

## Supporting Information

### “Access to the Pactamycin Core via an Epoxide Opening Cascade”

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#### 1. General Experimental Considerations:

Unless otherwise noted, materials were obtained from commercial sources and used without purification; otherwise, materials were purified according to *Purification of Laboratory Chemicals*.<sup>1</sup> All reactions requiring anhydrous conditions were performed under a positive pressure of nitrogen using flame-dried glassware. Diisopropylamine, triethylamine (NEt<sub>3</sub>), and N,N-diisopropylethylamine (Hünig's Base) were distilled from CaH<sub>2</sub> immediately prior to use. Dichloromethane (CH<sub>2</sub>Cl<sub>2</sub>), tetrahydrofuran (THF), toluene, and acetonitrile (CH<sub>3</sub>CN) were degassed with nitrogen and passed through a solvent purification system (Innovative Technologies Pure Solv). Methanol (MeOH) was distilled over magnesium prior to its usage. mCPBA was used as purchased (77% wt) with 4-chlorobenzoic acid and H<sub>2</sub>O impurities. HMPA is considered to be very toxic and should be handled with great care when used.

Yields were calculated for material judged homogeneous by thin-layer chromatography and <sup>1</sup>H NMR. Thin-layer chromatography was performed on silica plates eluting with the solvents indicated and visualized by a 254nm UV lamp. Flash column chromatography was performed with slurry-packed silica gel with solvents indicated in glass columns. <sup>1</sup>H NMR spectra were recorded at 500 MHz as indicated. The chemical shifts (δ) of proton resonances are reported relative to the deuterated solvent peak: 7.26 for CDCl<sub>3</sub> and 4.87 for H<sub>2</sub>O in CD<sub>3</sub>OD, using the following format: chemical shift [multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, app = apparent), coupling constant(s) (J in Hz), integral]. <sup>13</sup>C NMR spectra were recorded at 125 MHz. The chemical shifts of carbon resonances are reported relative to the deuterated solvent peak: 77.25 (center line) for CDCl<sub>3</sub> and 49.00 (center line) for CD<sub>3</sub>OD. Infrared spectra were recorded on a Nicolet 380-FT IR spectrometer fitted with a SmartOrbit sample system. All absorptions are reported in cm<sup>-1</sup> relative to polystyrene. Mass spectra were obtained by ESI/APCI for LRMS or ESI/APCI-TOF for HRMS. Melting points were recorded on a Fisher-Johns melting point apparatus using a digital thermocouple to determine temperature. Optical rotations were obtained at ambient temperature on a Perkin Elmer Model 343 polarimeter (Na<sub>D</sub> line) using a microcell with a 1 decimeter path length.

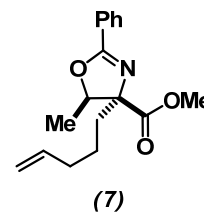
<sup>1</sup> *Purification of Laboratory Chemicals*. 2003, 5th Ed. Armarego, W. L. F.; Chai, C. L. L.

<sup>2</sup> Hoye, T.R.; Hansen, P.R.; Vyvyan, J.R. *J. Org. Chem.* **1994**, 59, 4096-4103.

## 2. Experimental Procedures:

### **(4R,5R)-methyl 5-methyl-4-(pent-4-en-1-yl)-2-phenyl-4,5-dihydrooxazole-**

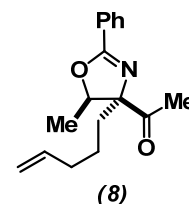
**4-carboxylate (7):** To a freshly distilled solution of diisopropylamine (57.0 mL, 0.410 mol, 1.45 equiv.) in THF (2 L) at  $-78^{\circ}\text{C}$  (dry ice/acetone) in a 3 L three neck roundbottomed flask containing a magnetic stir bar equipped with a thermocouple



under a stream of  $\text{N}_2$  was added  $n\text{BuLi}$  (157.0 mL, 2.5M in THF, 0.390 mol, 1.4 equiv.). Following complete addition the reaction was taken out of the cold bath and warmed for 30 min. or until the reaction temperature rose to  $0^{\circ}\text{C}$ . The reaction was then cooled back to  $-78^{\circ}\text{C}$  and HMPA (200.0 mL, 1.120 mol, 4 equiv.) was added to the solution quickly. The solution was further cooled to  $-85^{\circ}\text{C}$  (liq.  $\text{N}_2/\text{MeOH}$ ) and oxazoline **6** (61.2 g, 0.279 mol, 1 equiv.) was added dropwise over a period of 35 min. The reaction temperature was monitored by a thermocouple and never rose above  $-80^{\circ}\text{C}$  and never below  $-90^{\circ}\text{C}$ . The solution was then warmed to  $-78^{\circ}\text{C}$  and 5-iodo-1-pentene (109.0 g, 0.560 mol, 2 equiv.) was added over a period of 30 min. making sure the temperature never rose above  $-70^{\circ}\text{C}$ . The reaction was allowed to warm to rt over a period of 24h. The solvent was removed under reduced pressure. The crude material was dissolved in  $\text{CH}_2\text{Cl}_2$  (500 mL) and washed with sat.  $\text{LiCl}$  (3 x 500 mL) to yield analytically pure **7** (56.85 g, 71%) as a light yellow oil.  $R_f$  0.61 (50% ethyl acetate/hexanes).  $[\alpha]_D^{20} = +37.4$  ( $c = 0.7$ ,  $\text{CH}_2\text{Cl}_2$ ).  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ): 7.99 (d,  $J = 7.5$  Hz, 2H), 7.48 (t,  $J = 7.5$  Hz, 1H), 7.41 (t,  $J = 7.0$  Hz, 2H), 5.77 (dddd,  $J = 7.0, 7.0, 10.0, 17.0$  Hz, 1H), 5.02-4.92 (m, 2H), 4.58 (q,  $J = 7.0$  Hz, 1H), 3.75 (s, 3H), 2.14-2.05 (m, 3H), 1.76-1.62 (m, 2H), 1.46-1.36 (m, 1H), 1.32 (d,  $J = 6.5$  Hz, 3H) ppm.  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 125 MHz): 172.6, 164.3, 138.5, 131.8, 128.7, 128.5, 127.8, 115.0, 83.2, 81.0, 52.3, 39.1, 33.9, 23.4, 17.1 ppm. IR (neat): 2949 (w), 1731, 1646, 1449, 1283, 1148 (all s)  $\text{cm}^{-1}$ . HRMS (ESI) Calculated for  $\text{C}_{17}\text{H}_{22}\text{NO}_3$   $m/z$  288.1600 ( $\text{M}+\text{H}$ ), Obsd. 288.1590.

