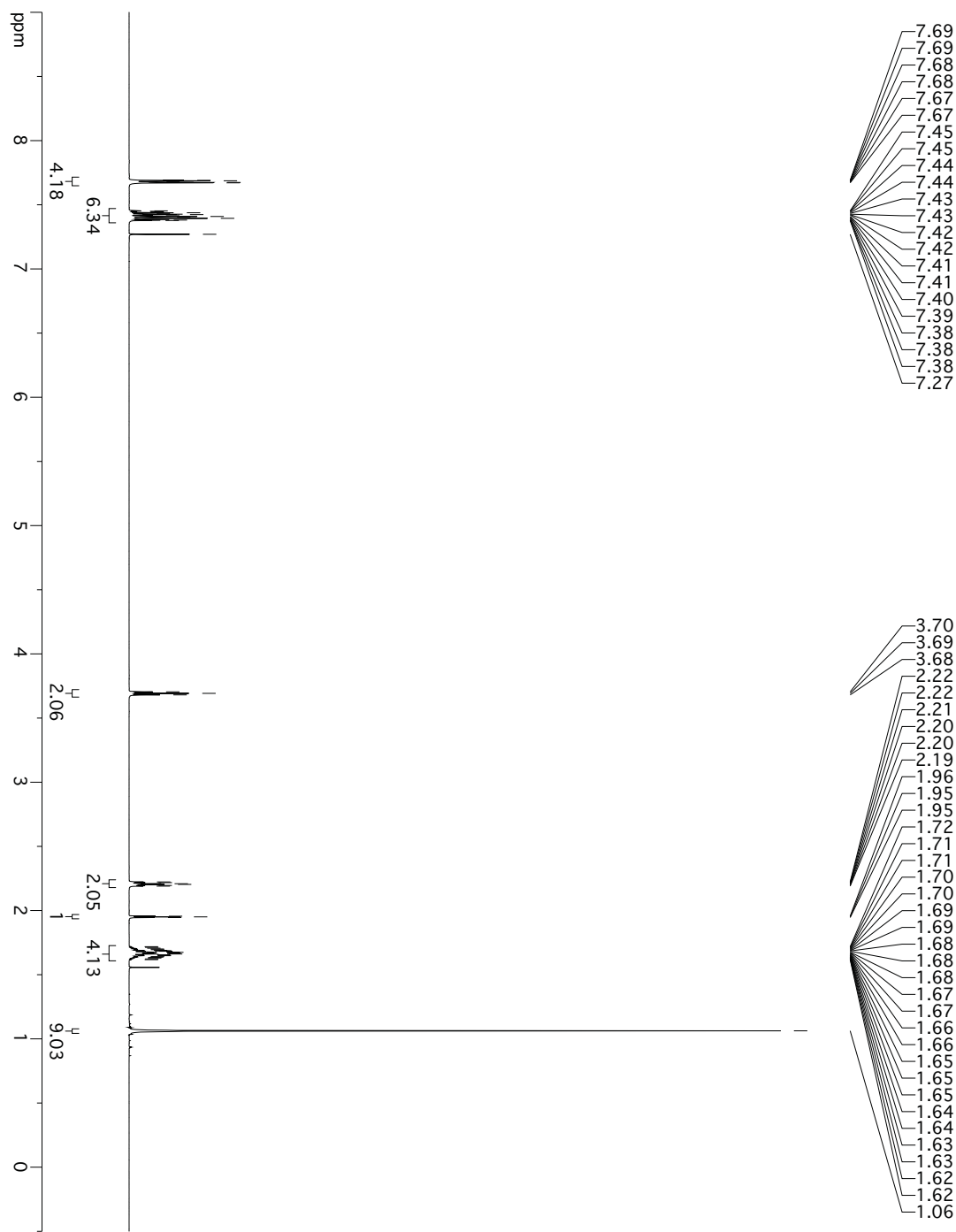
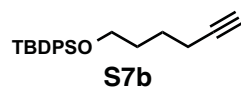




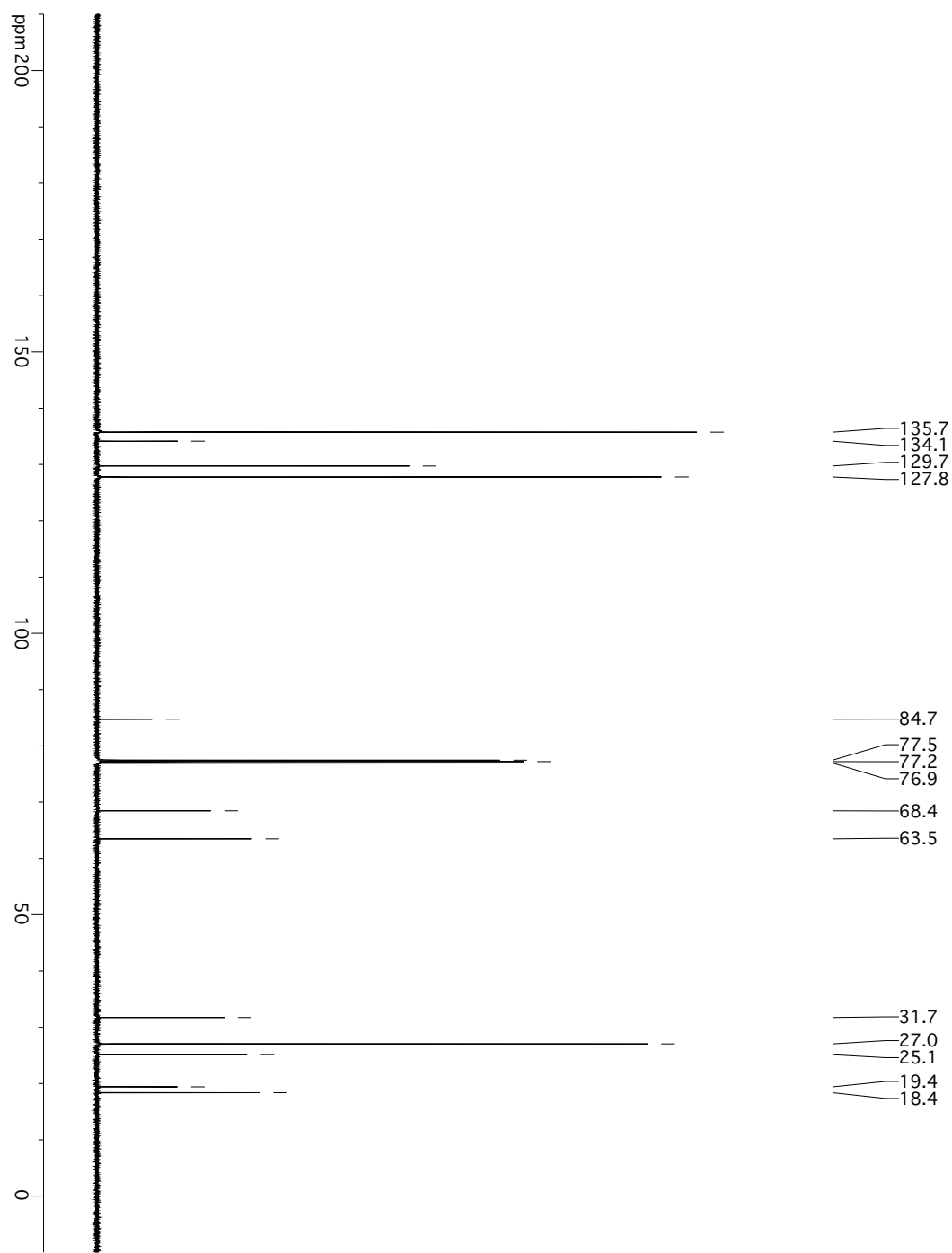
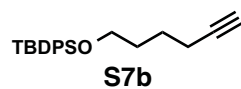


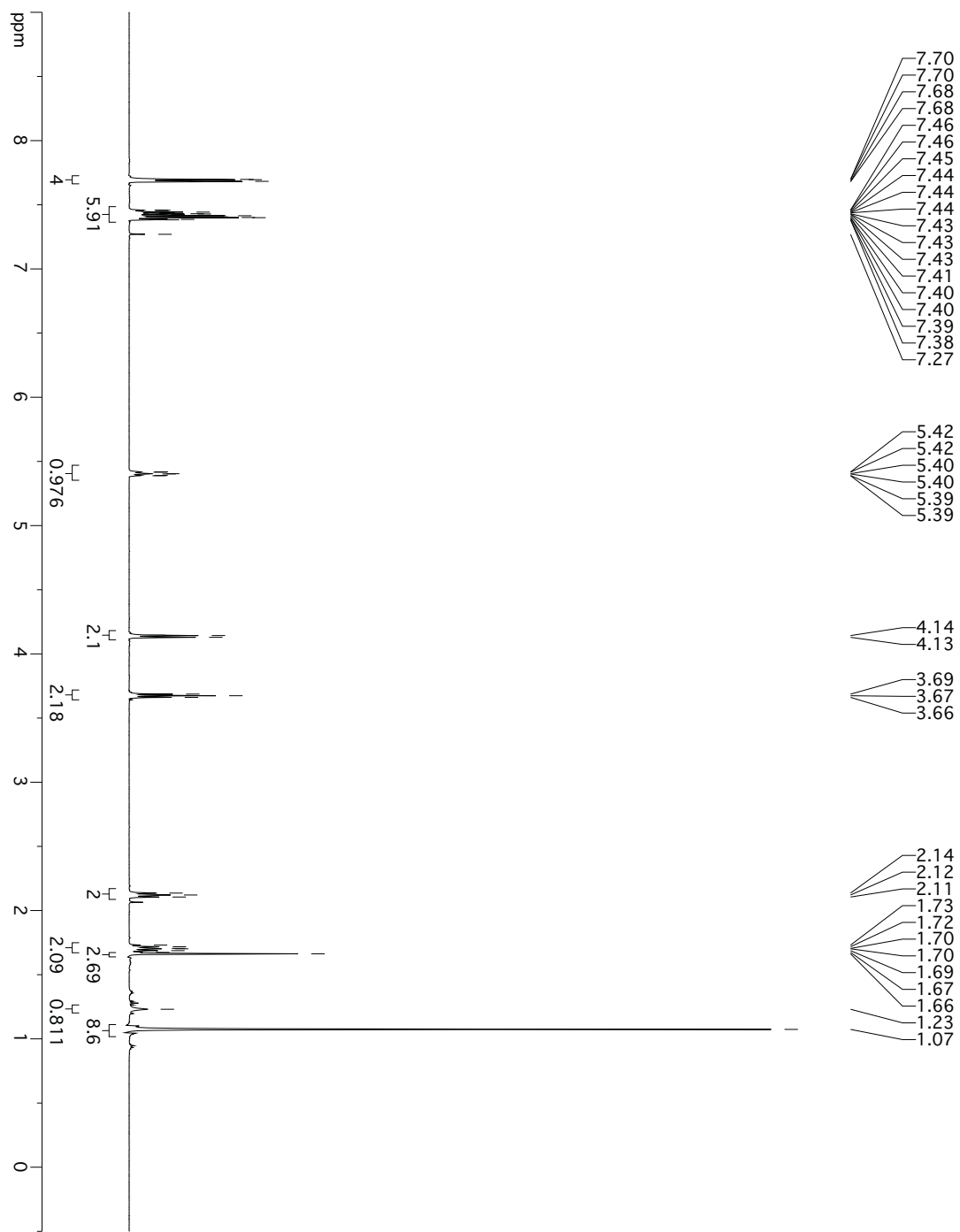
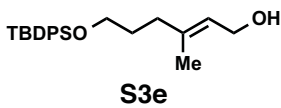


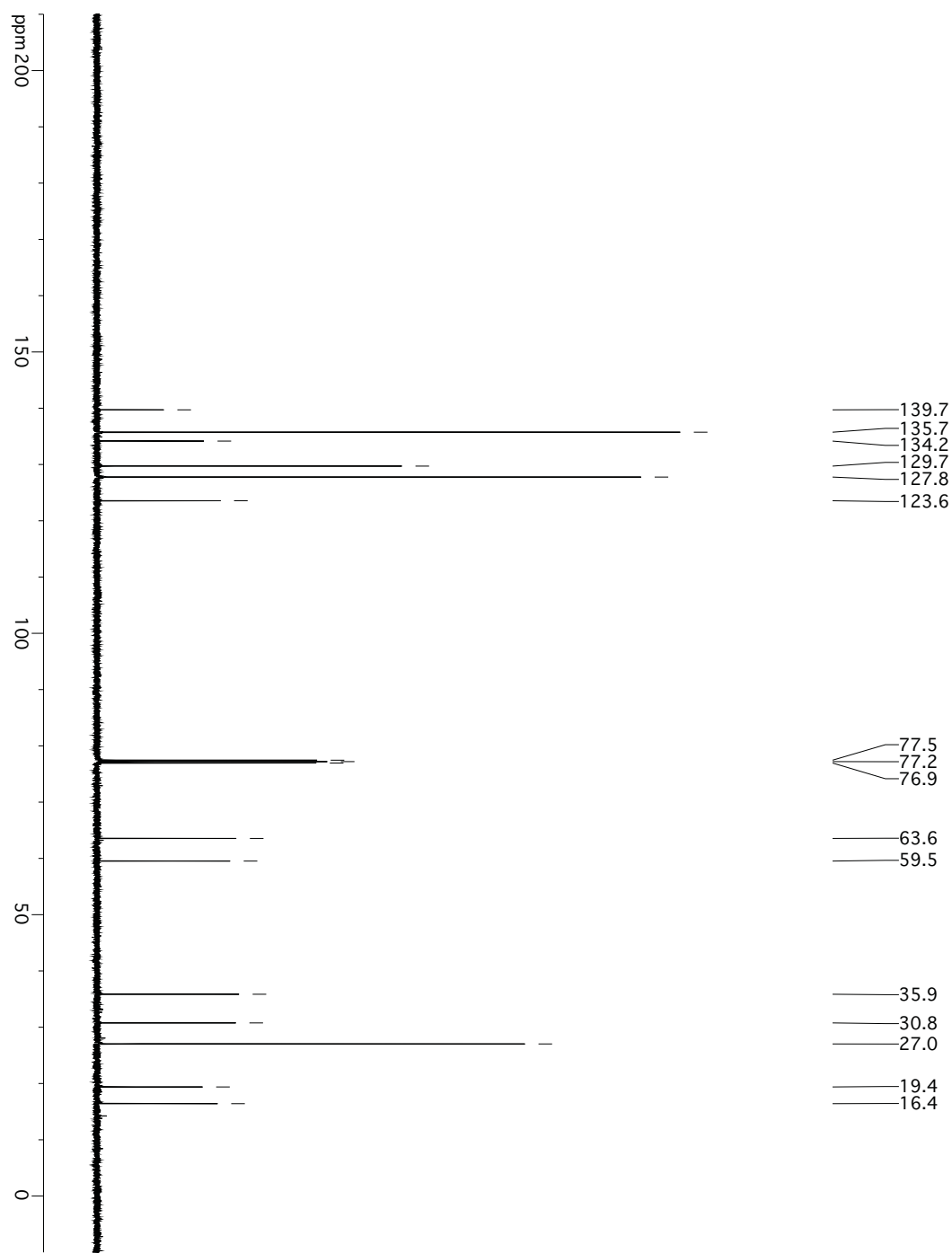
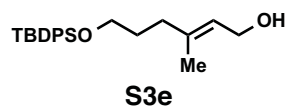


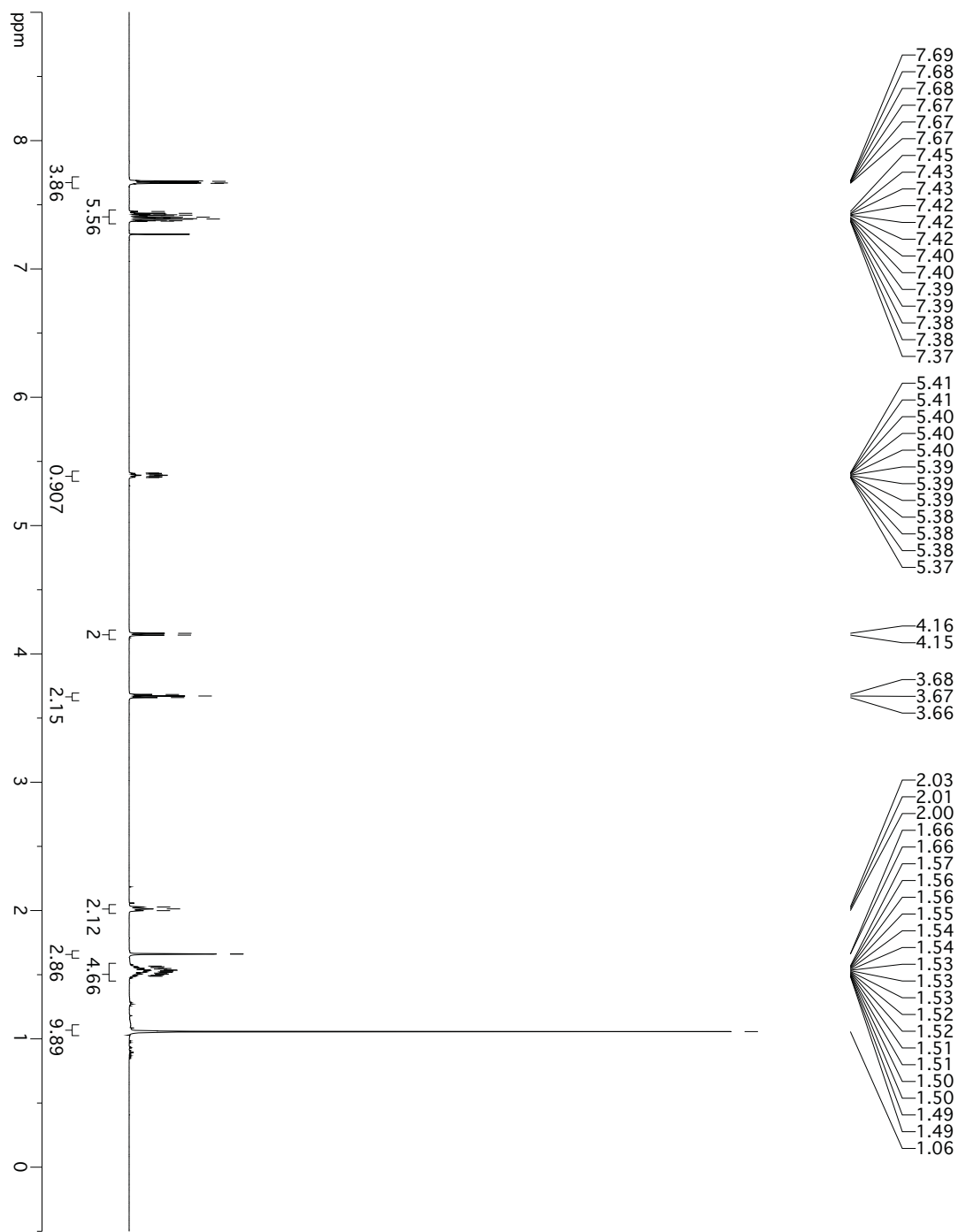
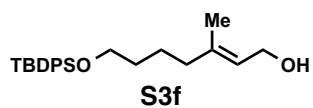


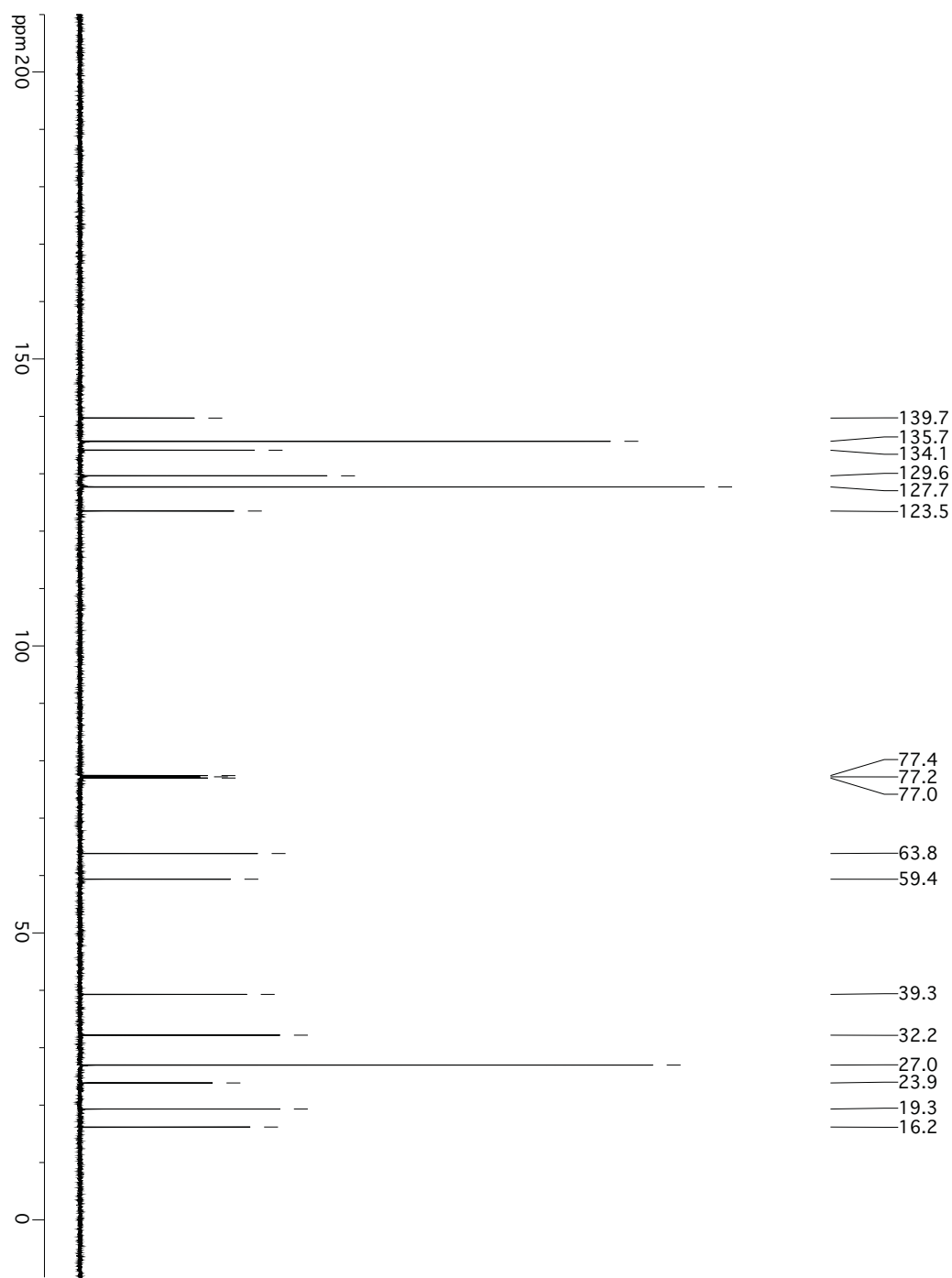
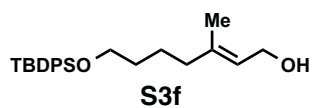