### **1-((4R,5R)-5-methyl-4-(pent-4-en-1-yl)-2-phenyl-4,5-dihydrooxazol-4**

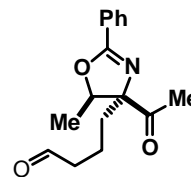
**yl)ethanone (8):** To a 1 L roundbottomed flask containing a magnetic stir bar, oxazoline **7** (10.0 g, 34.8 mmol, 1 equiv.) in a solution of THF (350 mL) and equipped



with a thermocouple under a stream of N<sub>2</sub> was added N,O-dimethylhydroxylamine (5.10 g, 52.2 mmol, 1.5 equiv.). The solution was stirred for 5 min. until the solids were finely slurried. The solution was further cooled to –5°C (Acetone/ice/dry ice) and MeMgBr (64.0ml, 3M in THF, 192.0 mmol, 5.5 equiv.) was added at rate where the temperature never rose above 0°C. The reaction was left to warm to rt and stirred until TLC analysis showed complete consumption of the starting material. The excess MeMgBr was quenched with sat. NH<sub>4</sub>Cl. The crude reaction mixture was then extracted with Et<sub>2</sub>O (100 ml x 2). The organic layer was dried with Na<sub>2</sub>SO<sub>4</sub> and concentrated under reduced pressure. Purification of the product was accomplished using flash chromatography eluting with 10% ethyl acetate/hexanes. The fractions containing product were concentrated under reduced pressure to give the methyl ketone **8** (7.80 g, 82%) as a light yellow oil.  $R_f$  = 0.66 (50% ethyl acetate/hexanes).  $[\alpha]_D^{20}$  = +43.2 ( $c$  = 0.3, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>): 8.01(d,  $J$  = 7 Hz, 2H), 7.51 (t,  $J$  = 7.5 Hz, 1H), 7.46 (t,  $J$  = 7.5 Hz, 2H), 5.75 (dddd,  $J$  = 7, 7, 10, 17 Hz, 1H), 5.00-4.91 (m, 2H), 4.58 (q,  $J$  = 6.5 Hz, 1H), 2.28 (s, 3H), 2.16-1.94 (m, 3H), 1.68-1.55 (m, 2H), 1.36-1.28 (m, 1H), 1.25 (d,  $J$  = 6.5 Hz, 3H) ppm. <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>): 218.5, 164.1, 138.5, 131.8, 128.6, 128.0, 115.0, 84.5, 83.5, 39.1, 34.1, 30.4, 23.1, 17.3 ppm. IR (neat): 2940 (w), 1710 (s), 1644 (s), 1450 (m), 1352 (m), 1150 (s) cm<sup>-1</sup>. HRMS (ESI) Calculated for C<sub>17</sub>H<sub>21</sub>NO<sub>2</sub>Na  $m/z$  294.1470 (M+Na), Obsd. 294.1451.

**4-((4R,5R)-4-acetyl-5-methyl-2-phenyl-4,5-dihydrooxazol-4-yl)butanal:** A 250

mL flask, open to the atmosphere, was charged with methyl ketone **8** (9.4 g, 34.8 mmol, 1 equiv.) and ethyl acetate (175 mL) and cooled to –78°C. Excess O<sub>3</sub> was then bubbled

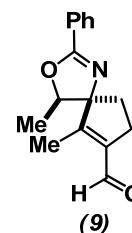


through the solution until a faint blue color was observed. The reaction was subsequently purged of excess O<sub>3</sub> by bubbling N<sub>2</sub> through the solution. When the blue color disappeared N<sub>2</sub> was bubbled through for an additional 10 min. The reaction was then placed under N<sub>2</sub>, a magnetic stir bar added, and PPh<sub>3</sub> (18.2 g, 69.7 mmol, 2 equiv.) added in a single portion. The reaction was allowed to warm to rt and further heated to reflux for 8h. The solvent was removed under reduced pressure. Purification of the product was accomplished using flash chromatography eluting with 10% ethyl acetate/hexanes. The fractions containing product were concentrated under reduced pressure to give aldehyde (7.02 g, 79%) as a light yellow oil. For fear of instability the product was

stored in benzene at  $-80^{\circ}\text{C}$  until used.  $R_f = 0.57$  (50% ethyl acetate/hexanes).  $[\alpha]_D^{20} = +25.8$  ( $c = 1.8$ ,  $\text{CH}_2\text{Cl}_2$ ).  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ): 9.73 (t,  $J = 3$  Hz, 1H), 8.00 (d,  $J = 7$  Hz, 2H), 7.52 (tt,  $J = 7$  Hz, 1H), 7.48 (t,  $J = 7$  Hz, 2H), 4.59 (q,  $J = 6.5$  Hz, 1H), 2.45 (td,  $J = 1.5, 7.5$  Hz, 2H), 2.28 (s, 1H), 2.03 (ddd,  $J = 4.5, 4.5, 18$  Hz, 1H), 1.91-1.84 (m, 1H), 1.65 (td,  $J = 4, 11.5$  Hz, 1H), 1.59-1.52 (m, 1H), 1.26 (d,  $J = 7$  Hz, 3H) ppm.  $^{13}\text{C}$  NMR (125 MHz,  $\text{CDCl}_3$ ): 212.1, 202.2, 164.6, 132.0, 128.6, 127.8, 84.3, 83.7, 44.1, 38.5, 30.4, 17.2, 16.7 ppm. IR (neat): 1708 (s), 1644 (s), 1450 (m), 1352 (m), 1063 (s)  $\text{cm}^{-1}$ . HRMS (ESI) Calculated for  $\text{C}_{17}\text{H}_{21}\text{NO}_2\text{Na}$   $m/z$  294.1470 ( $\text{M}+\text{Na}$ ), Obsd. 294.1451. HRMS (ESI) Calculated for  $\text{C}_{16}\text{H}_{19}\text{NO}_3\text{Na}$   $m/z$  296.1263 ( $\text{M}+\text{Na}$ ), Obsd. 296.1266.