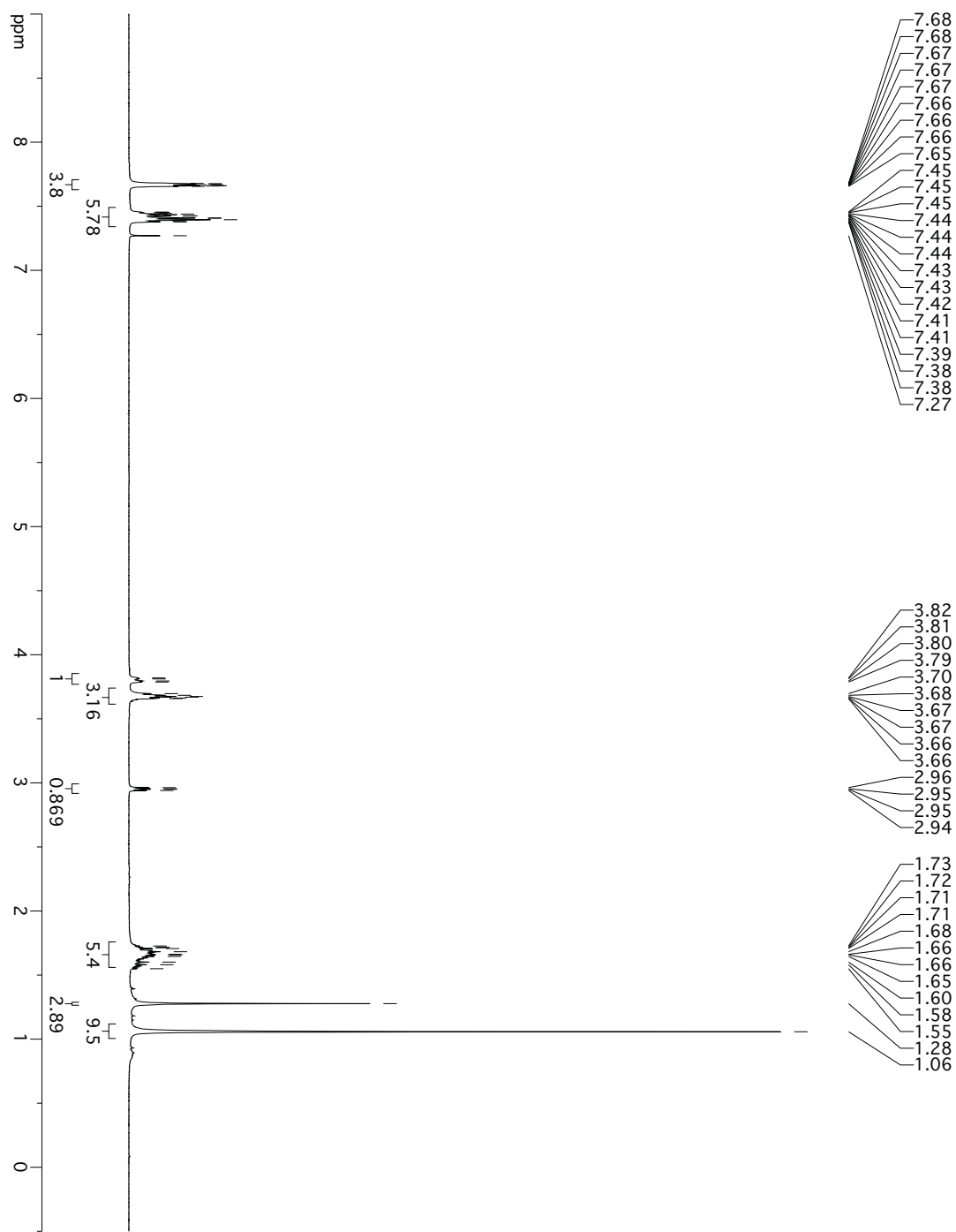
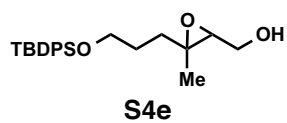


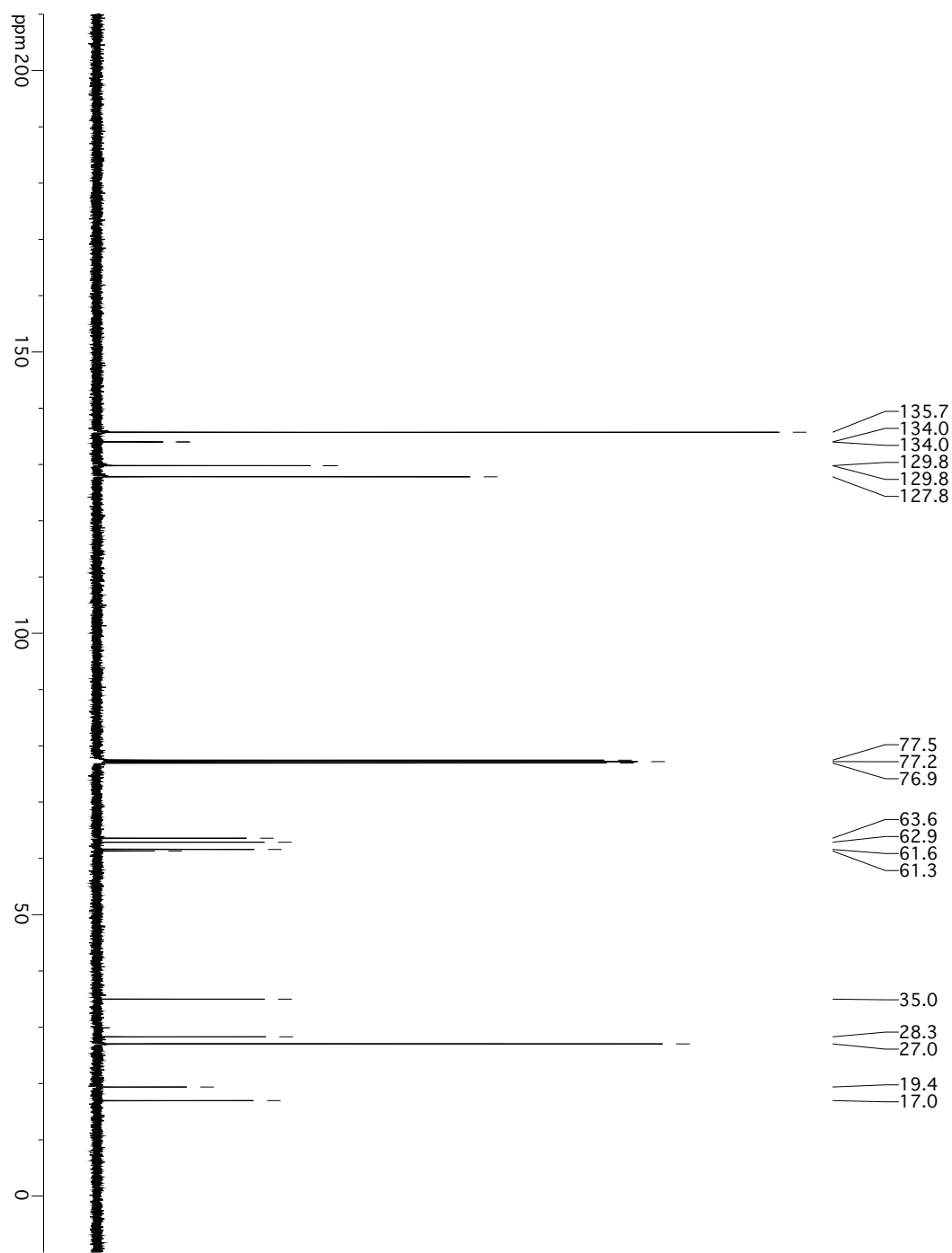
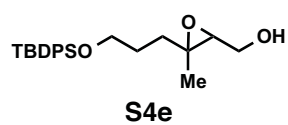


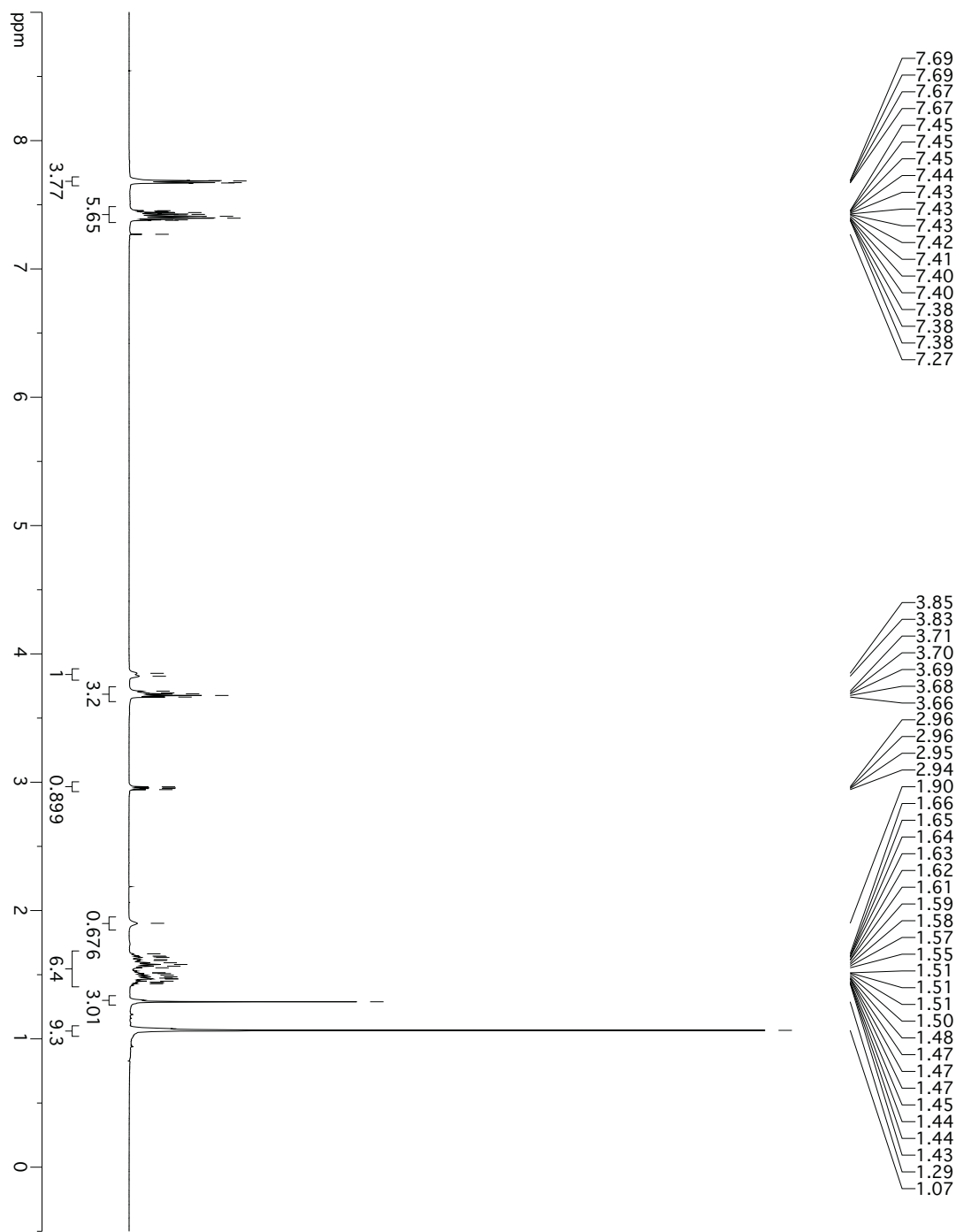
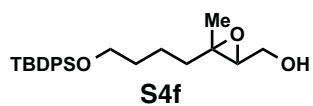




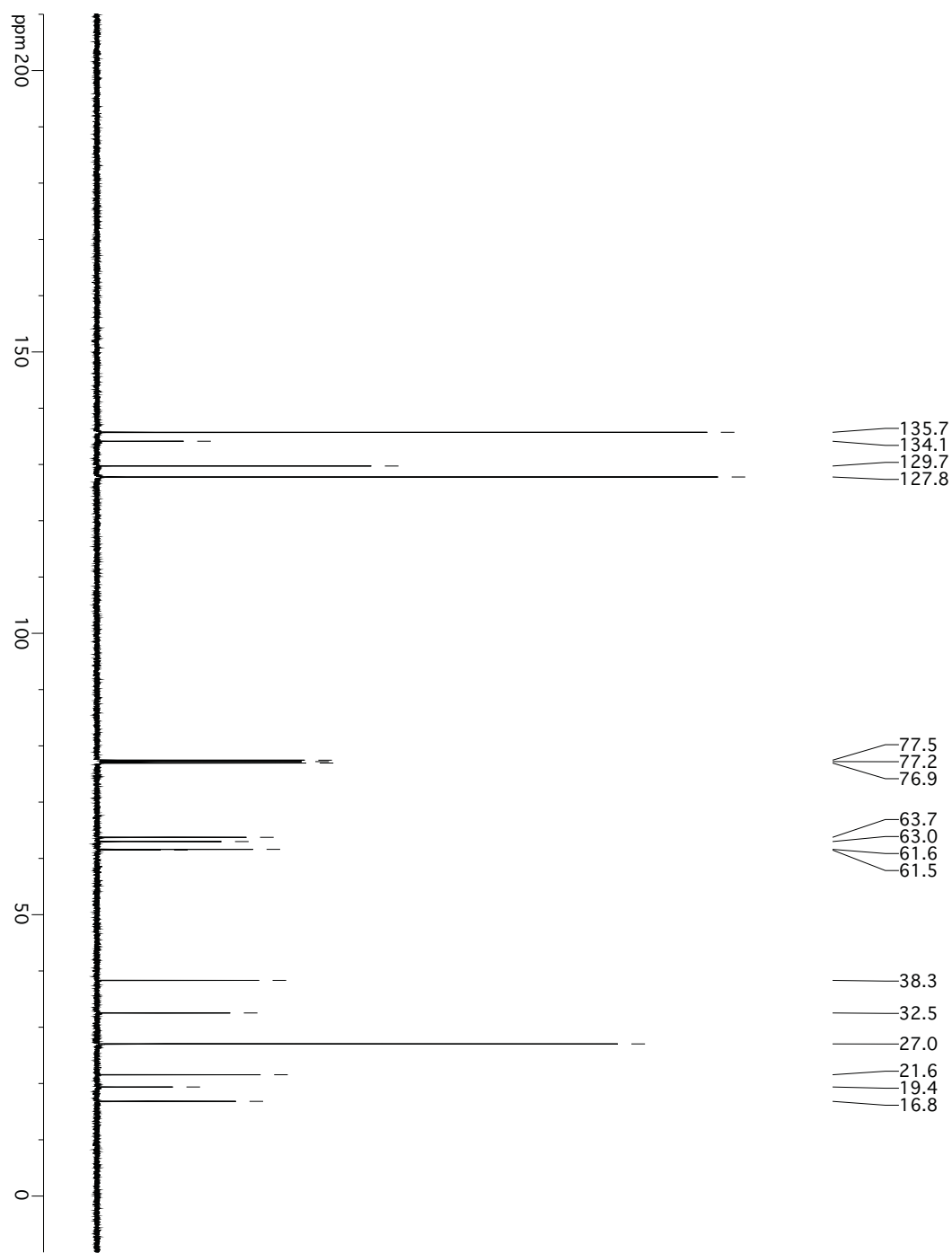
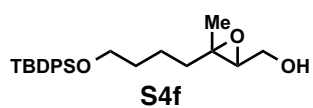


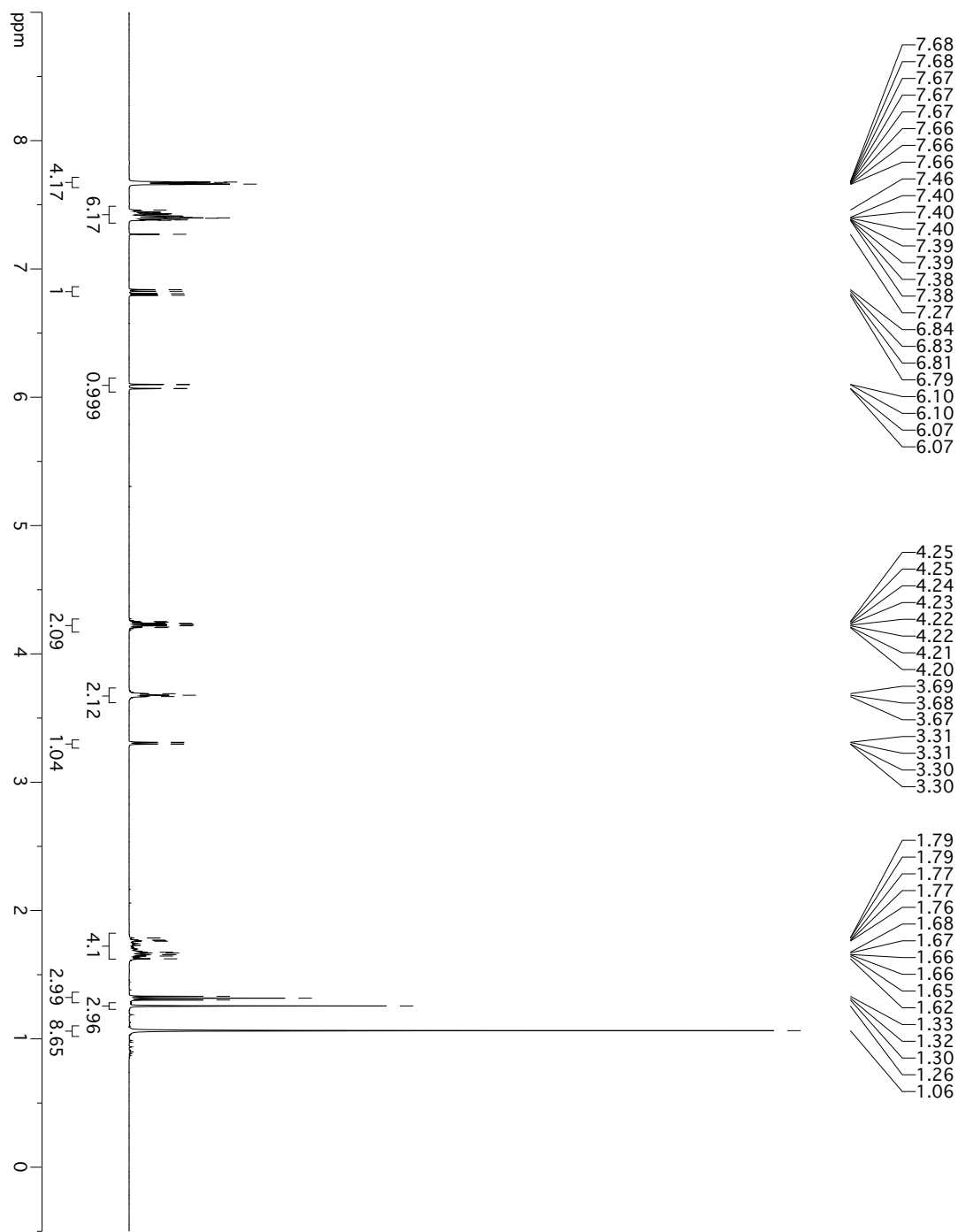
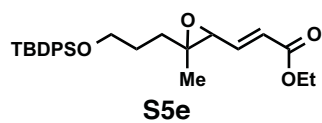


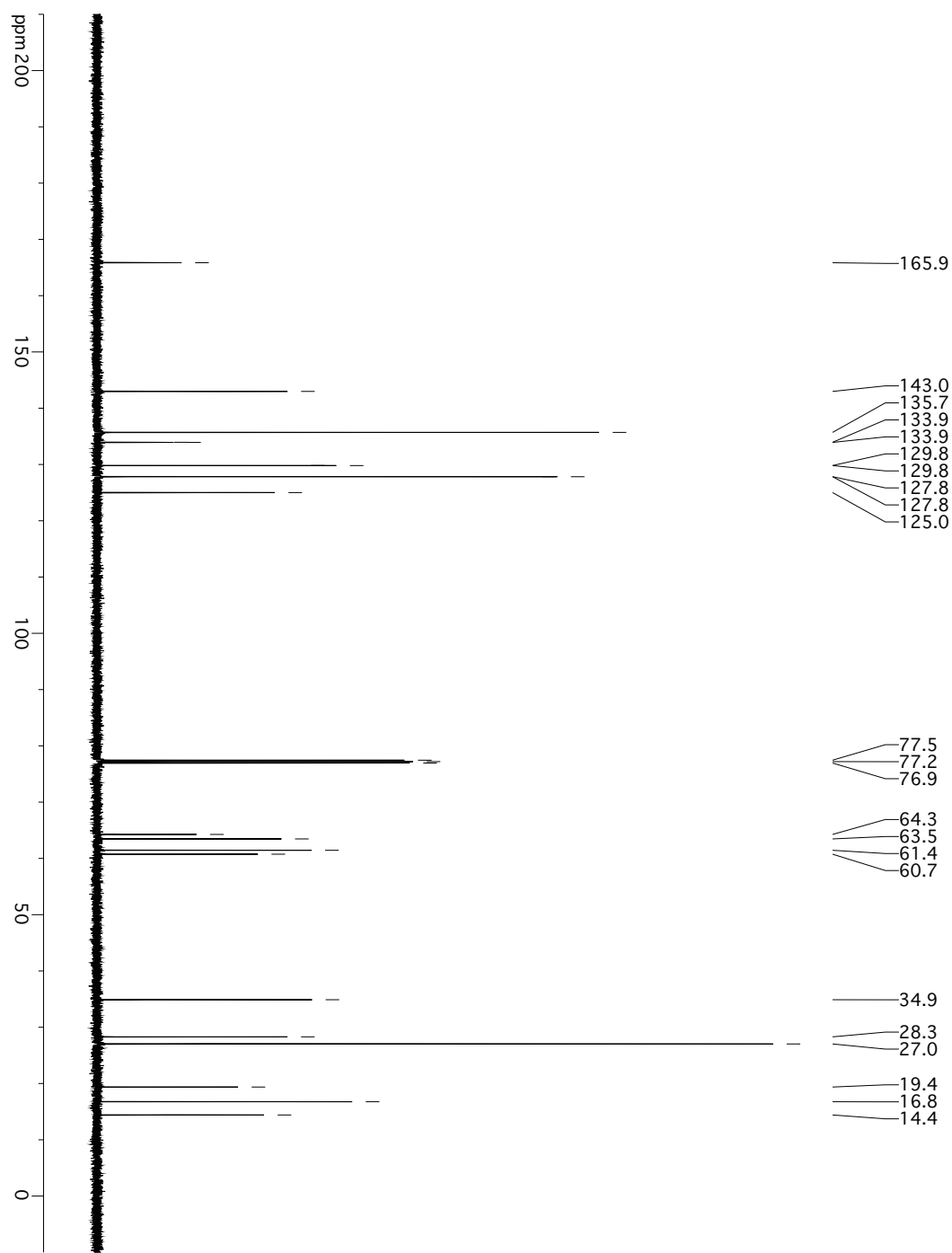
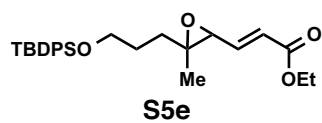