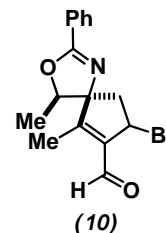
**(4R,5S)-4,6-dimethyl-2-phenyl-3-oxa-1-azaspiro[4.4]nona-1,6-diene-7-**

**carbaldehyde (9):** To a 250 mL flask containing keto aldehyde (7.50 g, 27.9 mmol, 1.0 equiv.) in toluene (200 mL) was added  $\text{SiO}_2$  (1.70 g, 28.3 mmol, 1 equiv.). The solution was stirred for 5 min. followed by the addition of freshly distilled diisopropylethylamine (19.4 mL, 111.6 mmol, 4 equiv.). The reaction was then heated to  $75^{\circ}\text{C}$  for 48 h or until TLC analysis showed complete consumption of the starting material. The solvent was removed under reduced pressure to yield a yellow slurry which was filtered through a plug of celite with dichloromethane to remove any excess silica. The filtrate was concentrated *in vacuo* and the resultant solid was recrystallized from *i*-PrOH to yield the cyclopentane **9** (6.04 g, 85%) as a light yellow solid.  $R_f = 0.58$  (50% ethyl acetate/hexanes). mp.  $87-89^{\circ}\text{C}$ .  $[\alpha]_D^{20} = -151.2$  ( $c = 0.3$ ,  $\text{CH}_2\text{Cl}_2$ ).  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ): 10.07 (s, 1H), 7.98 (d,  $J = 7.5$  Hz, 2H), 7.50 (t,  $J = 7.5$  Hz, 1H), 7.41 (t,  $J = 7.5$  Hz, 2H), 4.64 (q,  $J = 6.5$  Hz, 1H), 2.69-2.64 (m, 1H), 2.52-2.41 (m, 2H), 2.06 (t,  $J = 2$  Hz, 3H), 2.00-1.95 (m, 1H), 1.38 (d,  $J = 6.5$  Hz, 3H) ppm.  $^{13}\text{C}$  NMR (125 MHz,  $\text{CDCl}_3$ ): 189.2, 164.7, 159.5, 140.0, 132.0, 128.6, 127.6, 87.5, 85.6, 37.2, 27.4, 16.0, 12.3 ppm. IR (neat): 1667 (s), 1635 (s), 1285 (w), 1059 (m), 1012 (w)  $\text{cm}^{-1}$ . HRMS (ESI) Calculated for  $\text{C}_{16}\text{H}_{18}\text{NO}_2$   $m/z$  256.1338 ( $\text{M}+\text{H}$ ), Obsd. 256.1334.



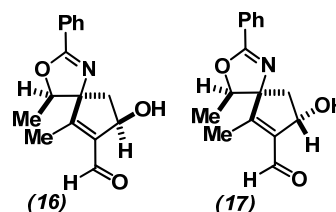
**(4R,5S)-8-bromo-4,6-dimethyl-2-phenyl-3-oxa-1-azaspiro[4.4]nona-1,6-**

**diene-7-carbaldehyde (10):** To a 100 mL flask equipped with a magnetic stirring bar under a stream N<sub>2</sub> containing cyclopentene **9** (1.10 g, 4.31 mmol, 1 equiv.) in a solution of CH<sub>2</sub>Cl<sub>2</sub> (65 mL) was added K<sub>2</sub>CO<sub>3</sub> (253 mg, 2.5 mmol, 4equiv.). Bromine (3.7 g, 21.0 mmol, 5equiv.) was added to the solution followed by AIBN (35 mg, 0.2 mmol, .05 equiv.). The reaction was then heated to 40 °C until NMR showed 50-80% consumption of the starting material. The excess bromine was quenched with aq. Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> (50 mL) and extracted with CH<sub>2</sub>Cl<sub>2</sub> (2 x 100 mL). The combined organics were dried with Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed under reduced pressure and the mixture was purified using flash chromatography eluting with 10% Ethyl acetate/hexanes. **9** would co-elute with the product **10** and any attempt to run the reaction for longer times would result in substantial decomposition. As such, a mixture of the bromide and starting material were carried forward to the next reaction. R<sub>f</sub> = 0.58 (50% ethyl acetate/hexanes).



**(4R,5S,7R)-8-formyl-4,9-dimethyl-2-phenyl-3-oxa-1-**

**azaspiro[4.4]nona-1,8-dien-7-yl-acetate(16) and (4R,5S,7S)-8-**  
**formyl-4,9-dimethyl-2-phenyl-3-oxa-1-azaspiro[4.4]nona-1,8-dien-7-**  
**yl-acetate (17):** A 100 mL flask was charged with a solution of bromo



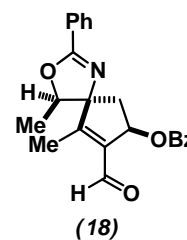
aldehyde **10** (90mg, .27 mmol, 1 equiv.) which contained ~40% of the aldehyde **9** in THF (5 mL). Sodium acetate (710mg, 8.6 mmol, 32 equiv.), and H<sub>2</sub>O (1 mL) were then added and the reaction was stirred for 8 h at reflux. The solvent was evaporated *in vacuo*. Purification of the product was accomplished using flash chromatography eluting with 5% ethyl acetate/hexanes followed by 10% ethyl acetate/hexanes. The fractions containing product were concentrated under reduced pressure to give acetates **16** (29 mg, 35%) and **17** (25 mg, 30%) as yellow oils. **(16):** R<sub>f</sub> = .13 (50% Ethyl acetate/Hexanes). [α]<sub>D</sub><sup>20</sup> = -98.2 (c= 0.6, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>): 10.07 (s, 1H), 7.99 (d, J = 7.5 Hz, 2H), 7.53 (t, J = 7 Hz, 1H), 7.44 (t, J = 7.5 Hz, 2H), 5.09 (t, J = 6 Hz, 1H), 4.63 (q, J = 7 Hz, 1H), 3.16 (br s, 1H), 2.48 (dd, J = 6.5, 13.5 Hz, 1H), 2.37 (dd, J = 7, 13.5 Hz, 1H), 2.09 (s, 3H), 1.32 (d, J = 7 Hz, 3H) ppm. <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>): 190.4, 165.1, 161.7, 140.7, 132.2, 128.7, 128.6, 127.4, 85.5, 84.0, 72.5, 46.5, 15.3, 12.5 ppm. IR (neat): 3383

(bs), 2935 (w), 1674 (s), 1637 (s), 1287 (w), 1059 (m)  $\text{cm}^{-1}$ . HRMS (ESI) Calculated for  $\text{C}_{16}\text{H}_{17}\text{NO}_3\text{Na}$   $m/z$  294.1106 (M+H), Obsd. 294.1109.