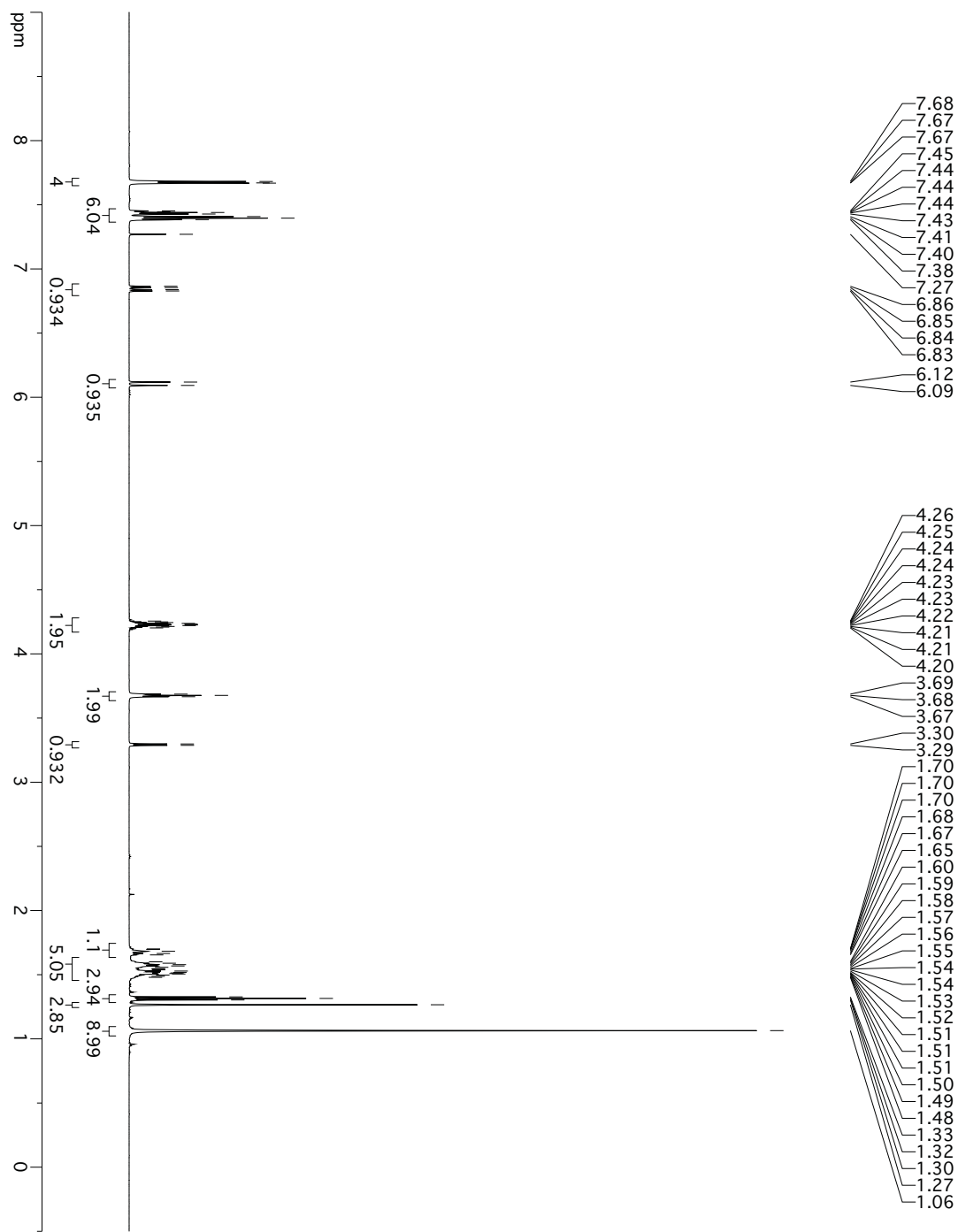
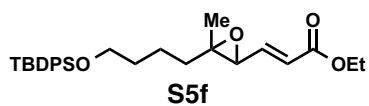


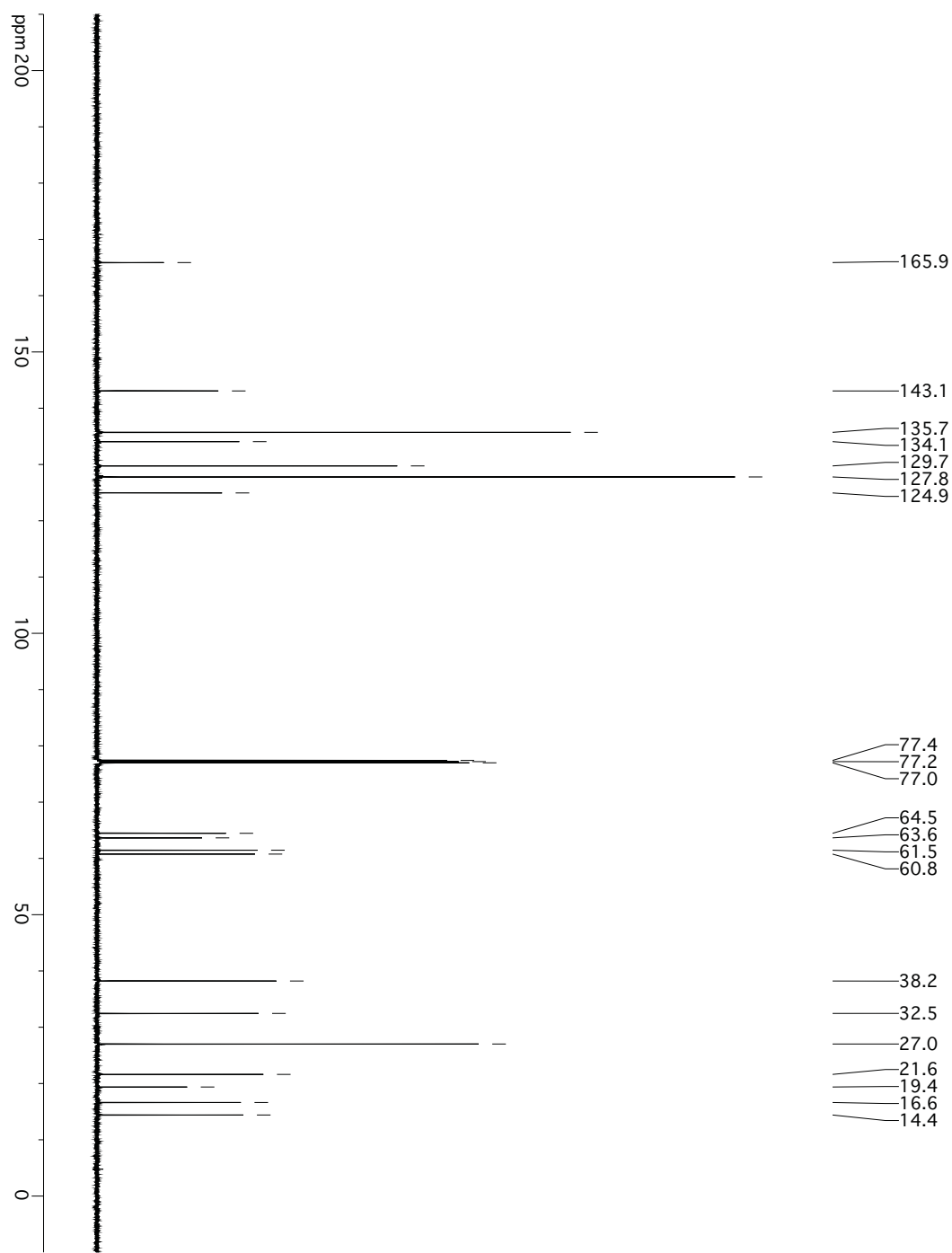
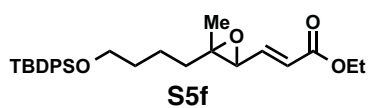


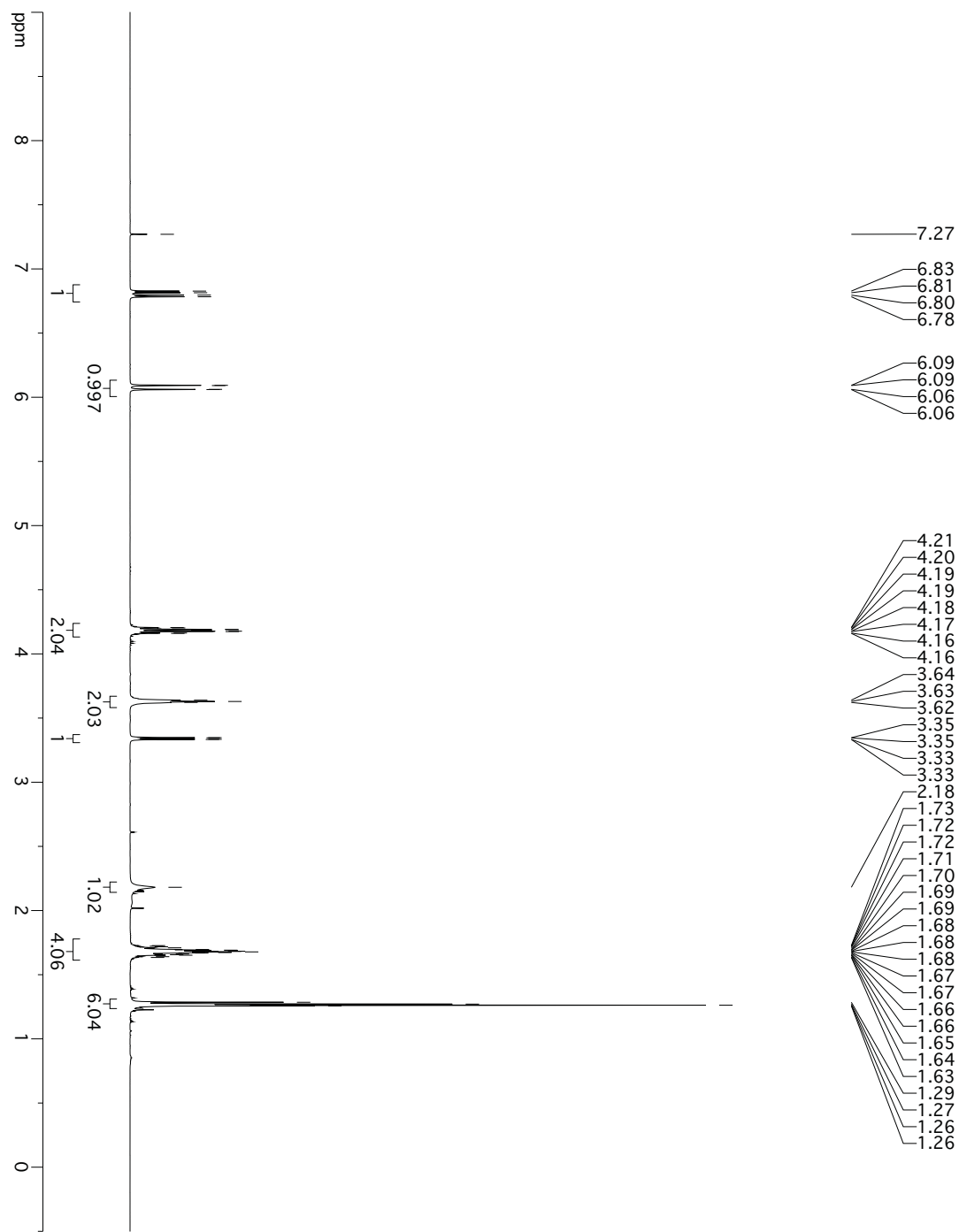
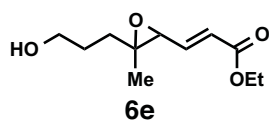


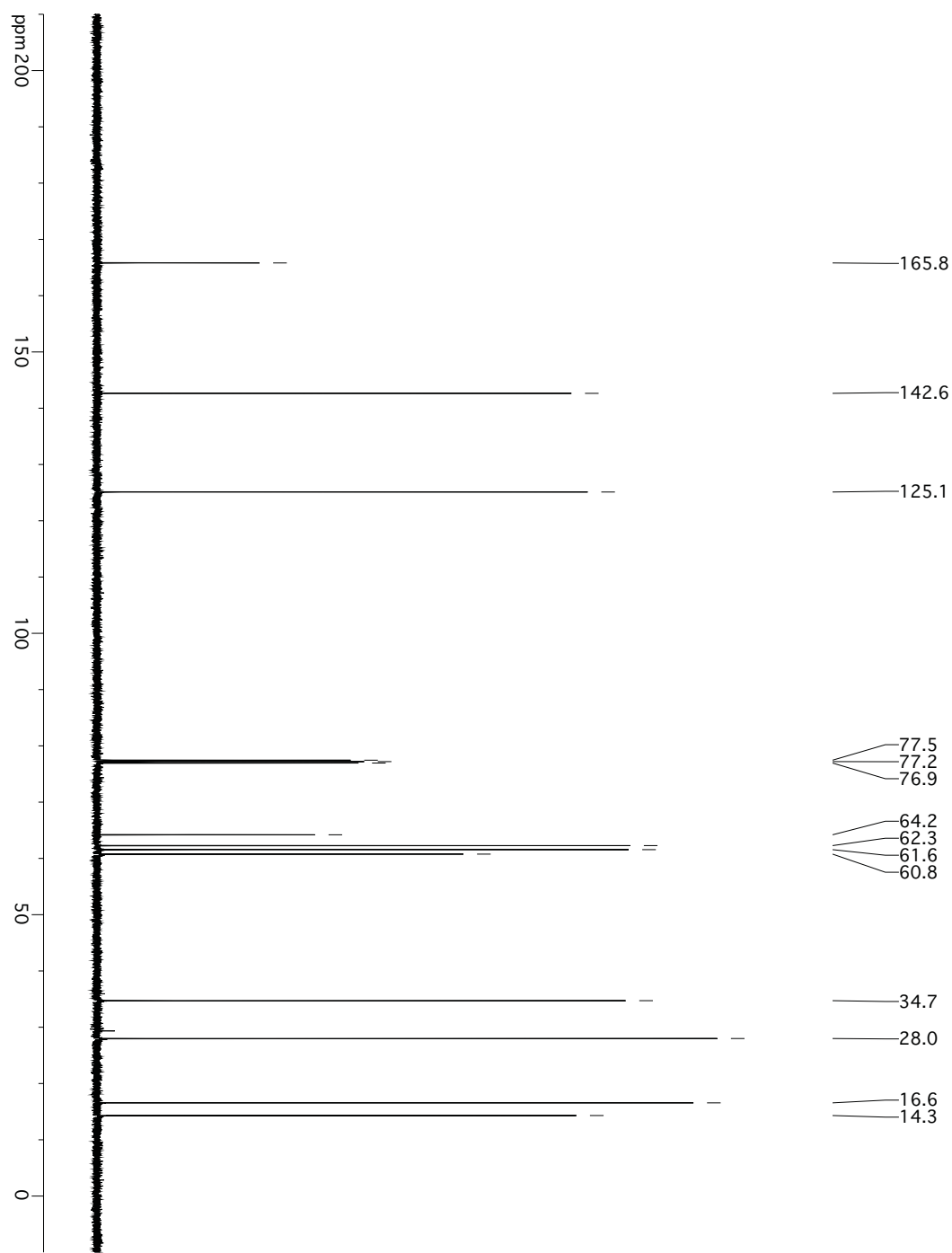
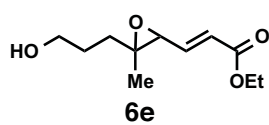


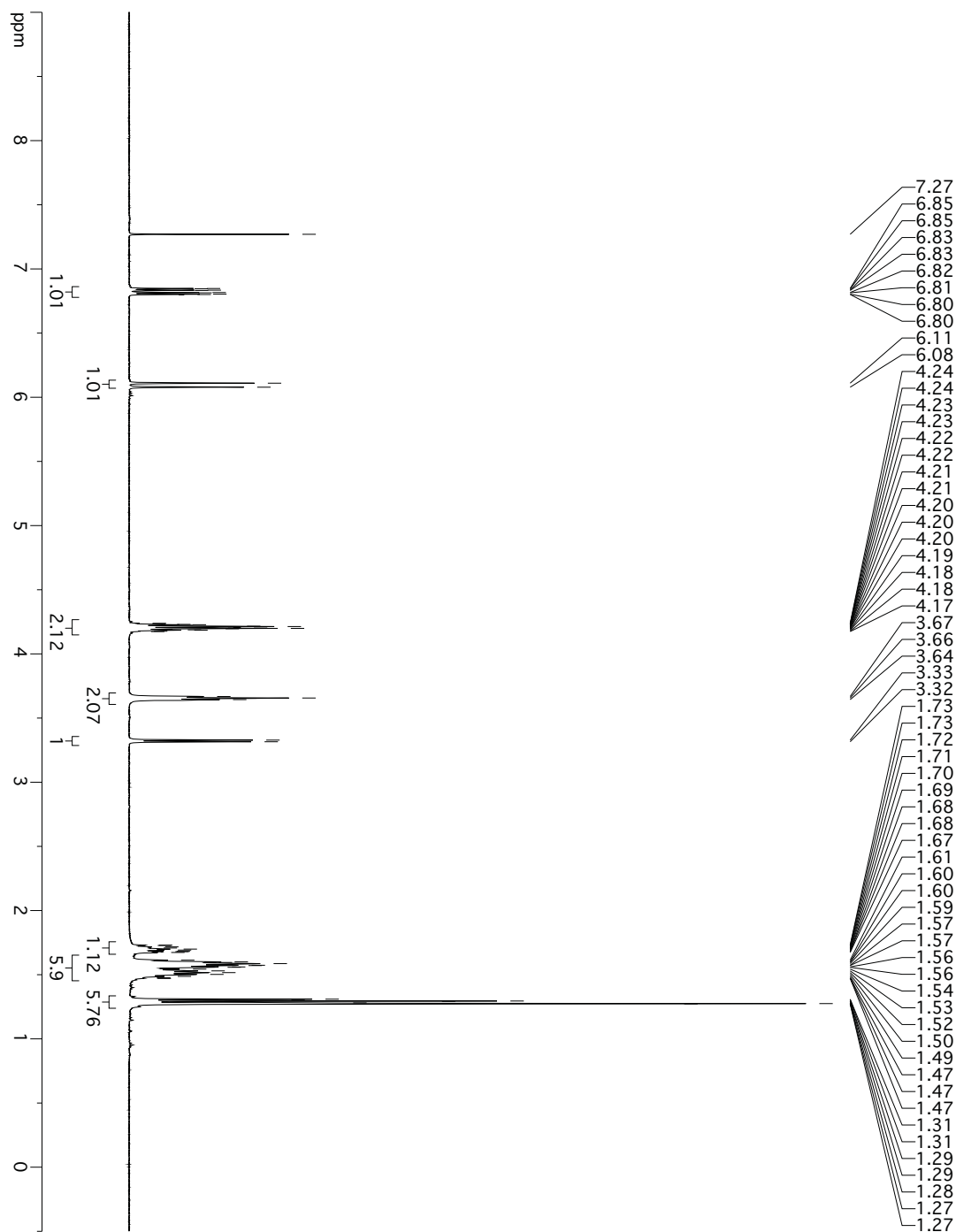
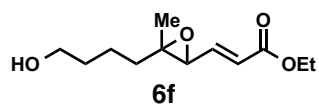




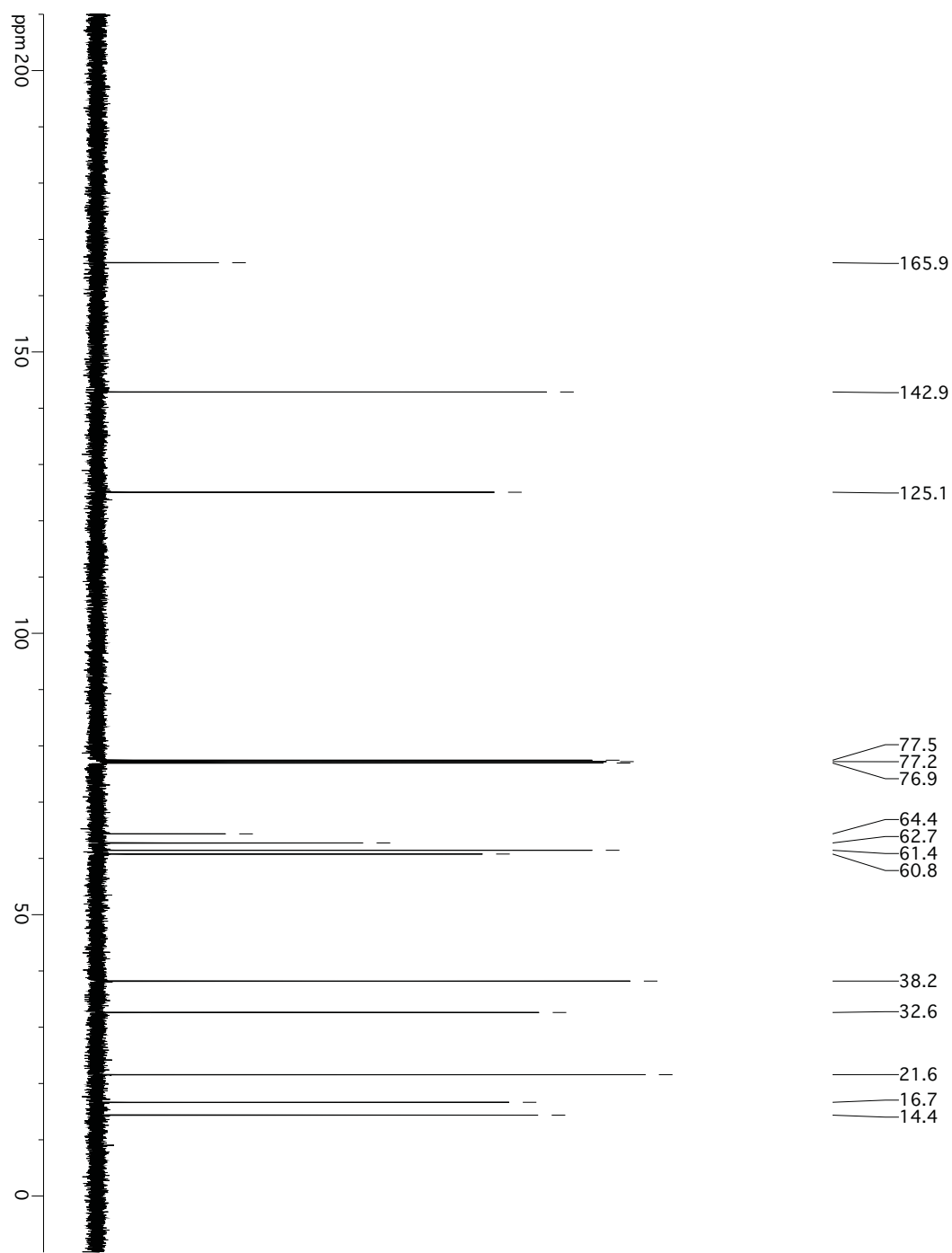
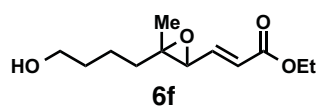


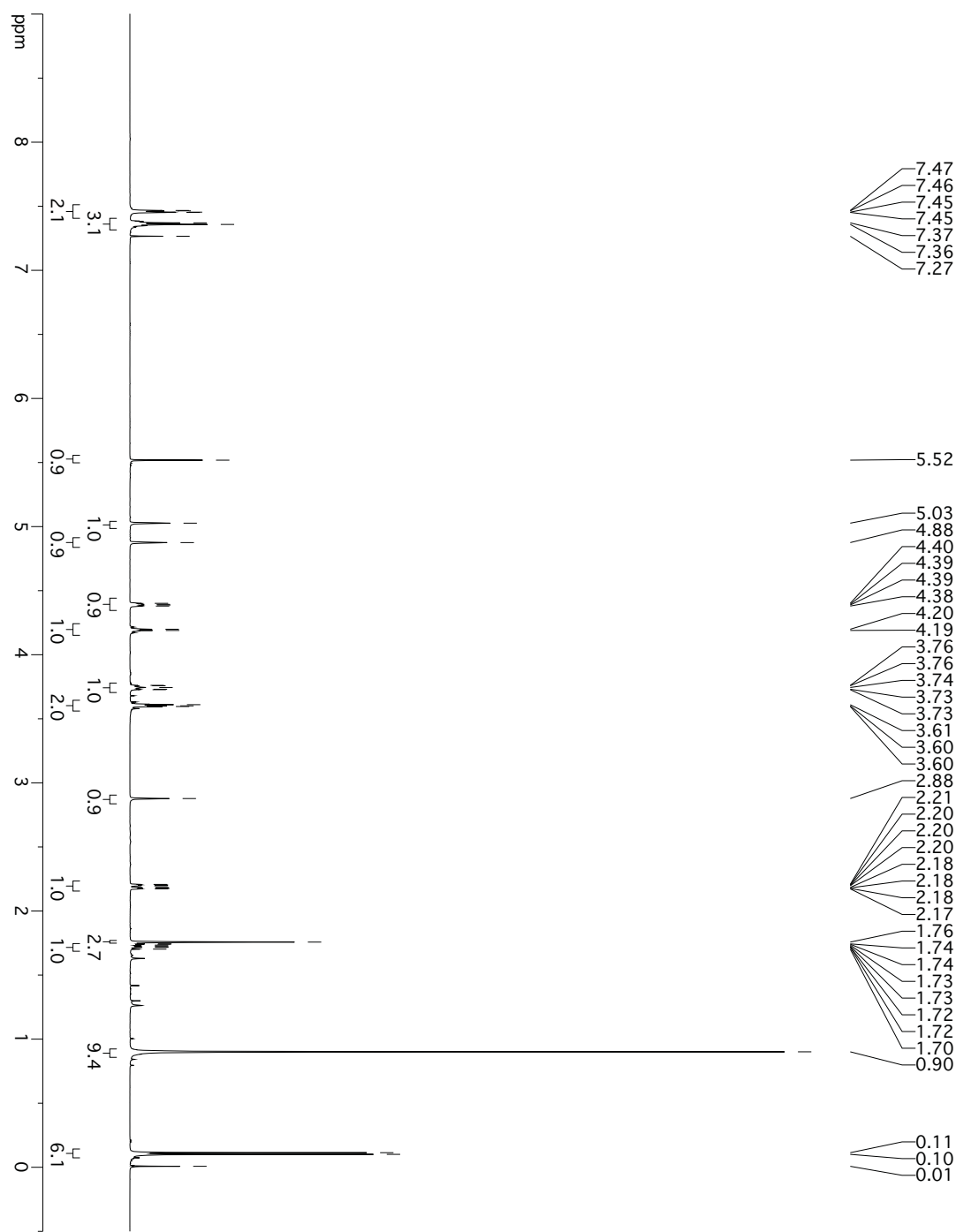
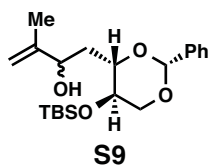


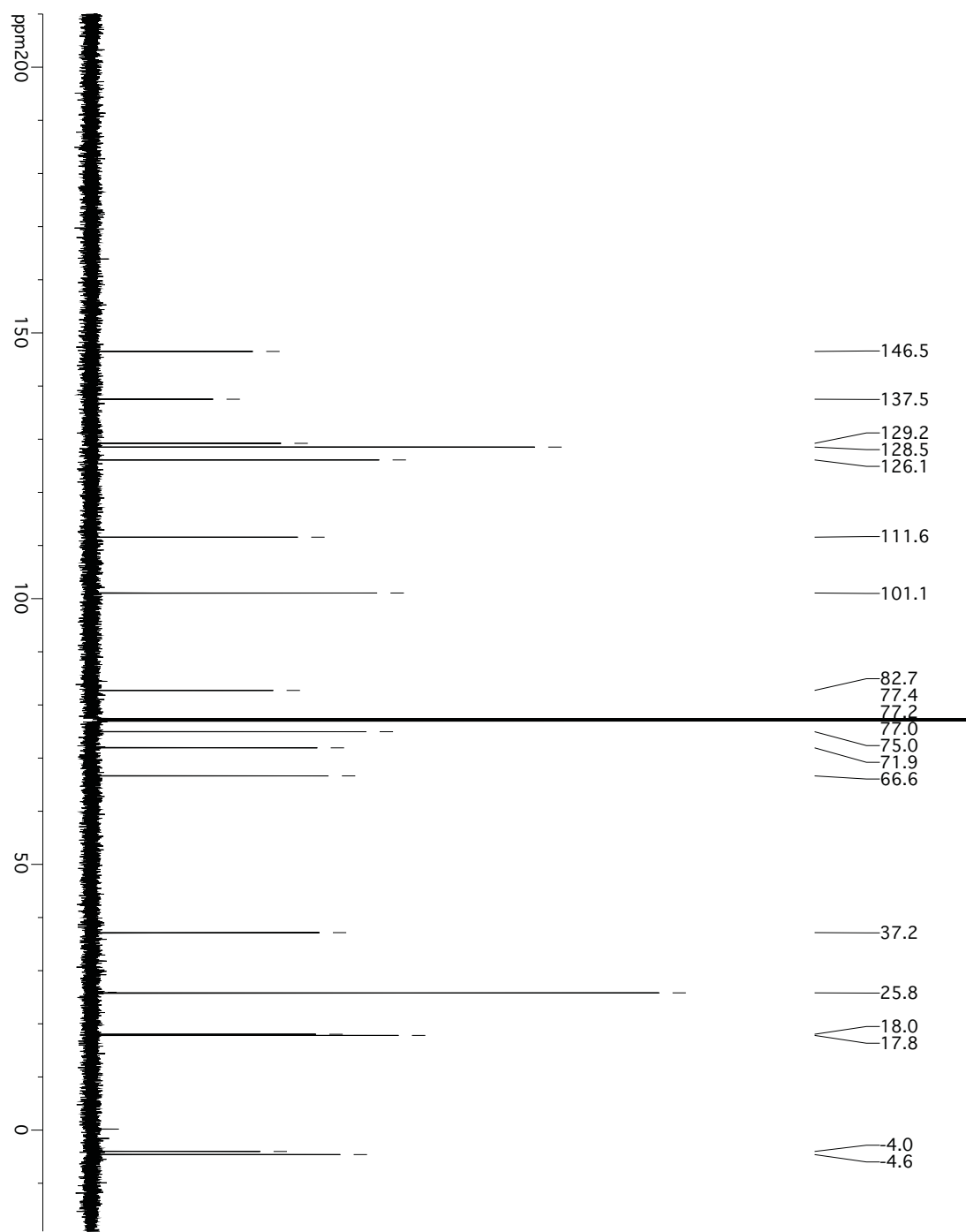
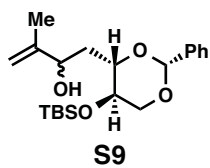


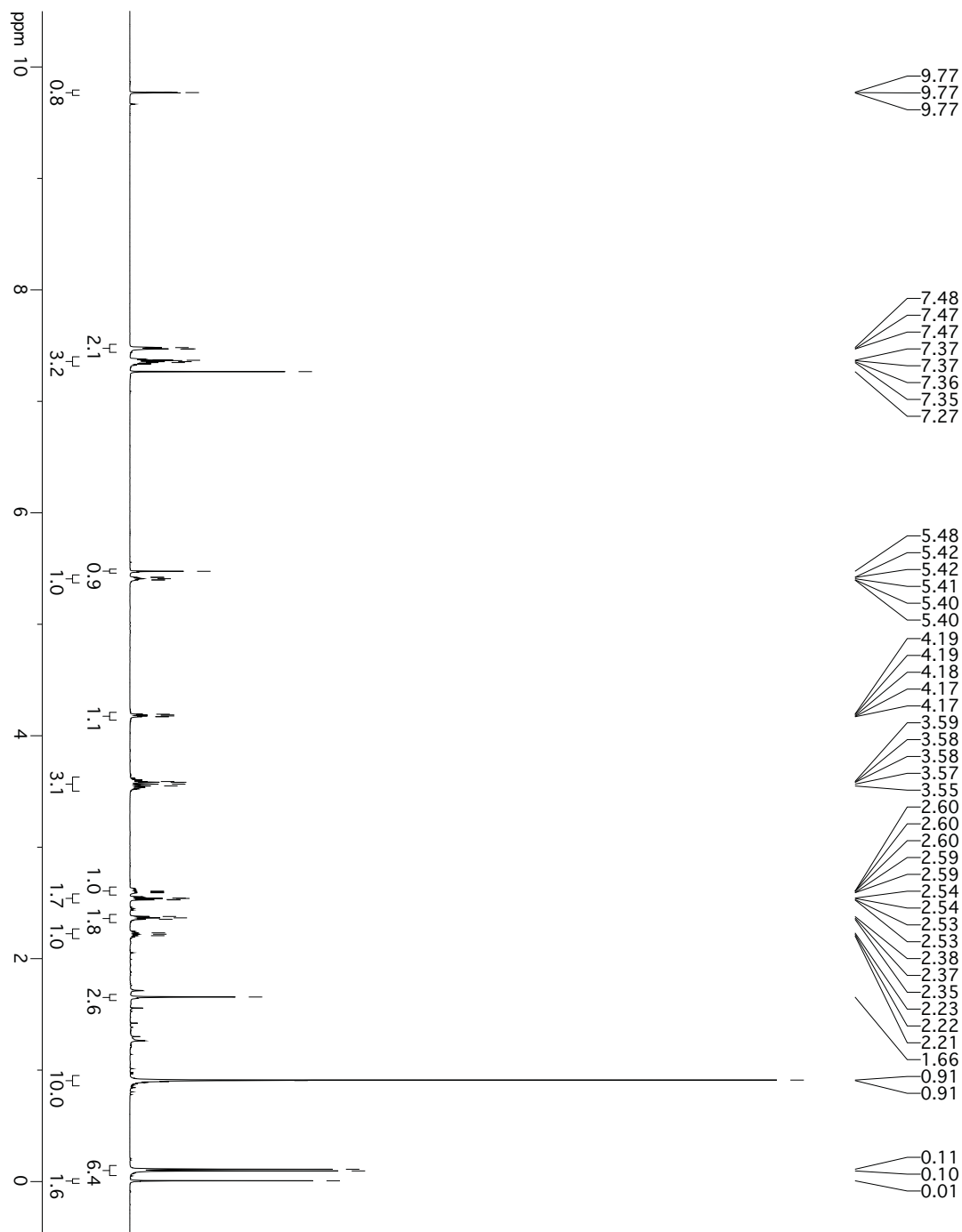
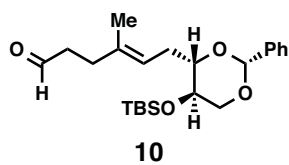


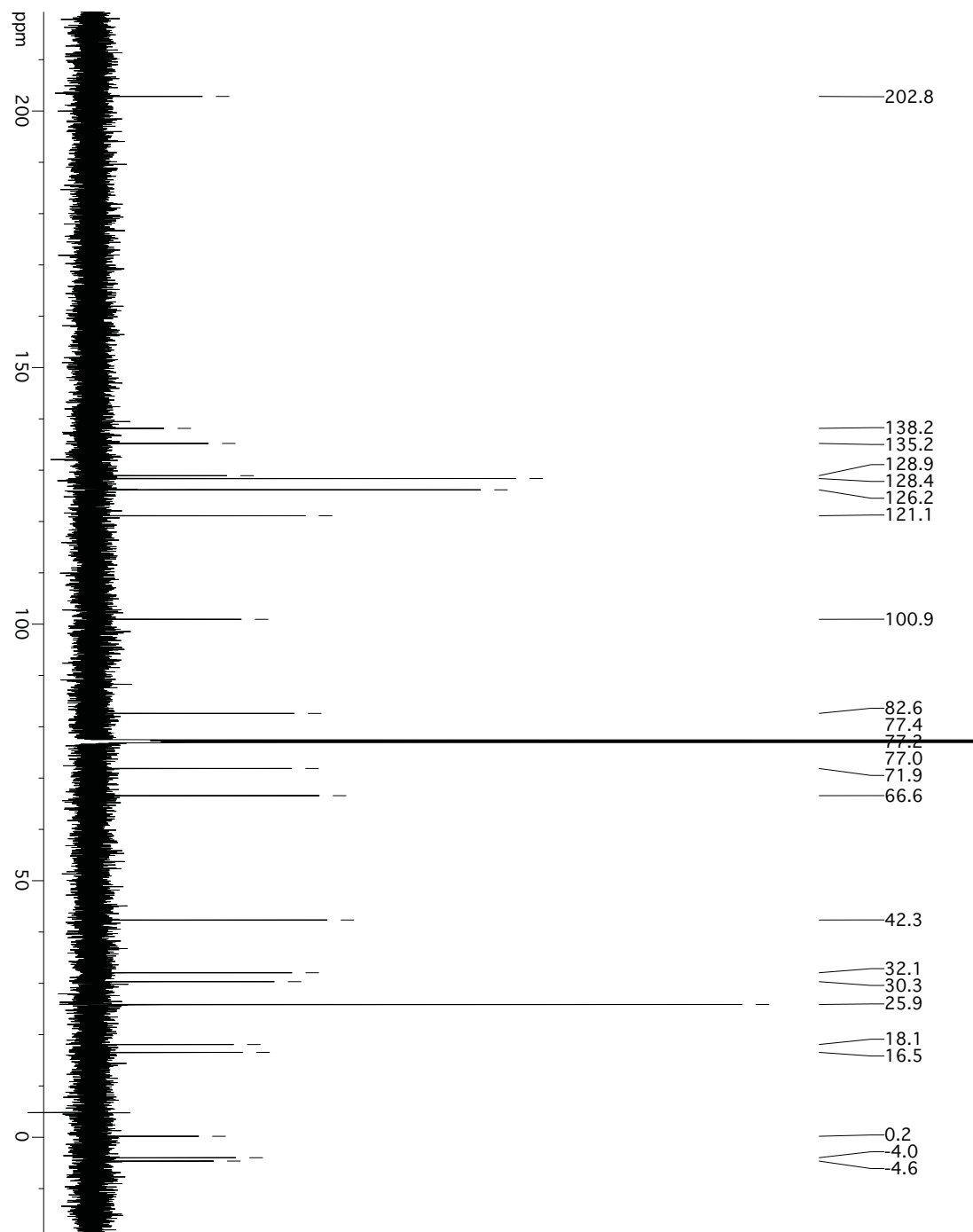
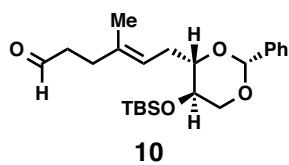


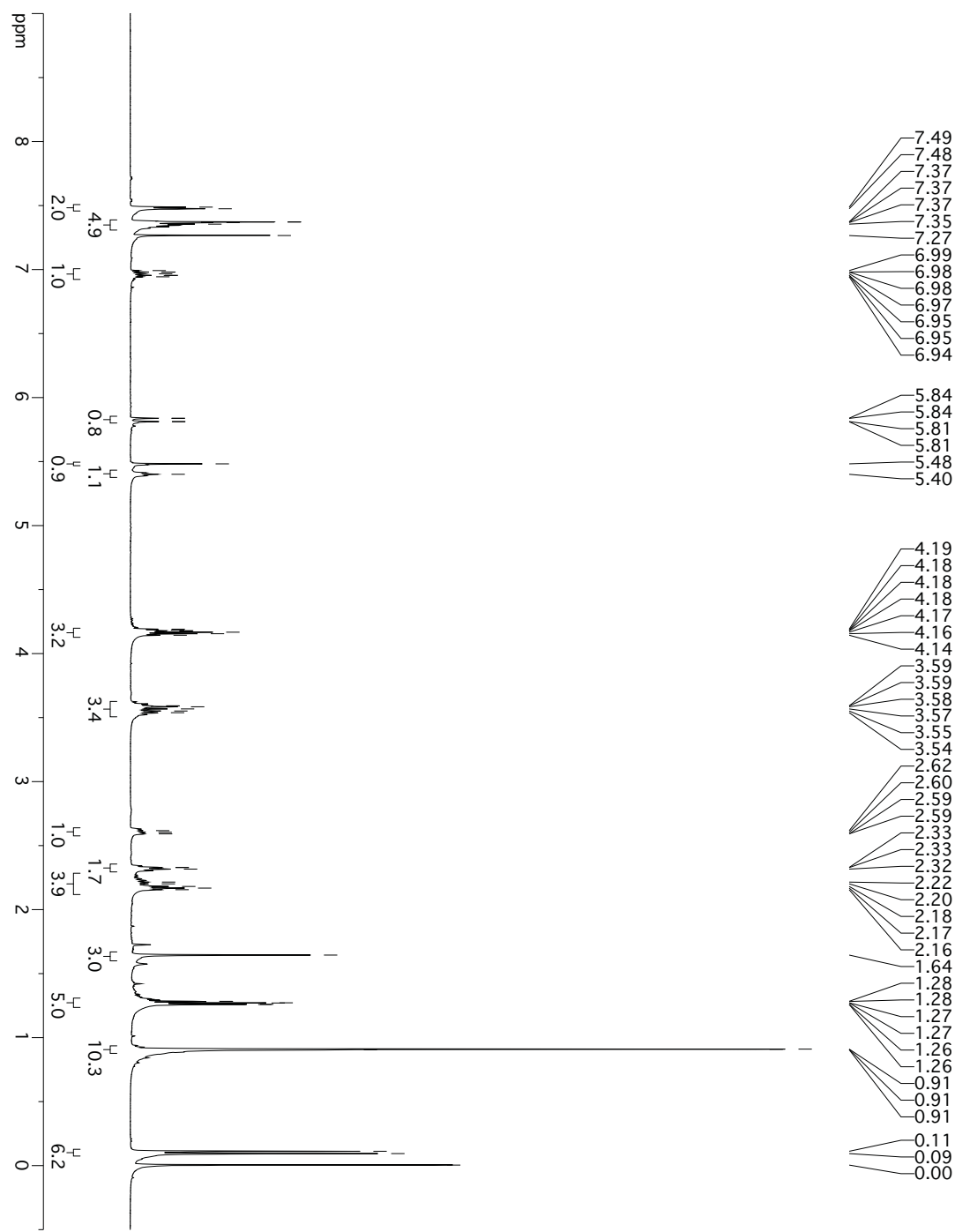
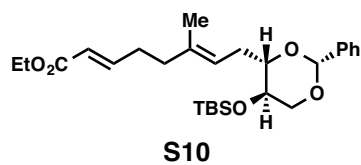


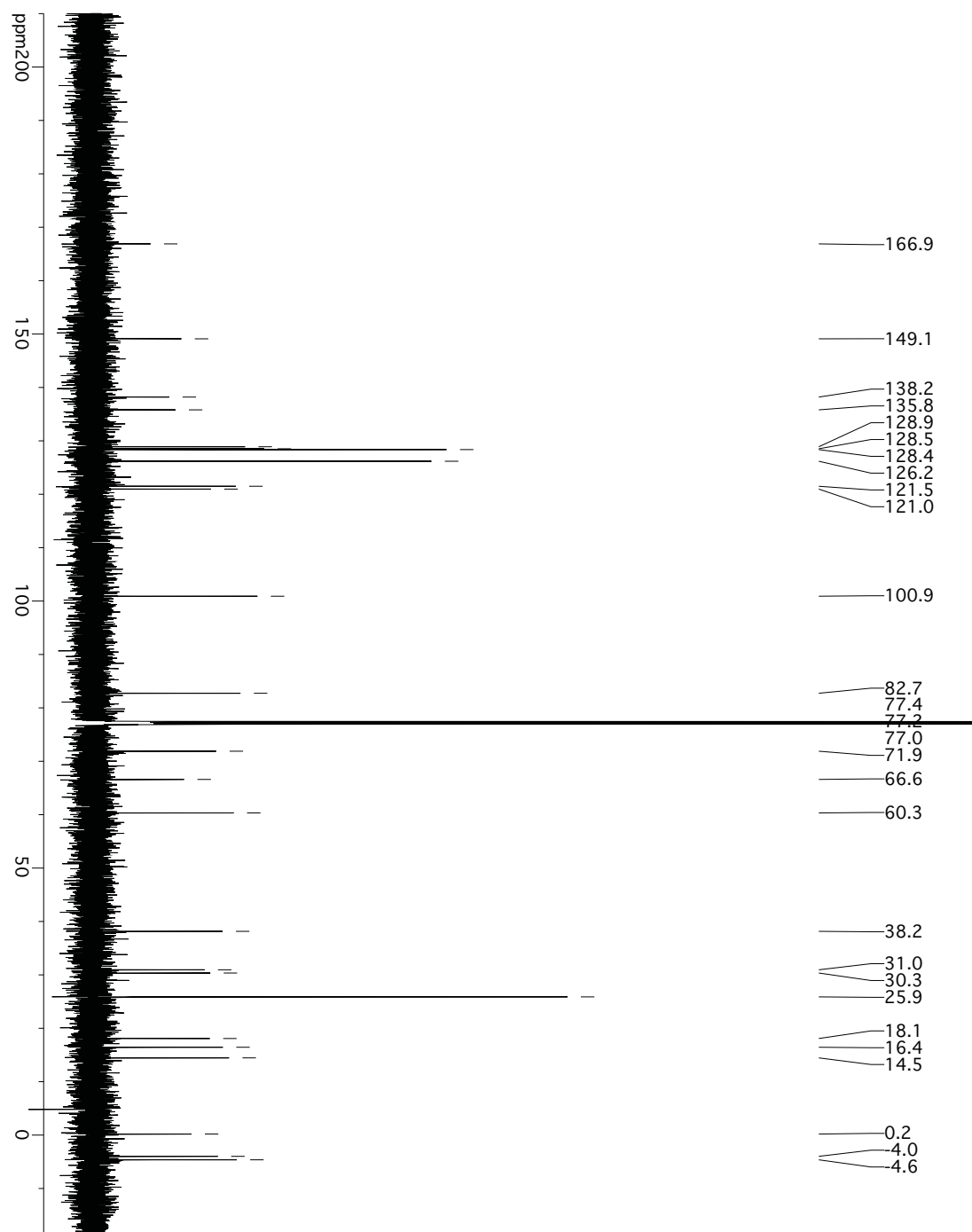
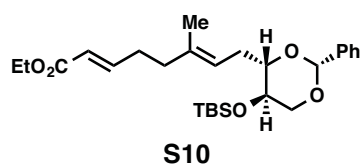


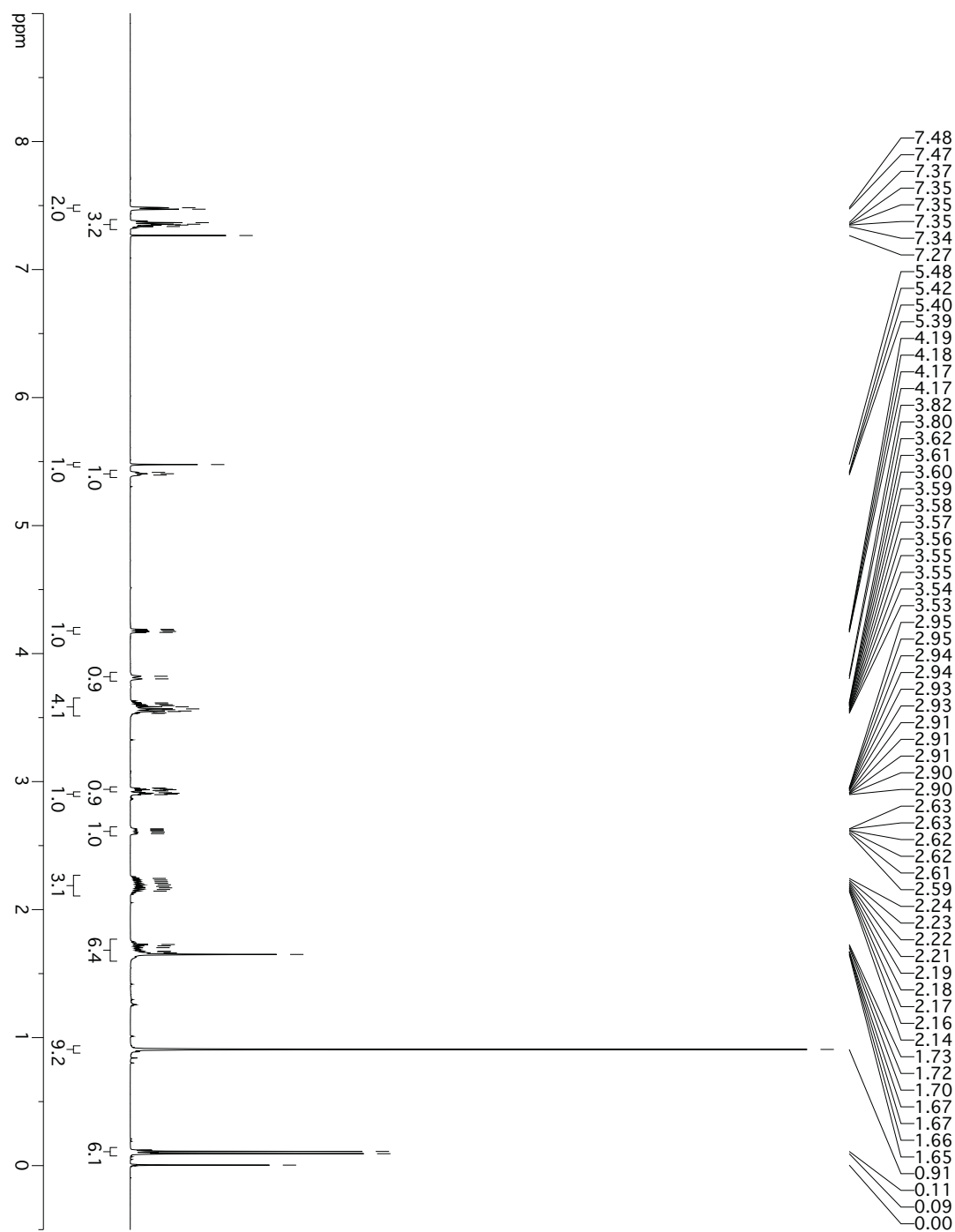
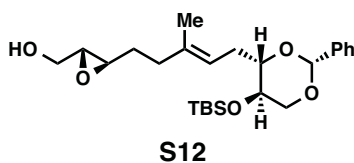