**(17):**  $R_f$  = .20 (50% Ethyl acetate/Hexanes).  $[\alpha]_D^{20} = -84.1$  ( $c$  = 0.7,  $\text{CH}_2\text{Cl}_2$ ).  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ): 10.07 (s, 1H), 7.98 (d,  $J$  = 7.5 Hz, 2H), 7.52 (t,  $J$  = 6.5 Hz, 1H), 7.44 (t,  $J$  = 7.5 Hz, 2H), 5.14 (d,  $J$  = 7.5 Hz, 1H), 4.74 (d,  $J$  = 6.5 Hz, 1H), 2.79 (q,  $J$  = 7 Hz, 1H), 2.46 (br s, 1H), 2.09 (s, 3H), 1.90 (d,  $J$  = 14.5 Hz, 1H), 1.51 (d,  $J$  = 7 Hz, 3H) ppm.  $^{13}\text{C}$  NMR (125 MHz,  $\text{CDCl}_3$ ): 189.8, 165.5, 162.3, 141.3, 132.1, 128.7, 128.6, 127.5, 86.4, 86.1, 72.1, 45.8, 14.8, 12.4 ppm. IR (neat): 3368 (bs), 2933 (w), 1671 (s), 1638 (s), 1281 (w), 1095 (w), 1059 (w)  $\text{cm}^{-1}$ . HRMS (ESI) Calculated for  $\text{C}_{16}\text{H}_{17}\text{NO}_3\text{Na}$   $m/z$  294.1106 (M+H), Obsd. 294.1101.

**(4R,5S,7R)-8-formyl-4,9-dimethyl-2-phenyl-3-oxa-1-azaspiro[4.4]nona-1,8-**

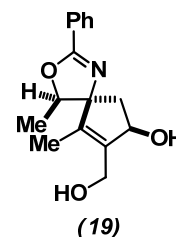
**dien-7-yl benzoate (18):** A 100 mL flask was charged with a solution of bromo aldehyde **10** (83mg, .25 mmol, 1 equiv.) which contained ~40% of the aldehyde **9** in THF (5 mL). Sodium benzoate (710mg, 5.0 mmol, 20 equiv.),  $\text{K}_2\text{CO}_3$  (140mg, 0.9 mmol, 4 equiv.), and  $\text{H}_2\text{O}$  (1 mL) were then added and the reaction was stirred for 12 h. The



solvent was evaporated *in vacuo*. Purification of the product was accomplished using flash chromatography eluting with 5% ethyl acetate/hexanes. The fractions containing product were concentrated under reduced pressure to give benzoate ester **18** (54 mg, 58%) as a white solid.  $R_f$  = .60 (50% Ethyl acetate/Hexanes). mp 47–50 °C.  $[\alpha]_D^{20} = -23.1$  ( $c$  = 1.3,  $\text{CH}_2\text{Cl}_2$ ).  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ): 10.06 (s, 1H), 8.03 – 7.99 (m, 4H), 7.56 – 7.52 (m, 2H), 7.46 – 7.41 (m, 4H), 6.27 (t,  $J$  = 6 Hz, 1H), 4.68 (q,  $J$  = 6.5 Hz, 1H), 2.69 – 2.61 (m, 2H), 2.16 (d,  $J$  = 1.5 Hz, 3H), 1.39 (d,  $J$  = 6.5 Hz, 3H) ppm.  $^{13}\text{C}$  NMR (125 MHz,  $\text{CDCl}_3$ ): 188.1, 166.5, 165.4, 161.9, 137.2, 133.3, 132.3, 130.3, 130.0, 128.8, 128.7, 128.6, 127.3, 95.0, 85.7, 84.7, 74.4, 45.3, 15.0, 13.0 ppm. IR (neat): 1715 (s), 1679 (s), 1636 (s), 1450 (w), 1272 (s), 1111 (s), 1096 (m)  $\text{cm}^{-1}$ . HRMS (ESI) Calculated for  $\text{C}_{23}\text{H}_{22}\text{NO}_4$   $m/z$  376.1549 (M+H), Obsd. 376.1563.

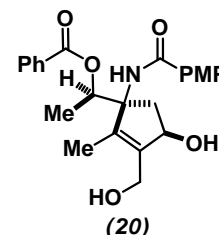
**(4R,5S,7R)-8-(hydroxymethyl)-4,9-dimethyl-2-phenyl-3-oxa-1-**

**azaspiro[4.4]nona-1,8-dien-7-ol (19):** A 50 mL flask was charged with **18** (29 mg, .07 mmol, 1 equiv.) and placed under N<sub>2</sub>. THF (5 mL) was then added and the solution cooled to 0 °C. LiAlH<sub>4</sub> (15 mg, .40 mmol, 5 equiv.) was then added in small portions and the reaction stirred for 1h. The reaction was quenched by Fieser's method<sup>3</sup> and



concentrated. The resultant material was purified by column chromatography eluting with a solution of 4% methanol in dichloromethane. The fractions containing product were concentrated to yield **19** (23 mg, 90%) as an off white solid.  $R_f = 0.5$  (10% MeOH/CH<sub>2</sub>Cl<sub>2</sub>). mp 123-126 °C.  $[\alpha]_D^{20} = -70.0$  ( $c = .2$ , CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>): 7.96 (d,  $J = 8$  Hz, 2H), 7.50 (t,  $J = 7$  Hz, 1H), 7.42 (t,  $J = 7.5$  Hz, 2H), 4.52 (q,  $J = 6.5$  Hz, 1H), 4.45 (1/2ABq,  $J = 12.5$  Hz, 1H), 4.32 (1/2ABq,  $J = 12.5$  Hz, 1H), 3.36 (bs, 2H), 1.63 (s, 3H), 1.32 (d,  $J = 7$  Hz, 3H) ppm. <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>): 164.0, 141.2, 138.1, 131.9, 128.7, 128.5, 127.7, 85.1, 83.8, 76.0, 58.6, 47.8, 14.7, 11.8 ppm. IR (neat): 3224 (bs), 2935 (w), 1632 (s), 1450 (w), 1321 (w), 1295 (w), 1280 (w), 1057 (s), 1014 (m) cm<sup>-1</sup>. HRMS (ESI) Calculated for C<sub>16</sub>H<sub>19</sub>NO<sub>3</sub>Na  $m/z$  296.1263 (M+Na), Obsd. 296.1253.