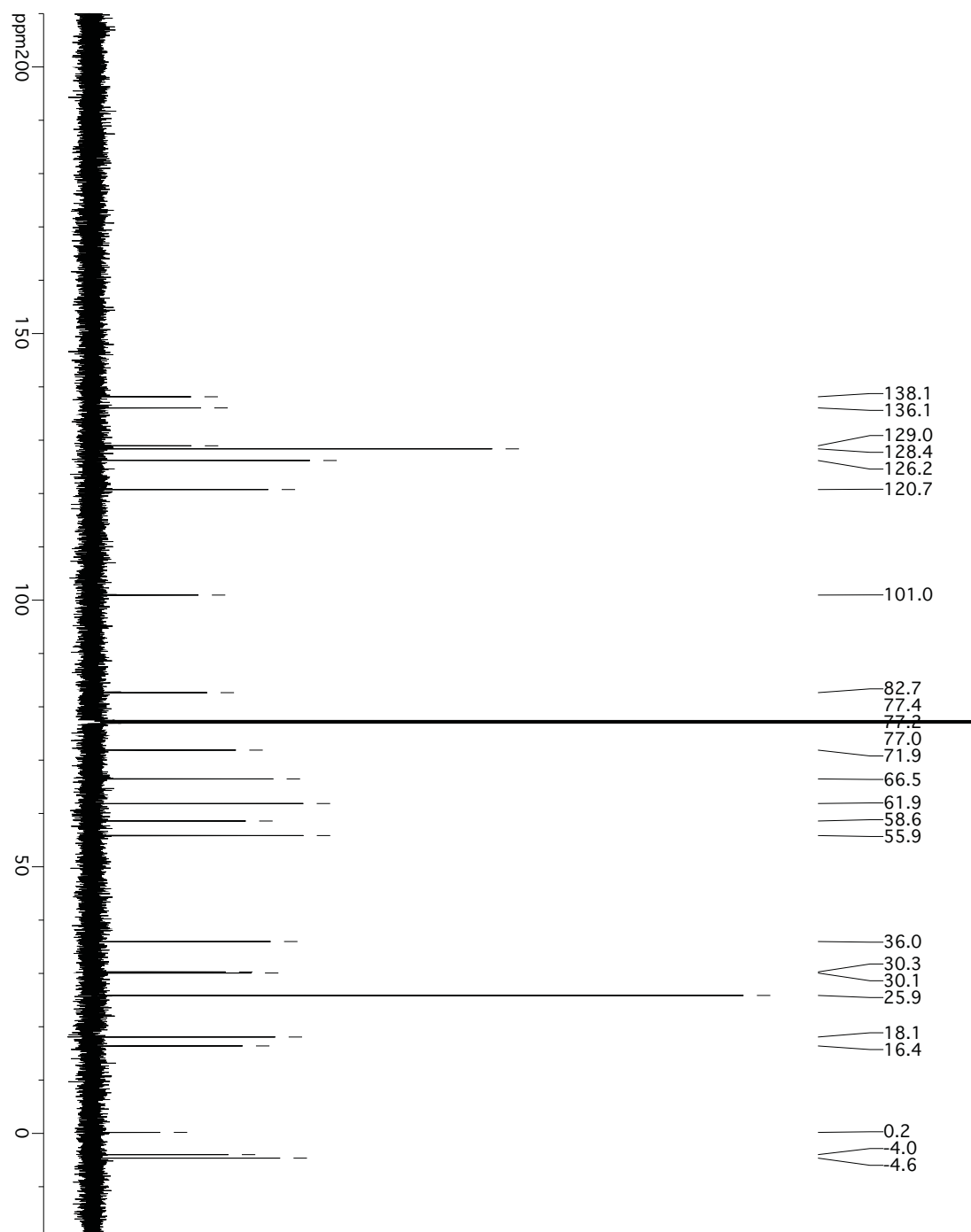
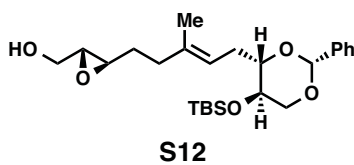


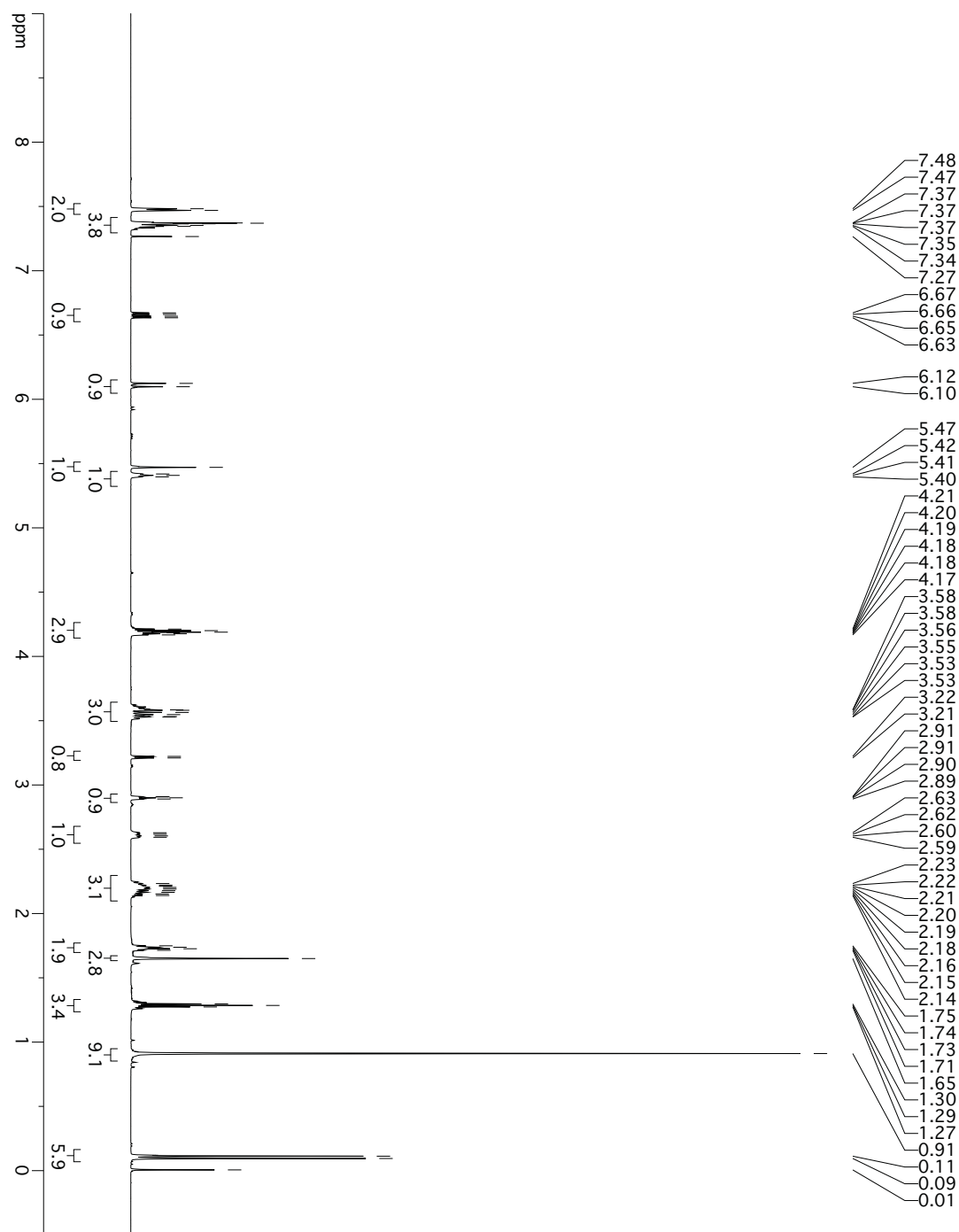
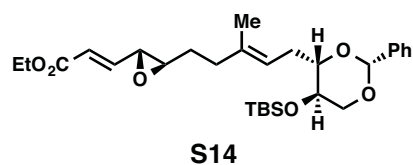


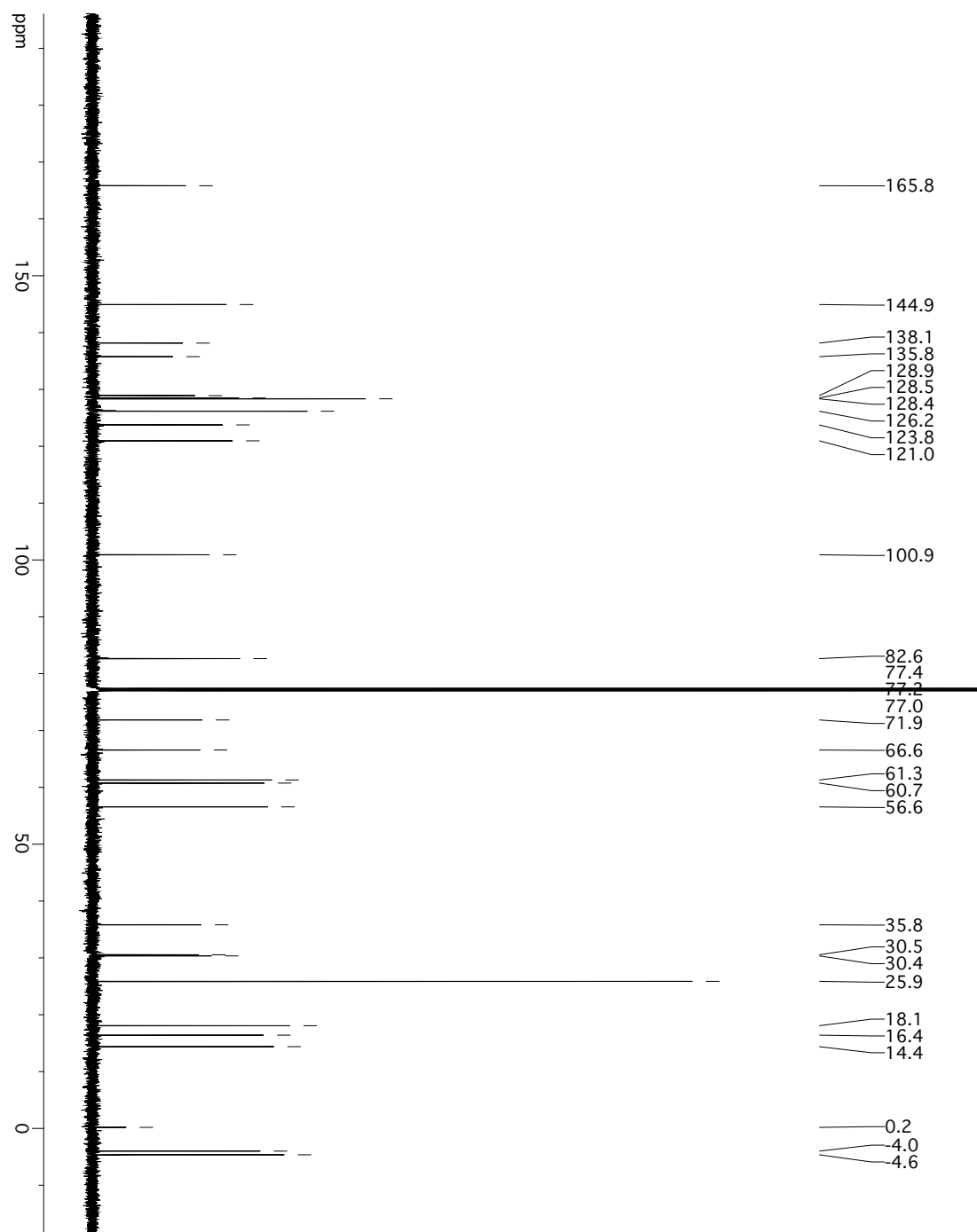
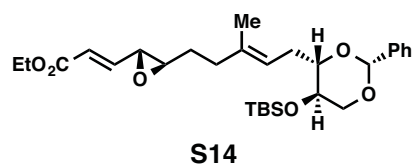


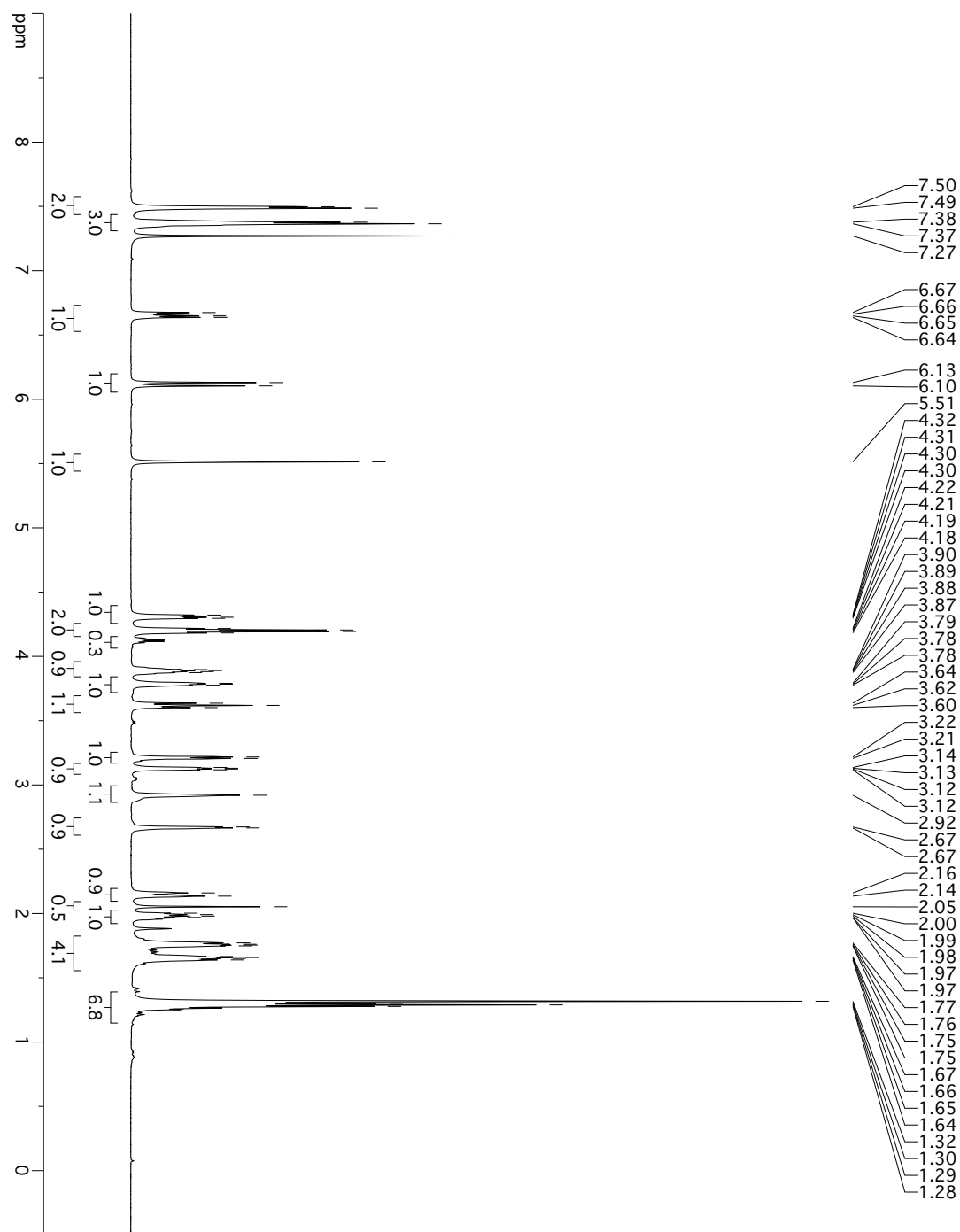
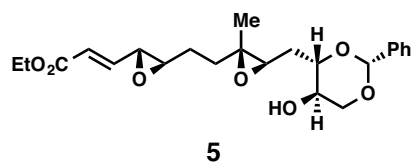


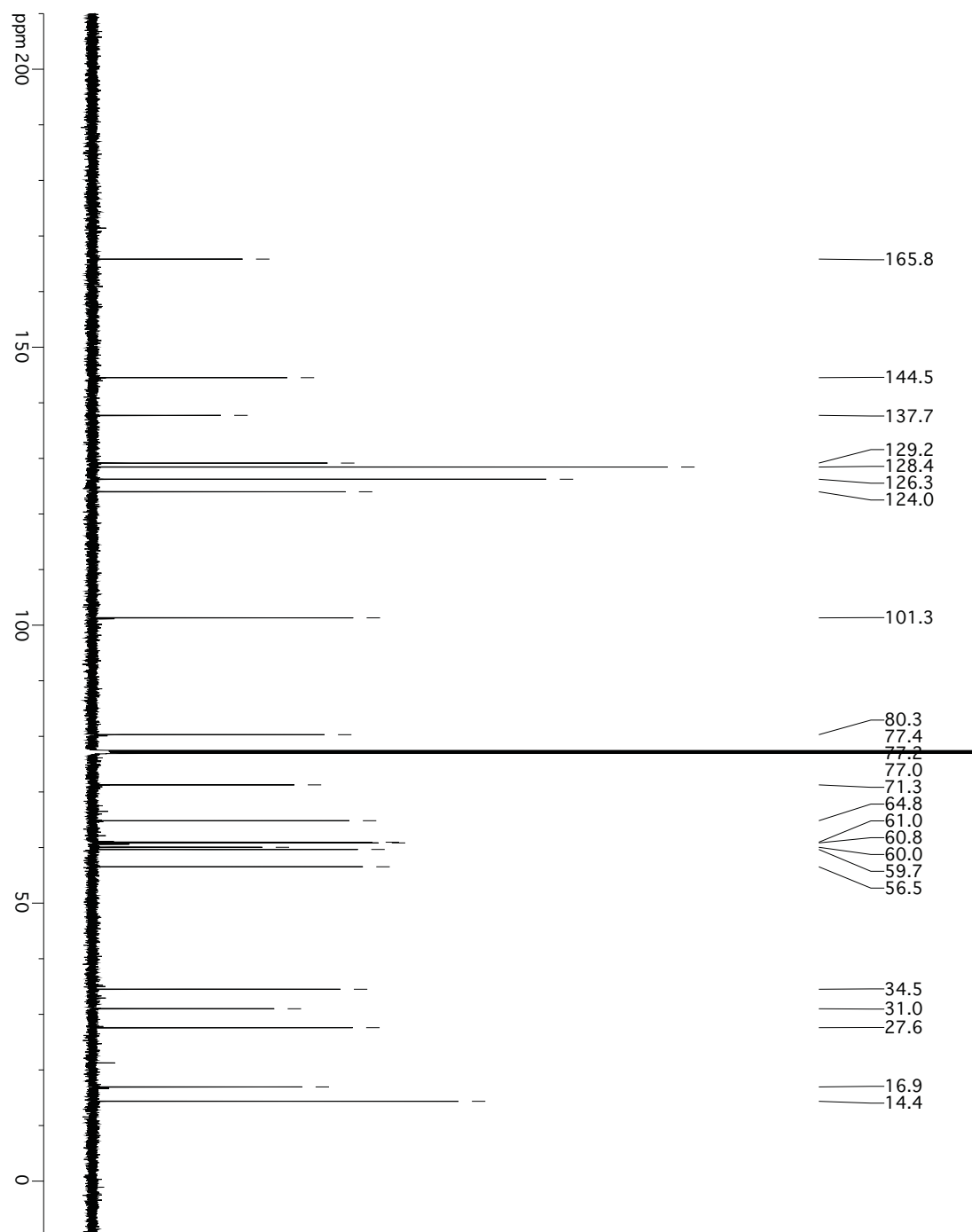
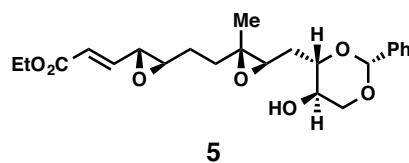


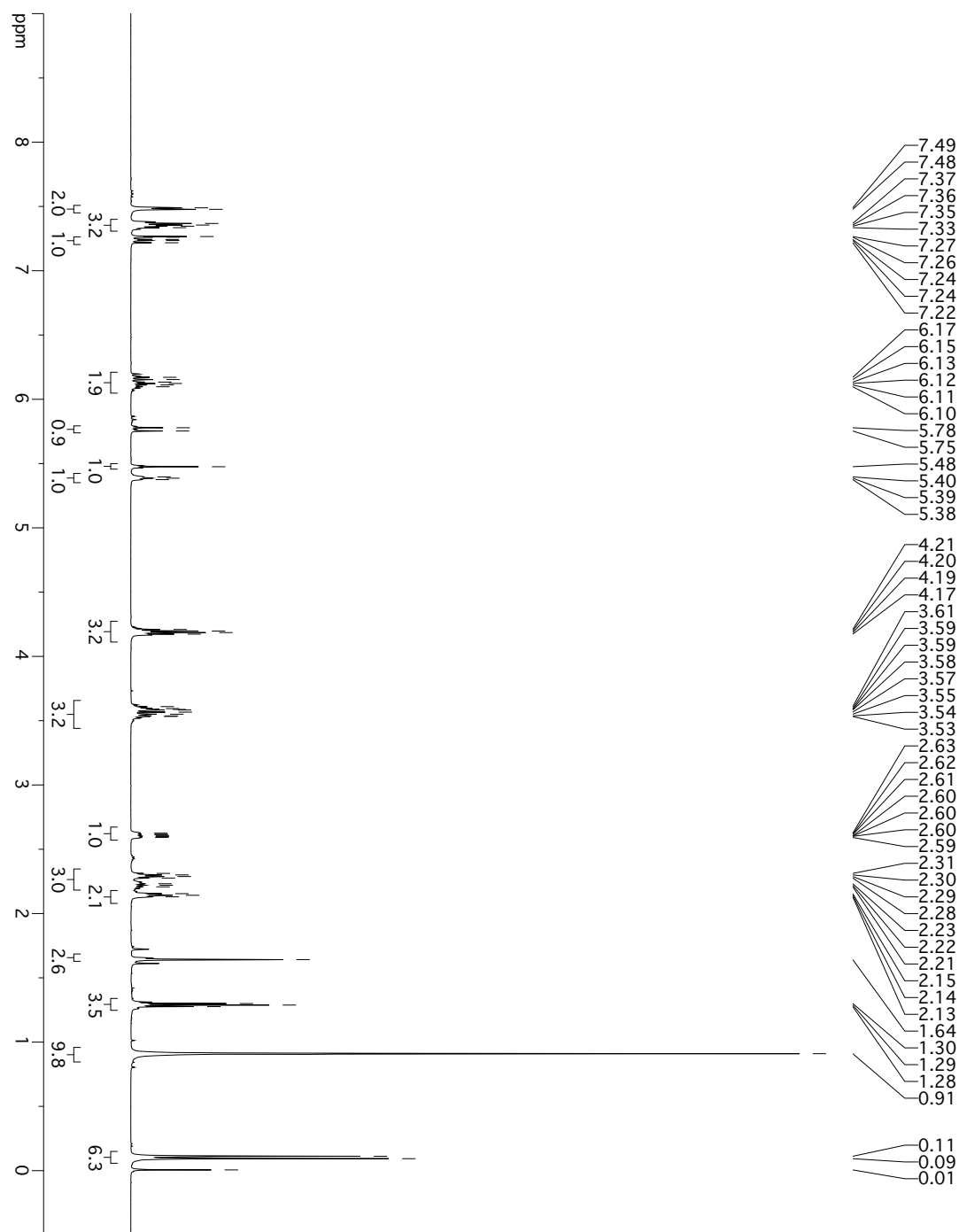
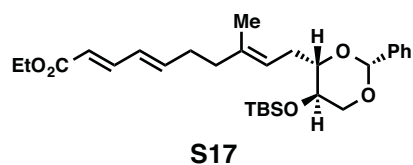


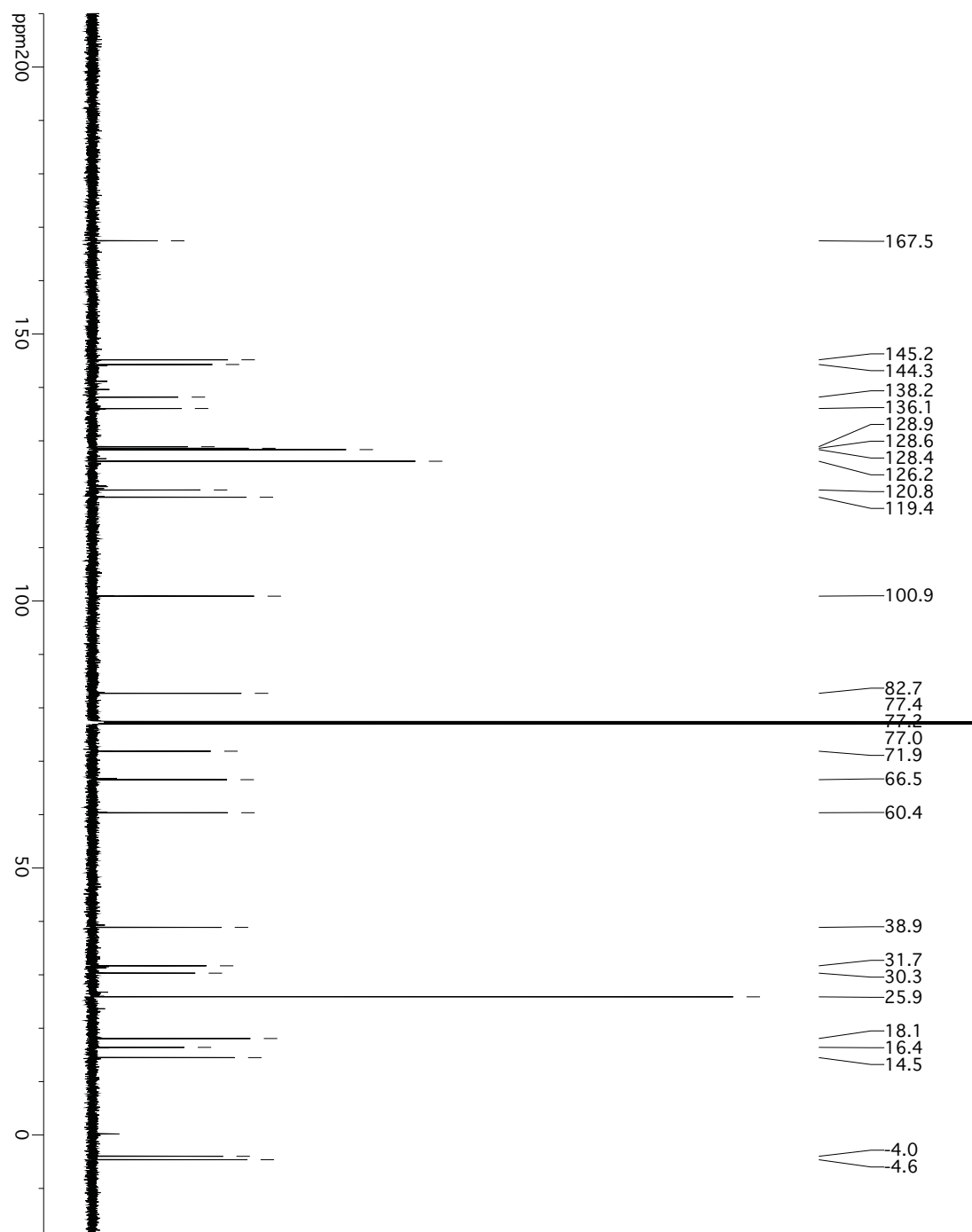
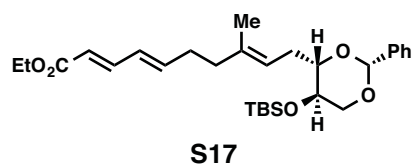


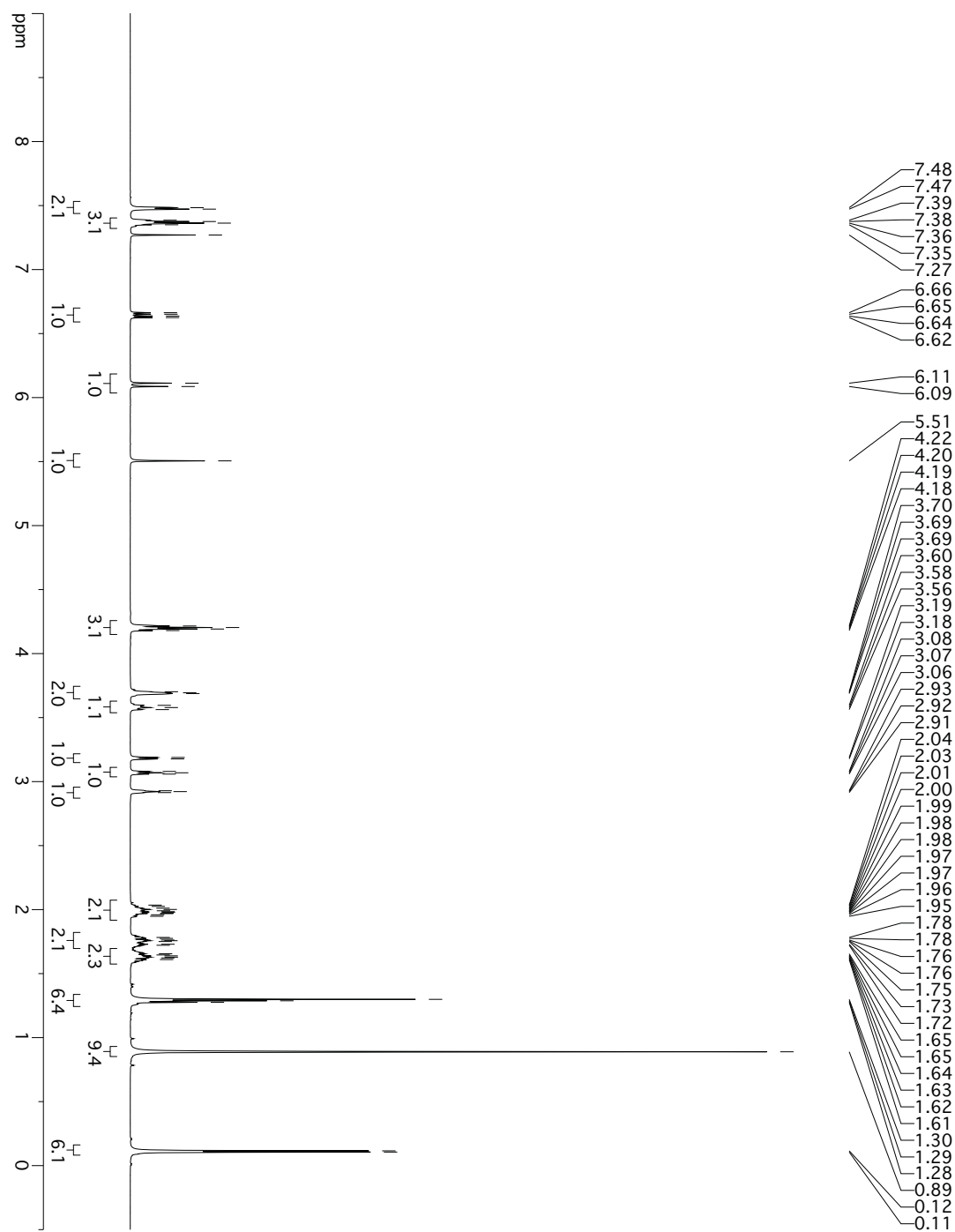
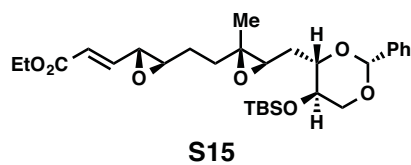




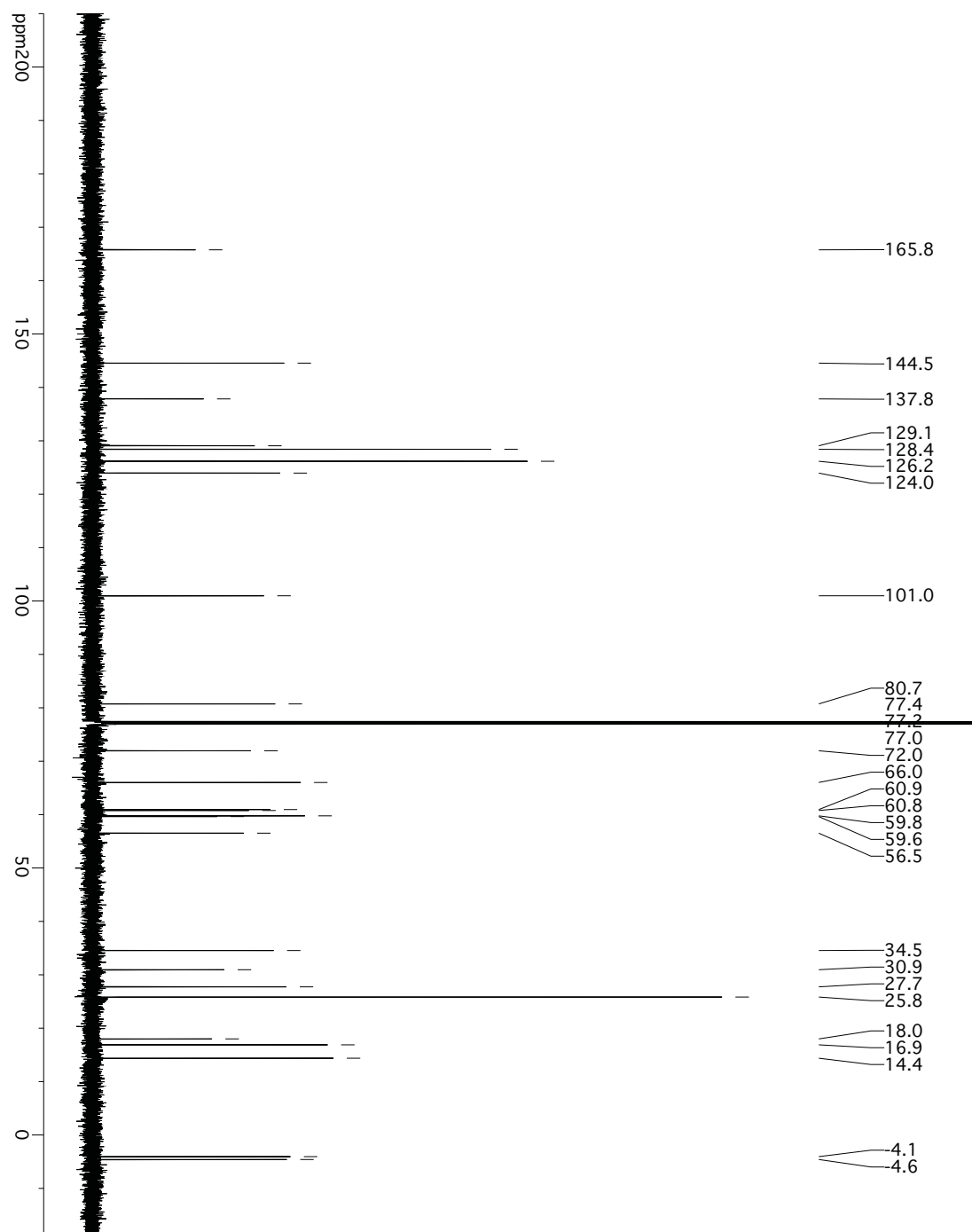
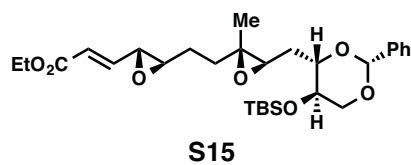


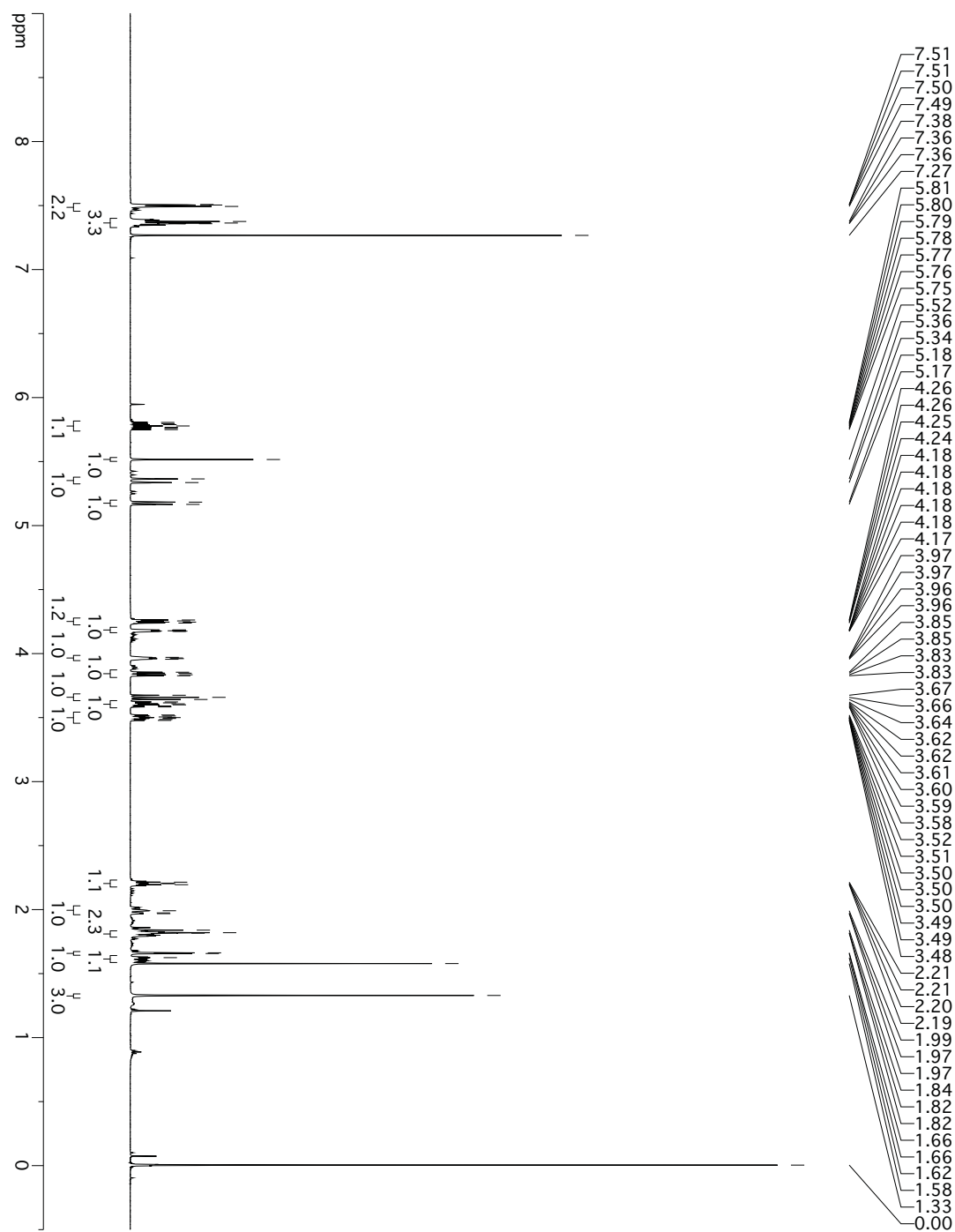
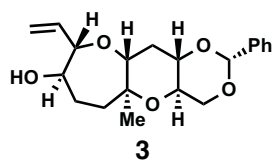


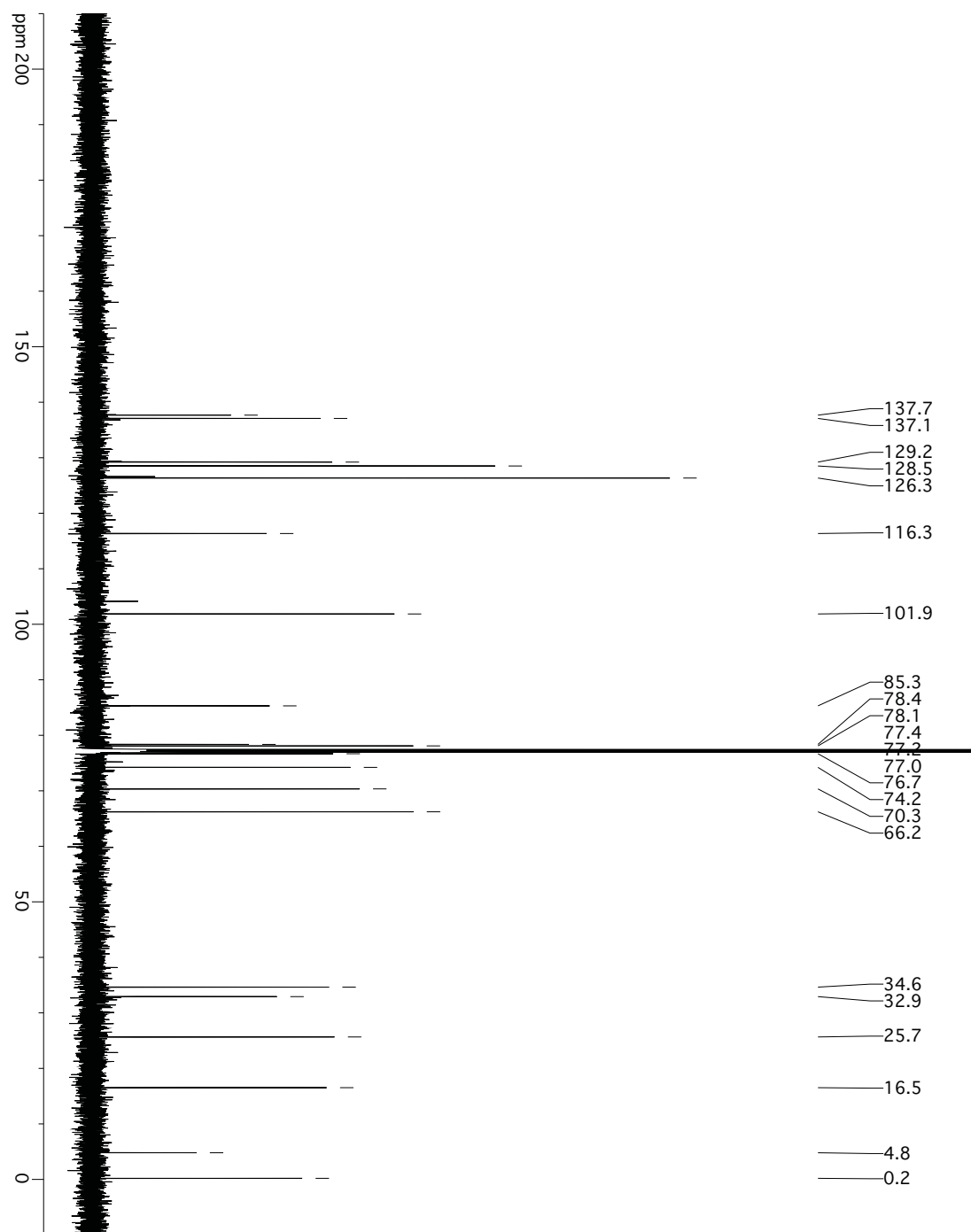
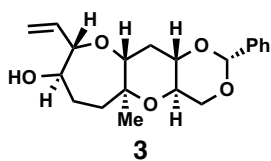


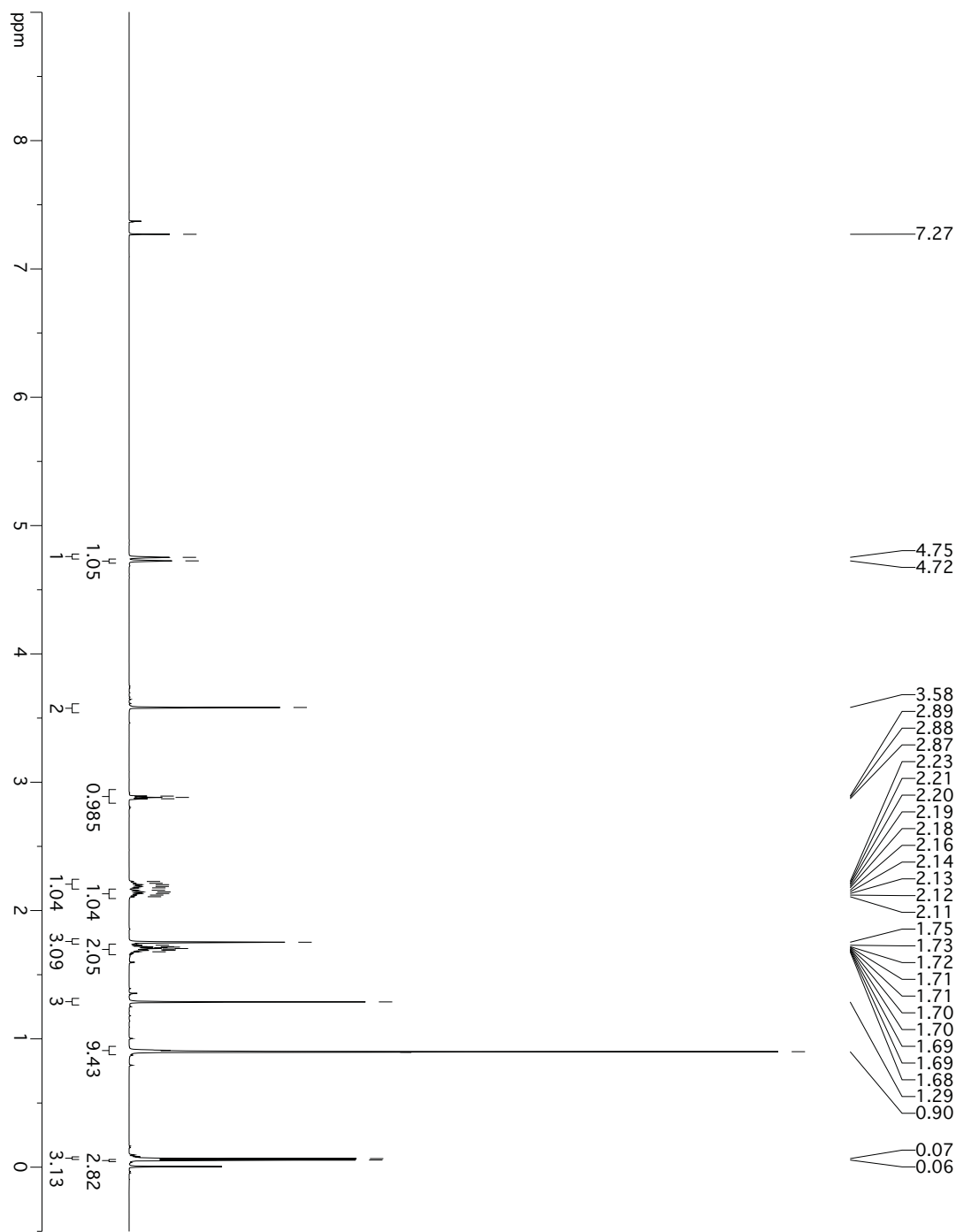
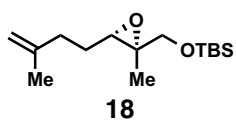