**PMBz Protected Amine (20):** A 50 mL flask was charged with diol **19** (40 mg, .15 mmol, 1 equiv.) and THF (6 mL). 2N HCl (6 mL) was then added and the reaction was stirred for 3 d. The reaction mixture was quenched with sat. NaHCO<sub>3</sub> (20 mL) and extracted with ethyl acetate (3 x 25 mL). The organics were combined and dried with Na<sub>2</sub>SO<sub>4</sub> and concentrated under reduced pressure to yield the free amine. A 25 mL round

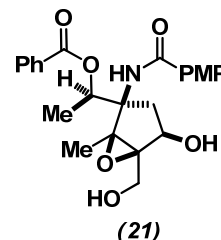


bottomed flask was charged with a solution of the crude amine from above (30 mg, 0.10 mmol, 1 equiv.) in CH<sub>2</sub>Cl<sub>2</sub> (5 mL). Para-methoxybenzoyl chloride (26 mg, 0.15 mmol, 1.5 equiv.) was then added and the reaction stirred for 3 h. The reaction was diluted with CH<sub>2</sub>Cl<sub>2</sub> (25 mL) transferred to a separatory funnel and washed with 1N NaOH (25 mL). The aqueous layer was extracted

<sup>3</sup>Fieser, L. F.; Fieser, M. *Reagents for Organic Synthesis* **1967**, 581-595.

again with  $\text{CH}_2\text{Cl}_2$  (2 x 10 mL). The organics were combined, dried with  $\text{Na}_2\text{SO}_4$ , and concentrated under reduced pressure. Purification of the product was accomplished using flash chromatography eluting with 50% ethyl acetate/hexanes followed by 100% ethyl acetate. The fractions containing product were concentrated under reduced pressure to give PMBz protected amine **20** (30 mg, 48% from diol **19**) as a white solid.  $R_f = 0.07$  (5% MeOH/ $\text{CH}_2\text{Cl}_2$ ). mp 173 – 175 °C.  $[\alpha]_D^{20} = -40.0$  ( $c = 0.5$ ,  $\text{CH}_2\text{Cl}_2$ ).  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ): 8.03 – 8.02 (m, 2H), 7.65 – 7.61 (m, 3H), 7.49 (t,  $J = 7.5$  Hz, 2H), 7.00 (s, 1H), 6.87 (d,  $J = 9$  Hz, 2H), 5.44 (q,  $J = 6.5$  Hz, 1H), 4.82 (d,  $J = 7$  Hz, 1H), 4.54 (1/2 ABq,  $J = 13$  Hz, 1H), 4.35 (1/2 ABq,  $J = 13$  Hz, 1H), 3.82 (s, 3H), 2.62 (dd,  $J = 8, 15$  Hz, 1H), 2.34 (d,  $J = 15.5$  Hz, 1H), 1.74 (s, 3H), 1.33 (d,  $J = 6.5$  Hz, 3H) ppm.  $^{13}\text{C}$  NMR (125 MHz,  $\text{CDCl}_3$ ): 167.1, 166.8, 162.8, 143.1, 134.7, 134.1, 129.9, 129.6, 129.0, 128.9, 126.7, 114.2, 76.0, 74.8, 71.8, 59.1, 55.7, 45.6, 15.2, 11.3 ppm. IR (neat): 3306 (bs), 1716 (s), 1647 (m), 1606 (s), 1257 (s), 1176 (w), 1069 (w)  $\text{cm}^{-1}$ . HRMS (ESI) Calculated for  $\text{C}_{24}\text{H}_{27}\text{NO}_6$  Na  $m/z$  448.1736 (M+Na), Obsd. 448.1745.

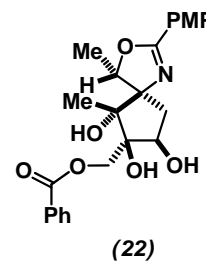
**Epoxide (21):** A 25 mL round bottomed flask was charged with the PMBz protected amine **20** (20 mg, 50  $\mu\text{mol}$ , 1 equiv.) and  $\text{CH}_2\text{Cl}_2$  (2 mL). *m*-CPBA (21 mg, 90  $\mu\text{mol}$ , 2 equiv.) was then added in a single portion along with sat.  $\text{NaHCO}_3$  (2 mL). The reaction was stirred for 3 h and then diluted with  $\text{CH}_2\text{Cl}_2$  (25 mL), transferred to a separatory funnel and washed with  $\text{H}_2\text{O}$  (1 x 25 mL). The organics were dried with  $\text{Na}_2\text{SO}_4$  and concentrated under reduced pressure. Purification of the product was accomplished using flash chromatography eluting with 50% ethyl acetate/hexanes followed by 100% ethyl acetate. The fractions containing product were concentrated under reduced pressure to give the epoxide **21** (15 mg, 75%) as a clear oil.  $R_f = 0.44$  (2% MeOH/ $\text{CH}_2\text{Cl}_2$ ).  $[\alpha]_D^{20} = -0.18$  ( $c = 0.5$ ,  $\text{CH}_2\text{Cl}_2$ ).  $^1\text{H}$  NMR (500 MHz,  $\text{CD}_3\text{OD}$ ): 8.02 (d,  $J = 6.5$  Hz, d), 7.90 (bd,  $J = 29$  Hz, 1H), 7.70 – 7.67 (m, 2H), 7.62 – 7.58 (m, 1H), 7.49 – 7.46 (m, 3H), 6.94 – 6.90 (m, 2H), 6.42 (q,  $J = 6.5$  Hz, 1H), 4.63 (t,  $J = 8$  Hz, 1H), 3.99 (1/2 ABq,  $J = 12$  Hz, 1H), 3.82 (s, 3H), 3.45 (1/2 ABq,  $J = 12$  Hz, 1H), 2.76 (dd,  $J = 8, 13.5$  Hz, 1H), 1.71 (dd,  $J = 7.5, 14$  Hz, 1H), 1.69 (s, 3H), 1.38 (d,  $J = 6.5$  Hz, 3H) ppm.  $^{13}\text{C}$  NMR (125 MHz,  $\text{CD}_3\text{OD}$ ): 170.9, 167.1, 163.9, 134.3, 133.0, 131.6, 130.7, 130.4, 129.6, 128.6, 114.6, 73.2, 71.8, 70.6, 68.5, 58.4, 55.9, 39.7, 22.1, 15.8, 13.6 ppm. IR (neat): 3369 (bs), 1716 (s), 1606 (s),





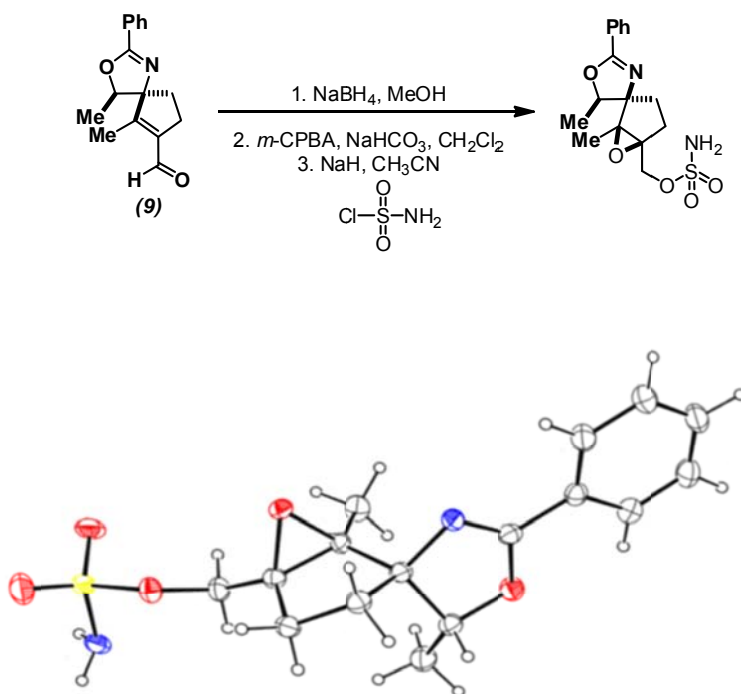
1503 (s), 1257 (s), 1177 (w), 1069 (w)  $\text{cm}^{-1}$ . HRMS (ESI) Calculated for  $\text{C}_{24}\text{H}_{27}\text{NO}_7\text{Na}$   $m/z$  464.1685 (M+Na), Obsd. 464.1697.