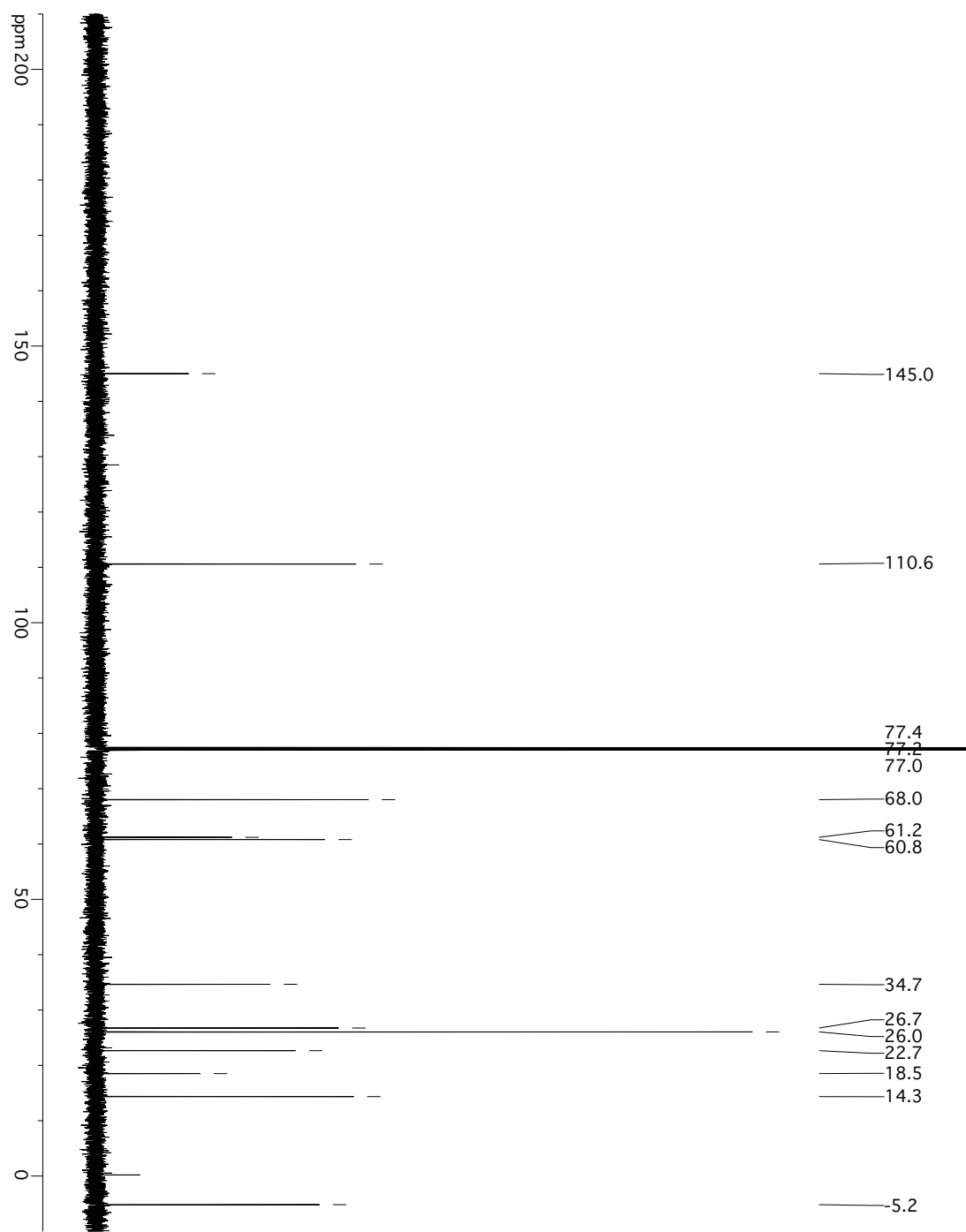
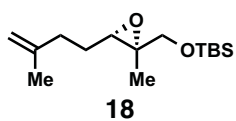


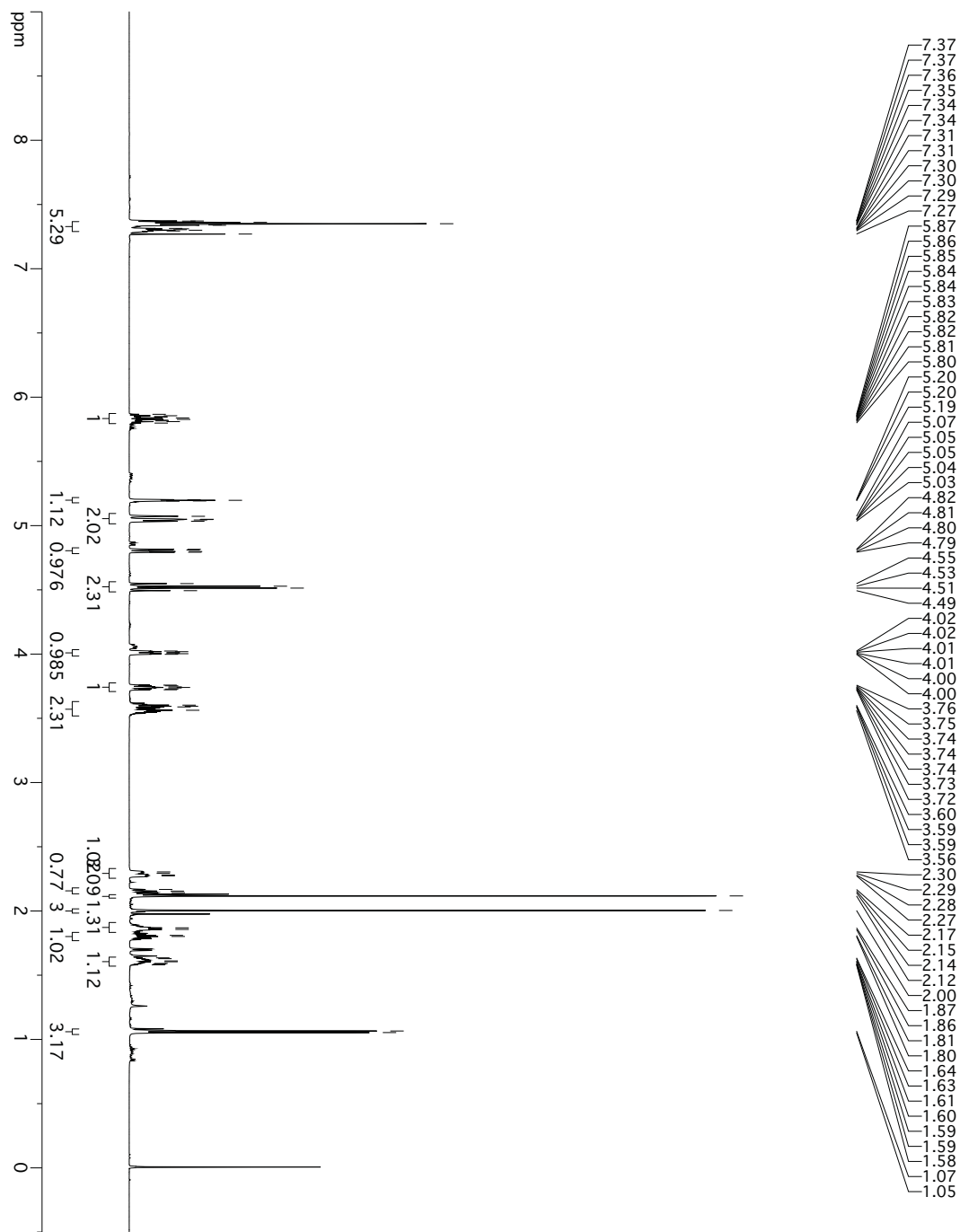
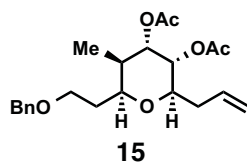


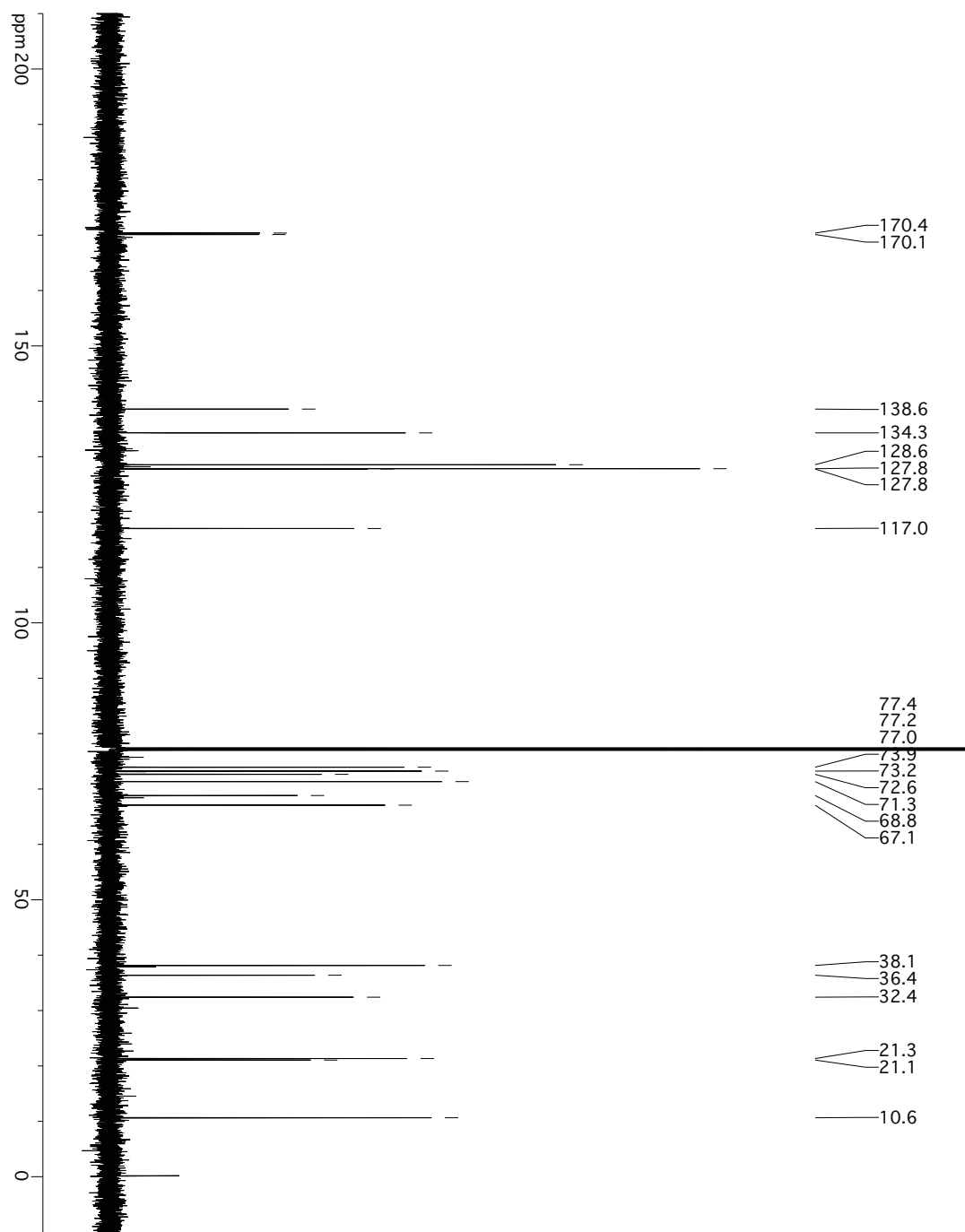
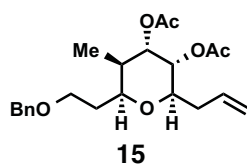


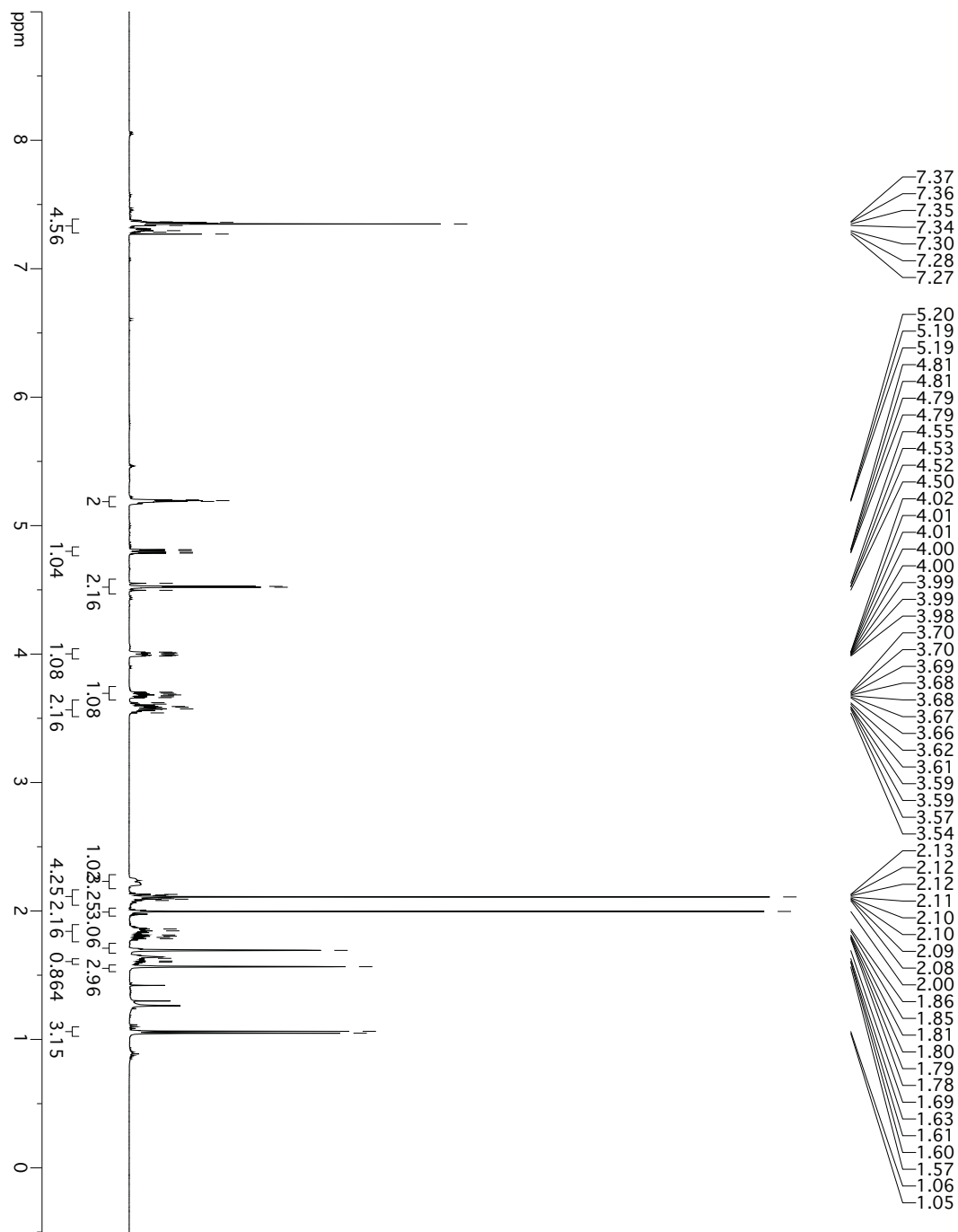
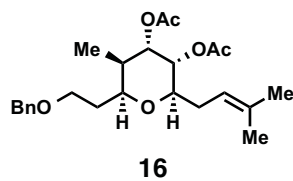




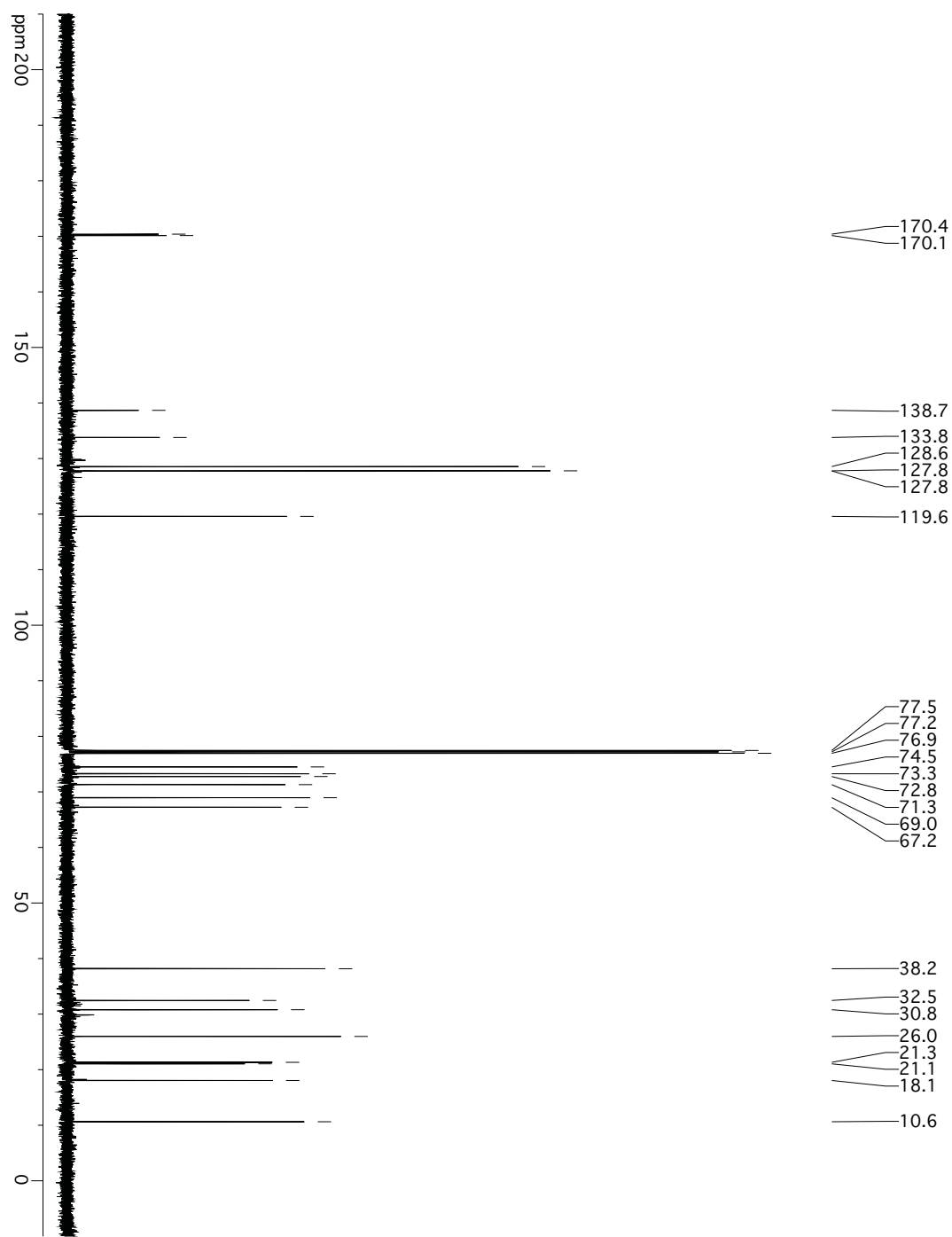
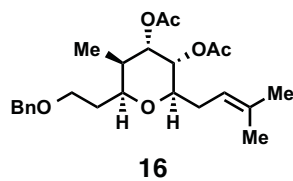


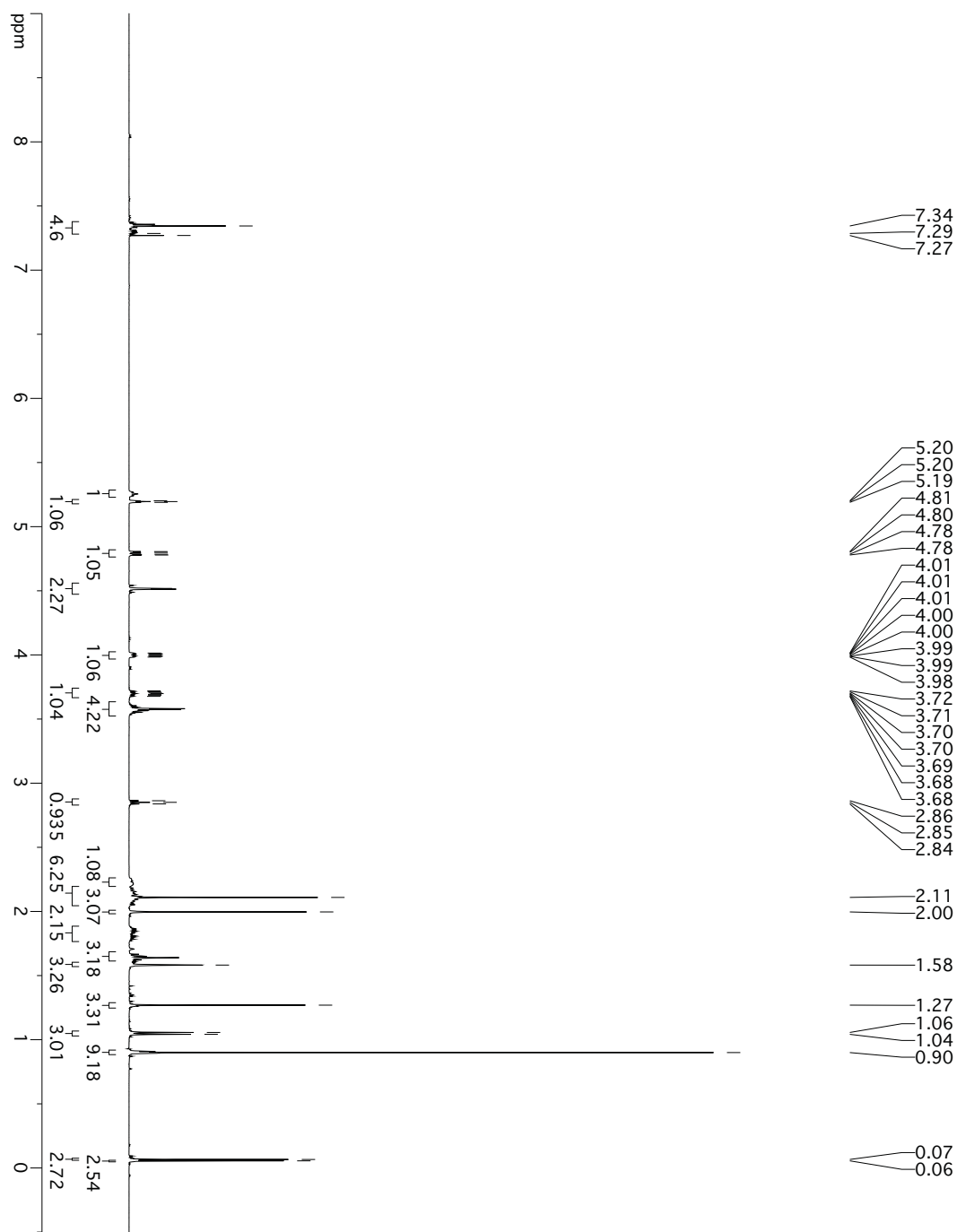
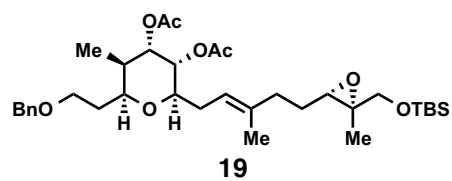