**Triol (22):** A 50 mL flask was charged with the epoxide **21** (15 mg, 0.03 mmol, 1 equiv.) and  $\text{CH}_2\text{Cl}_2$ . The flask was cooled to 0 °C and  $\text{BF}_3 \cdot \text{OEt}_2$  (12 mg, 0.09 mmol, 3 equiv.) was added. After stirring for 1 h, benzoic acid (37 mg, 0.30 mmol, 10 equiv.) was added and the reaction was left to stir for an additional 3 h. The mixture was transferred to a separatory funnel and washed with 10% NaOH (3 x 20 mL). The

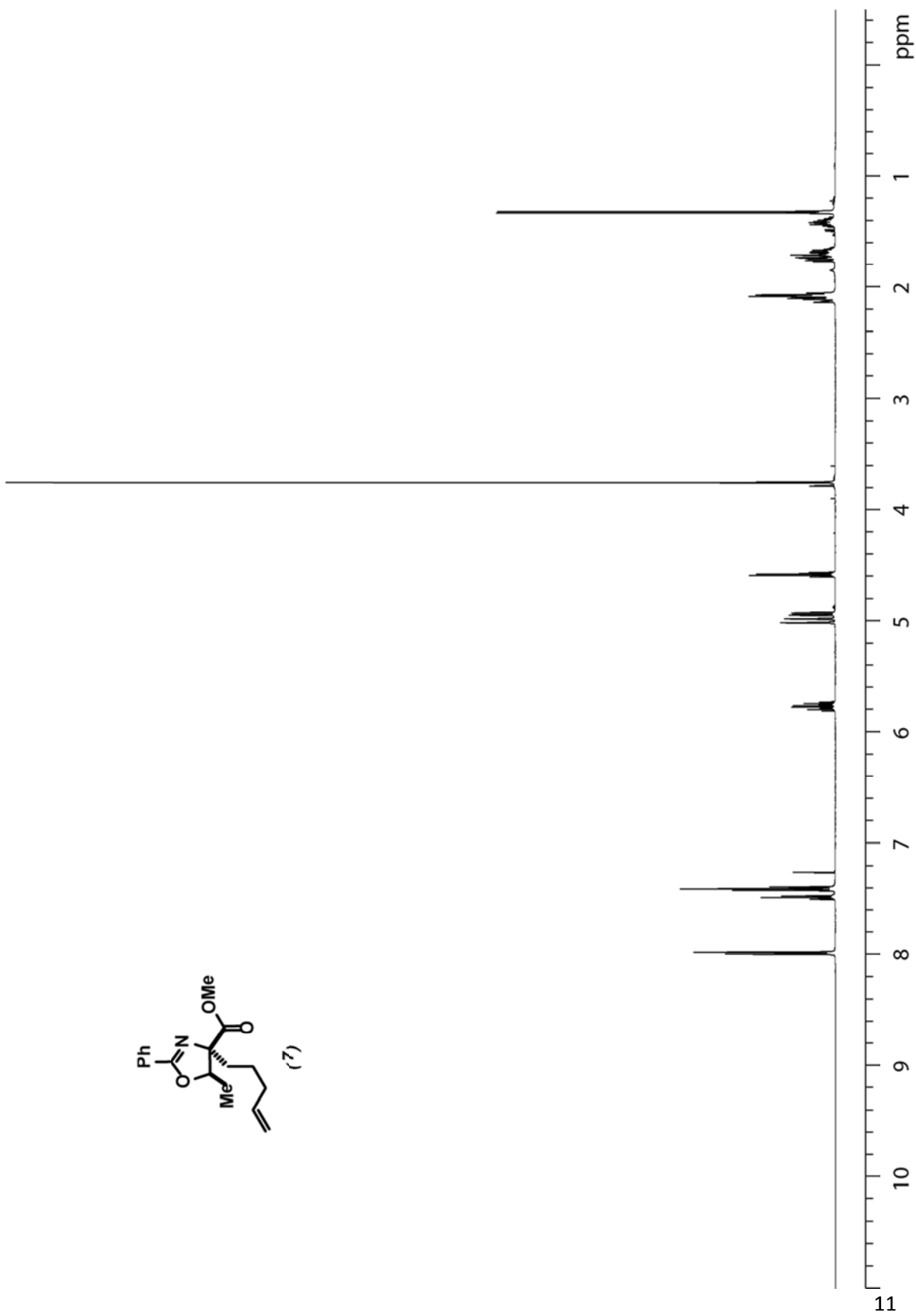


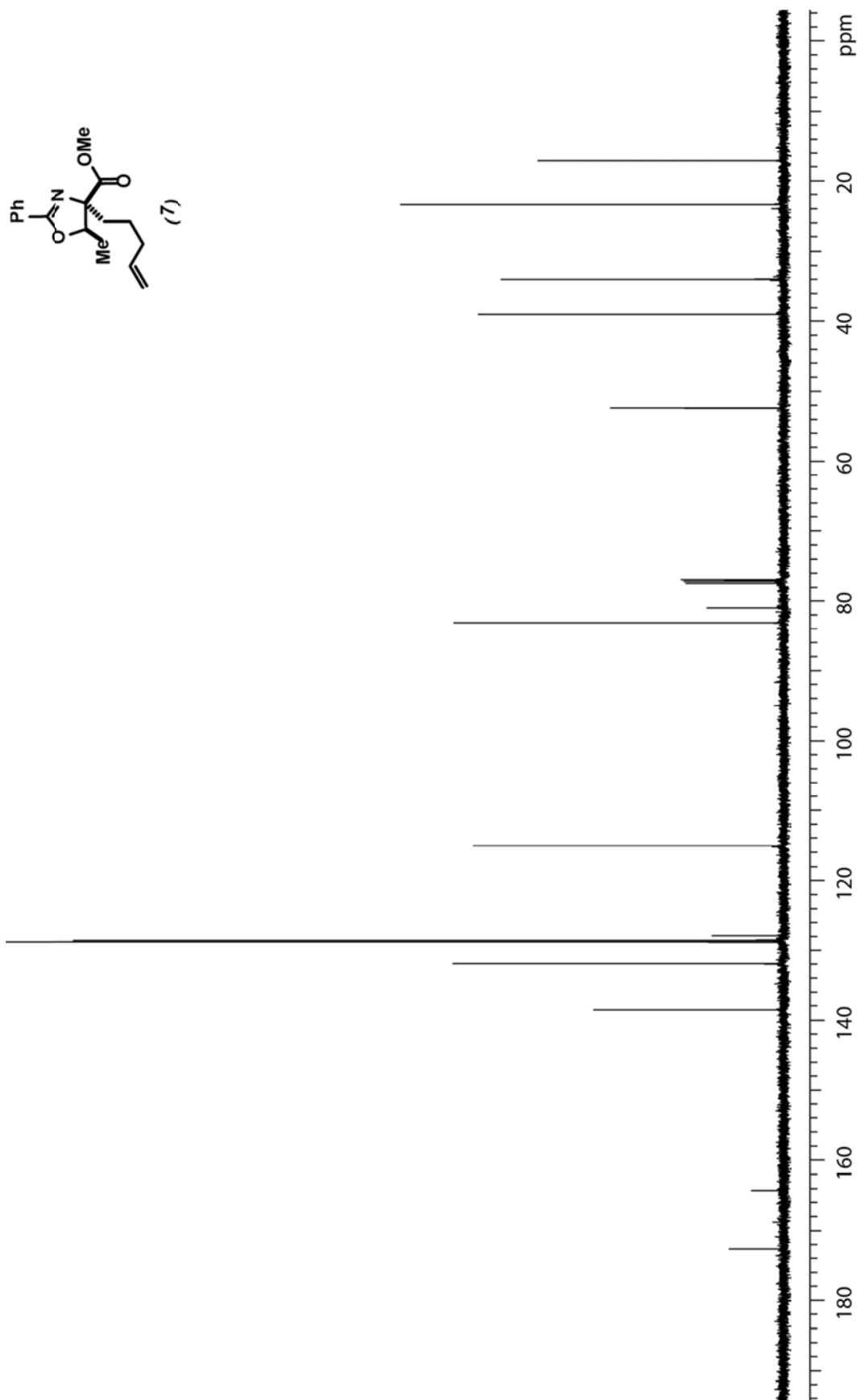
organic layer was dried over  $\text{Na}_2\text{SO}_4$  and concentrated *in vacuo*. Purification of the product was accomplished using flash chromatography eluting with 2% MeOH/ $\text{CH}_2\text{Cl}_2$ . The fractions containing product were concentrated under reduced pressure to give triol **22** (12 mg, 90%) as a clear oil.  $R_f = .47$  (4% MeOH/ $\text{CH}_2\text{Cl}_2$ ).  $[\alpha]_D^{20} = +10.0$  (c0.3, MeOH).  $^1\text{H}$  NMR (500 MHz,  $\text{CD}_3\text{OD}$ ): 8.09 – 8.07 (m, 2H), 7.85 – 7.83 (m, 2H), 7.61 – 7.57 (m, 1H), 7.49 – 7.45 (m, 2H), 6.99 – 6.97 (m, 2H), 4.91 (q,  $J = 6.5$  Hz, 1H), 4.59 (1/2 ABq,  $J = 7.5$  Hz, 1H), 4.50 (1/2 ABq,  $J = 11.5$  Hz, 1H), 4.31 (dd,  $J = 4, 10$  Hz, 1H), 3.84 (s, 3H), 2.72 (dd,  $J = 9.5, 14$  Hz, 1H), 1.64 (dd,  $J = 4.5, 15$  Hz, 1H), 1.37 (d,  $J = 6.5$  Hz, 3H) ppm.  $^{13}\text{C}$  NMR ( $\text{CD}_3\text{OD}$ , 125 MHz): 168.3, 164.1, 162.7, 134.2, 131.6, 131.0, 130.7, 129.5, 120.7, 114.9, 84.4, 84.4, 83.9, 79.9, 74.3, 66.8, 55.9, 40.8, 18.6, 16.9 ppm. IR (neat): 3361 (bs), 2926 (w), 1718 (w), 1645 (s), 1275 (s), 1100 (s), 1028 (w)  $\text{cm}^{-1}$ . HRMS (ESI) Calculated for  $\text{C}_{24}\text{H}_{27}\text{NO}_7\text{Na}$   $m/z$  464.1685 (M+Na), Obsd. 464.1695.