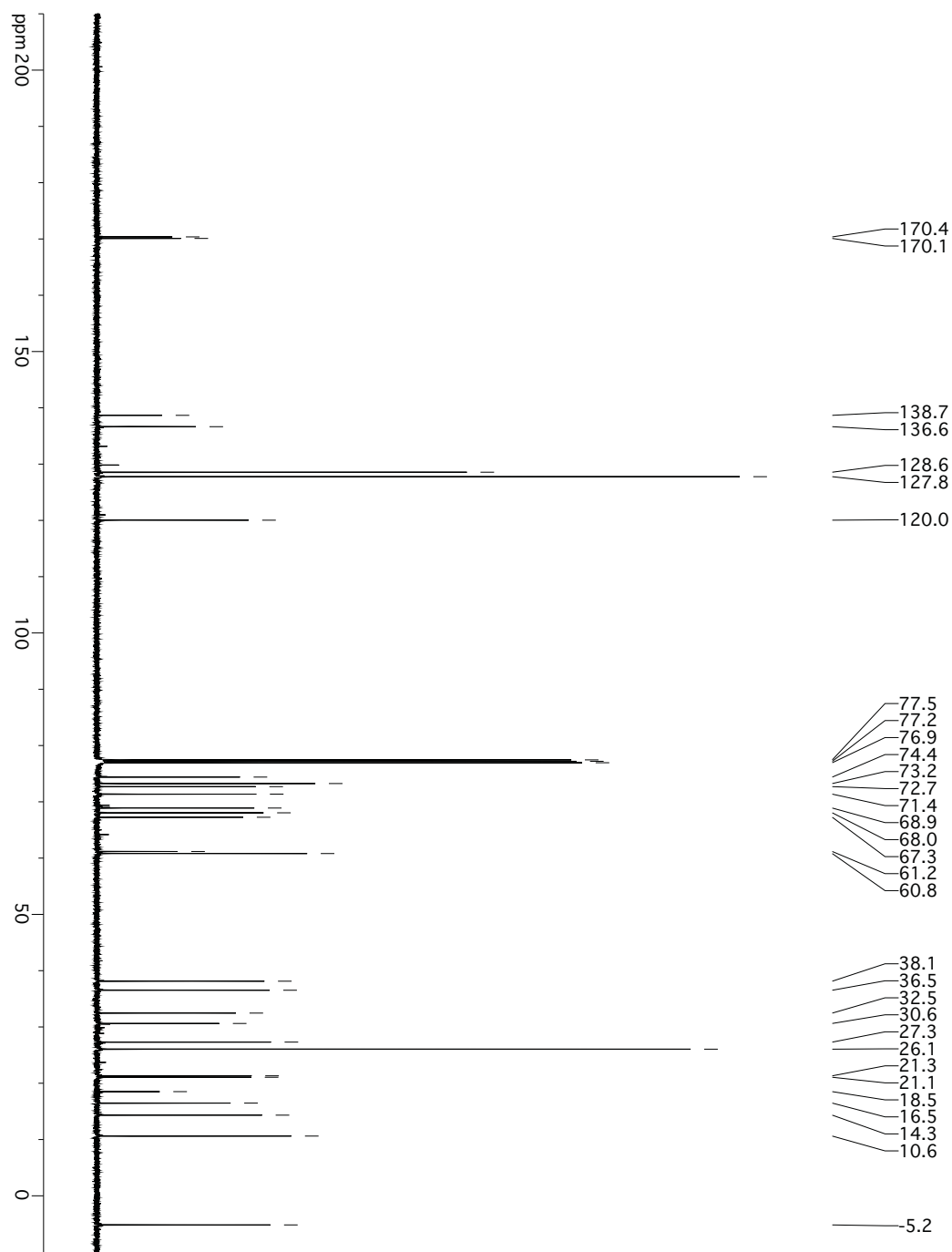
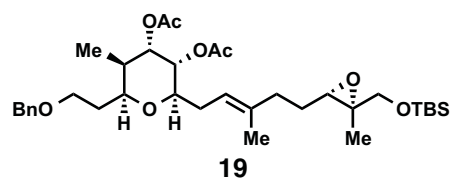


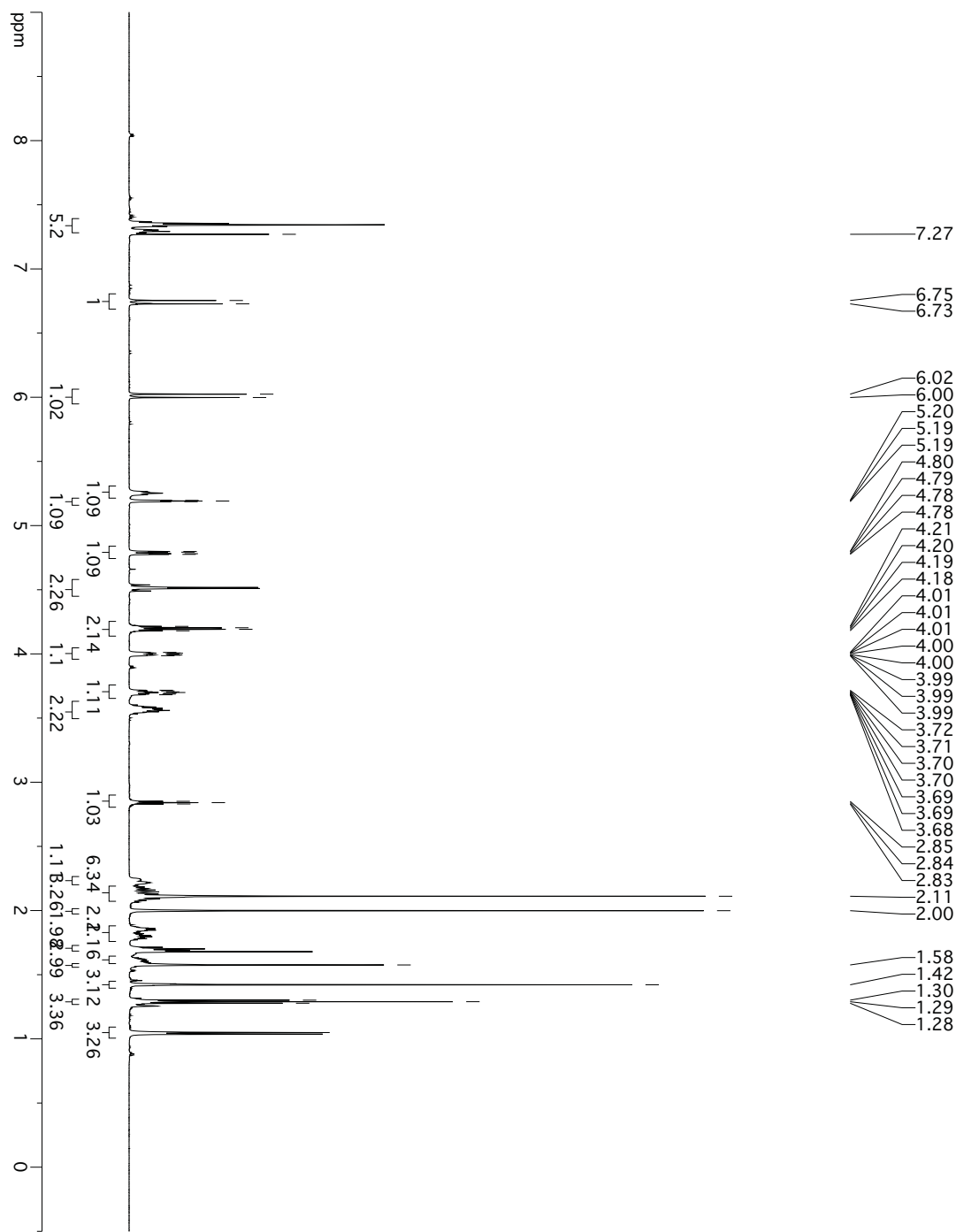
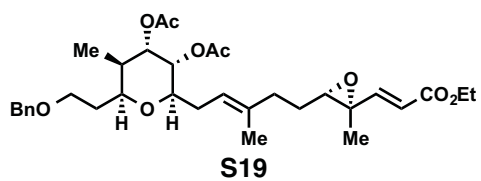


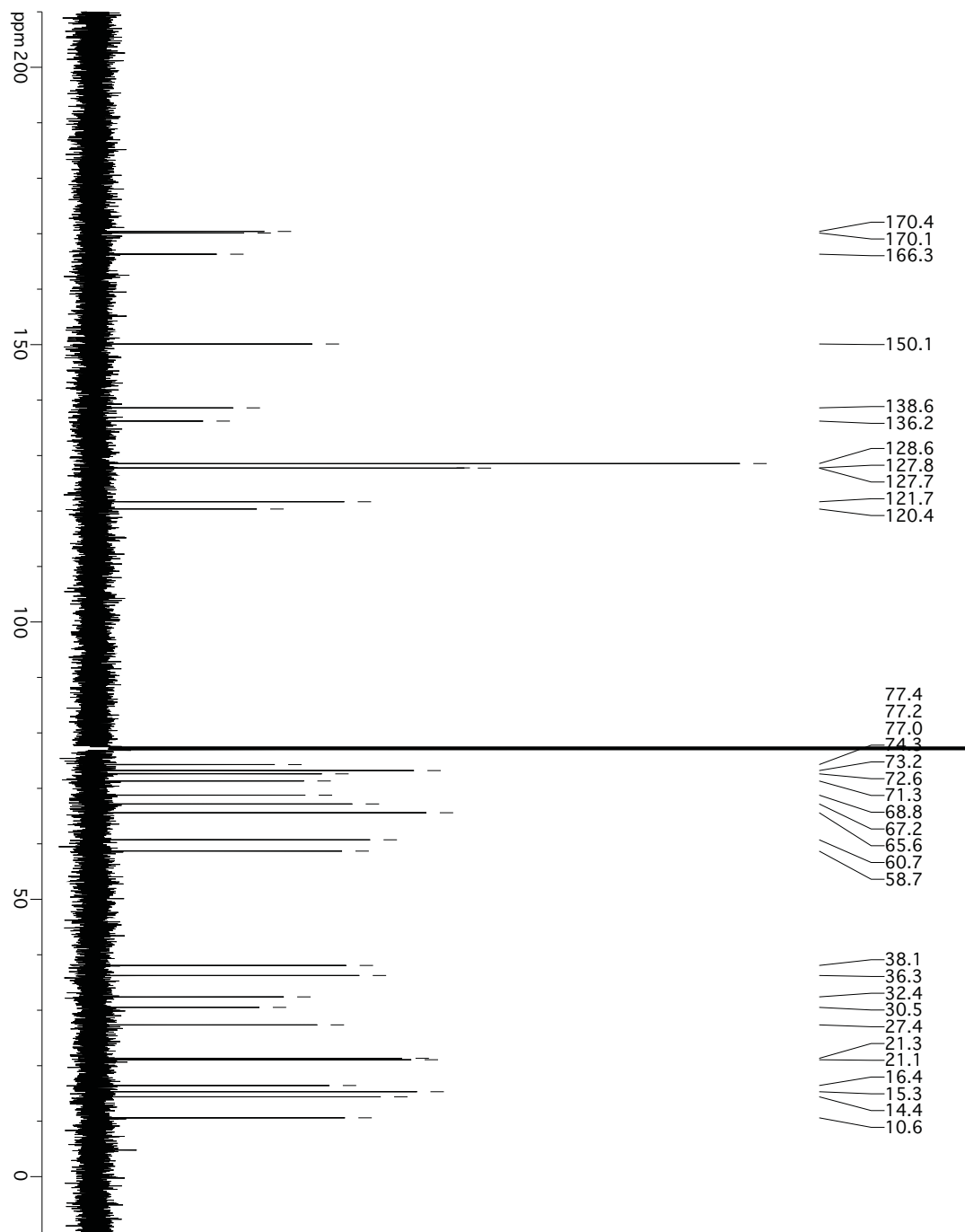
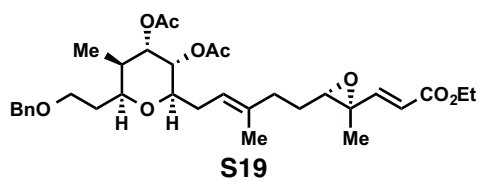


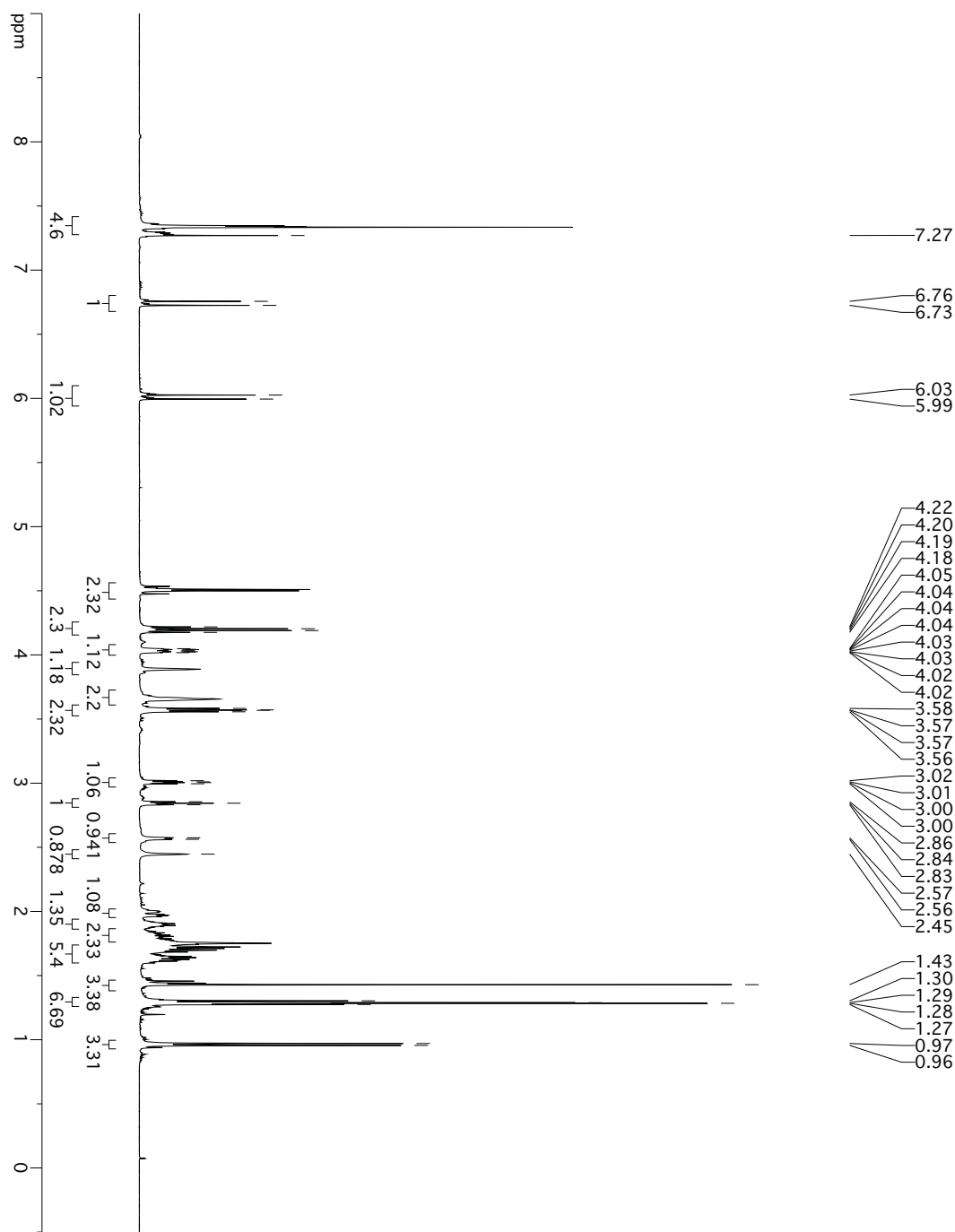
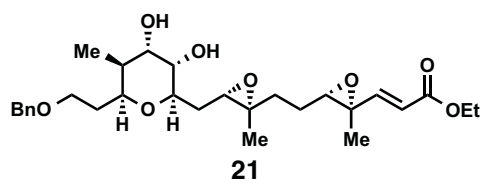


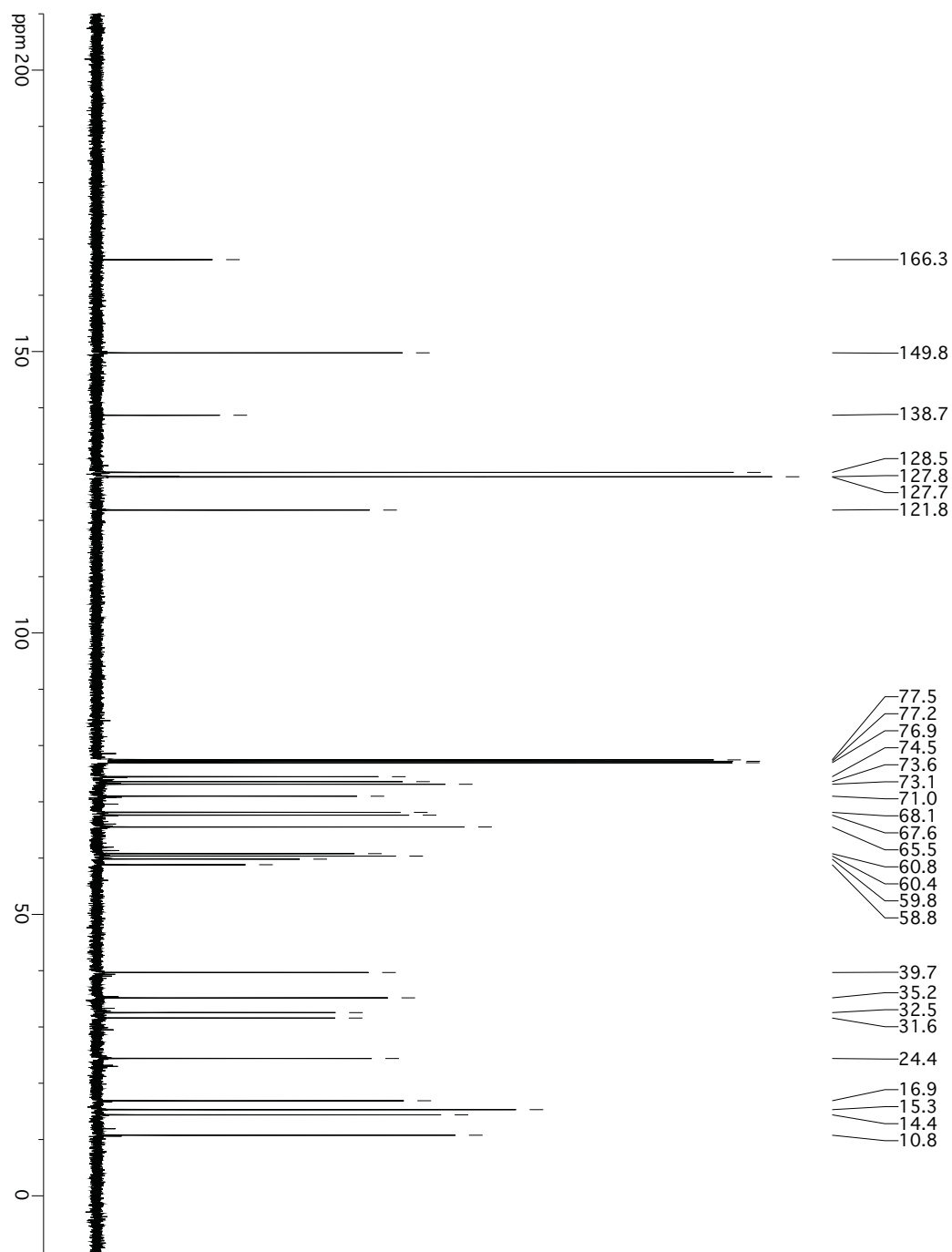
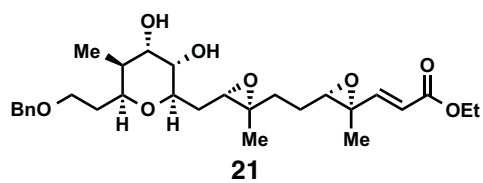


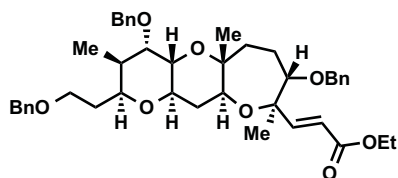




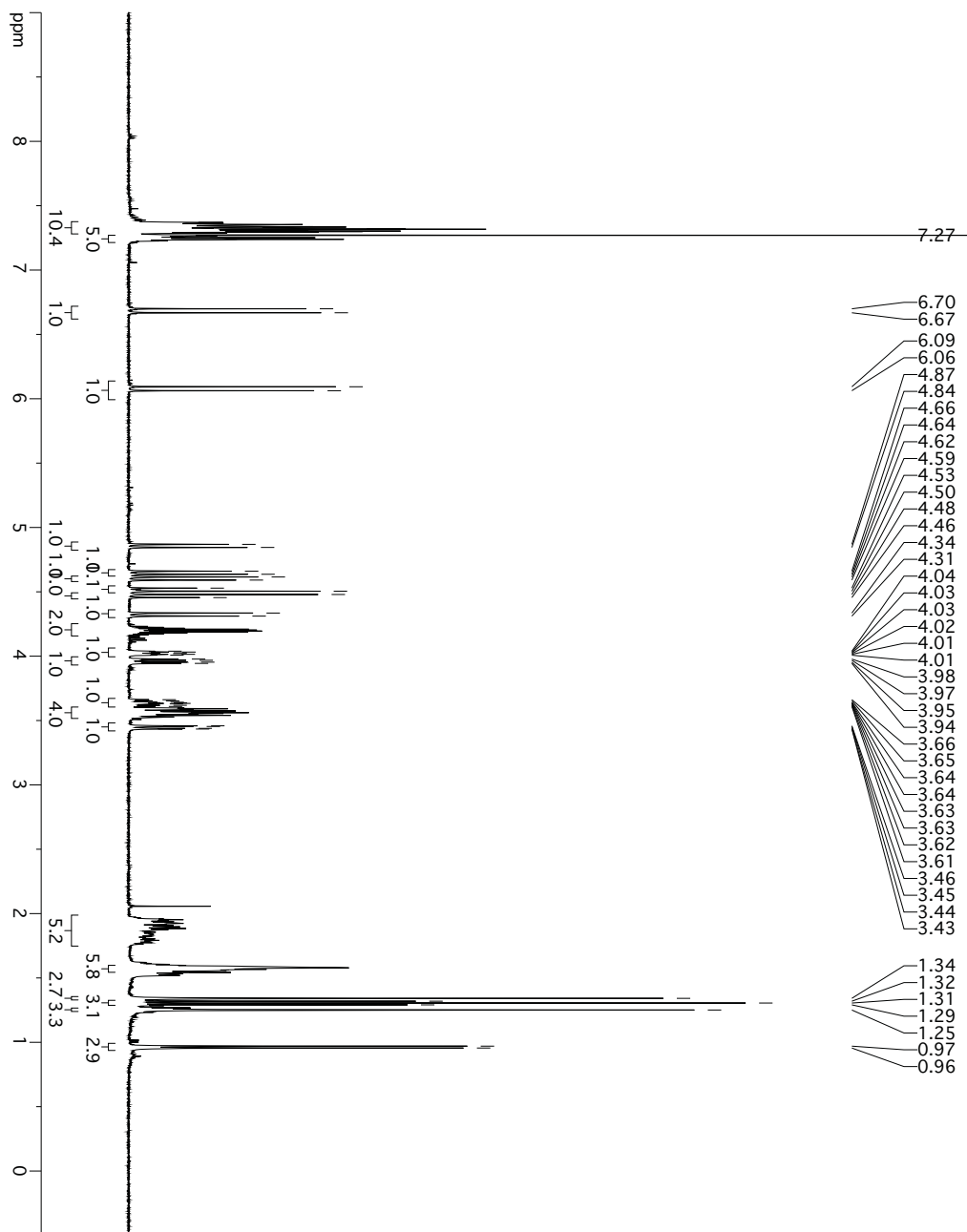




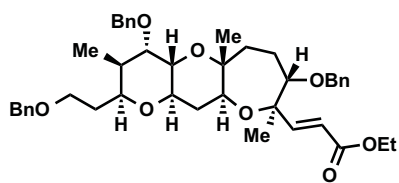




S20







S20