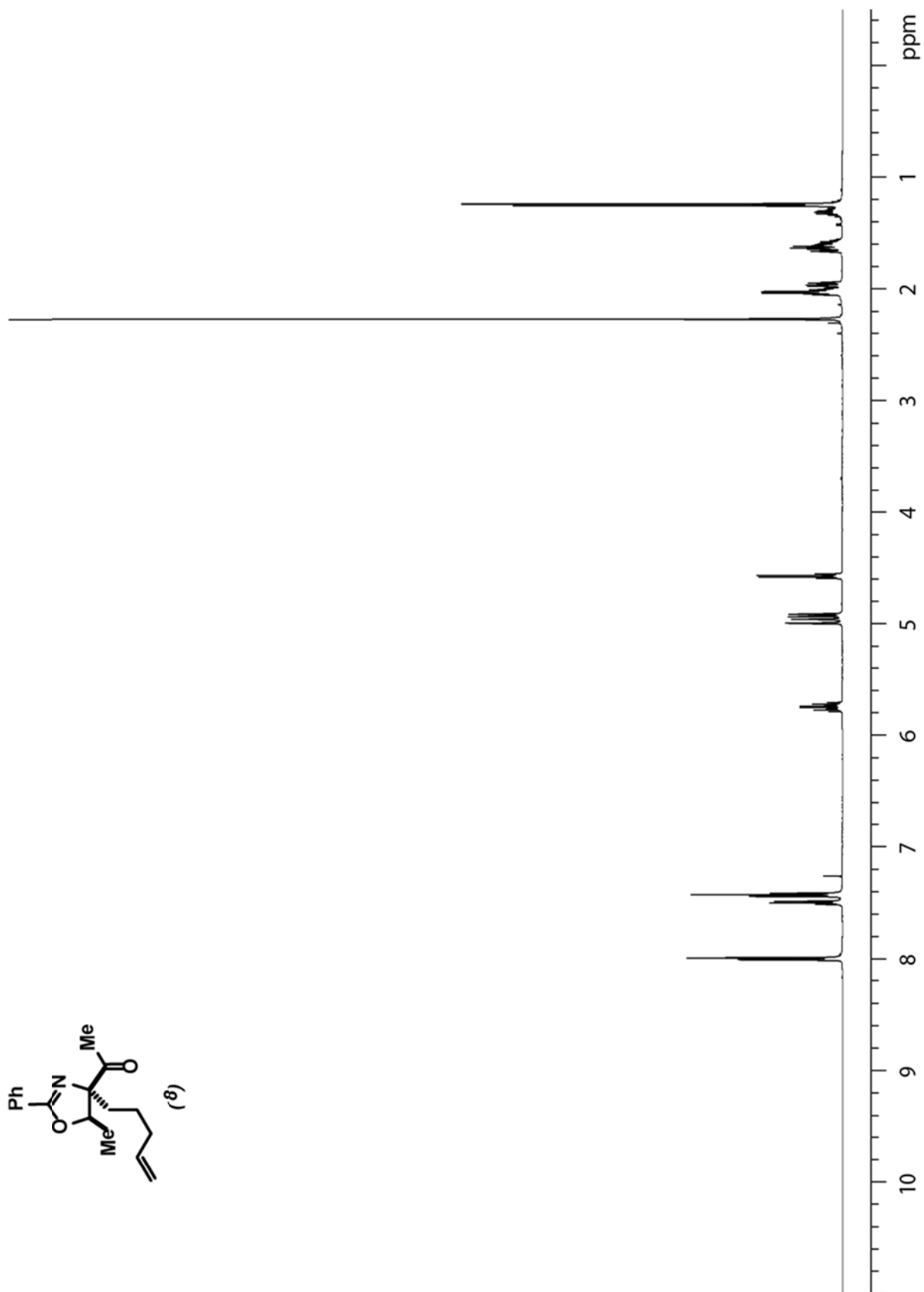
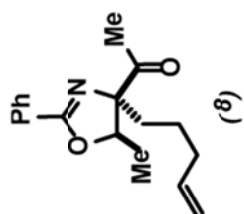
**An explanation of oxazoline directed stereocontrol:** While exploring alternative synthetic approaches, we had prepared the sulfamoyl ester shown below. Epoxidation of the allylic alcohol was highly stereoselective to give epoxidation from the top face of the cyclopentene core. This was confirmed by X-ray crystallography (this structure has been deposited in the Cambridge Crystallographic Data Centre No. 887951). Further analysis suggests that the stereochemistry of the epoxide results from a steric block of the bottom face by the oxazoline methyl group.

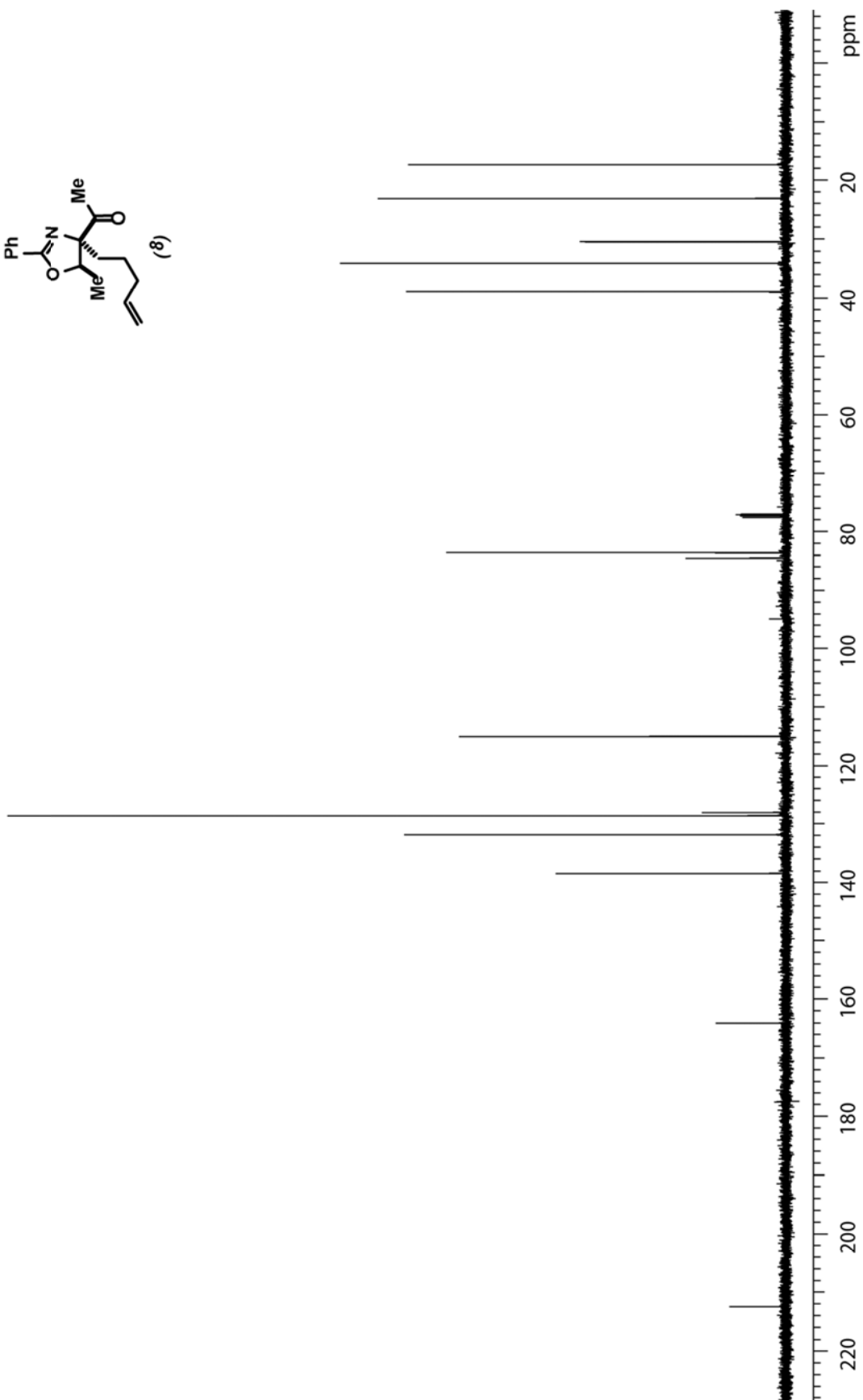
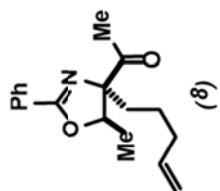


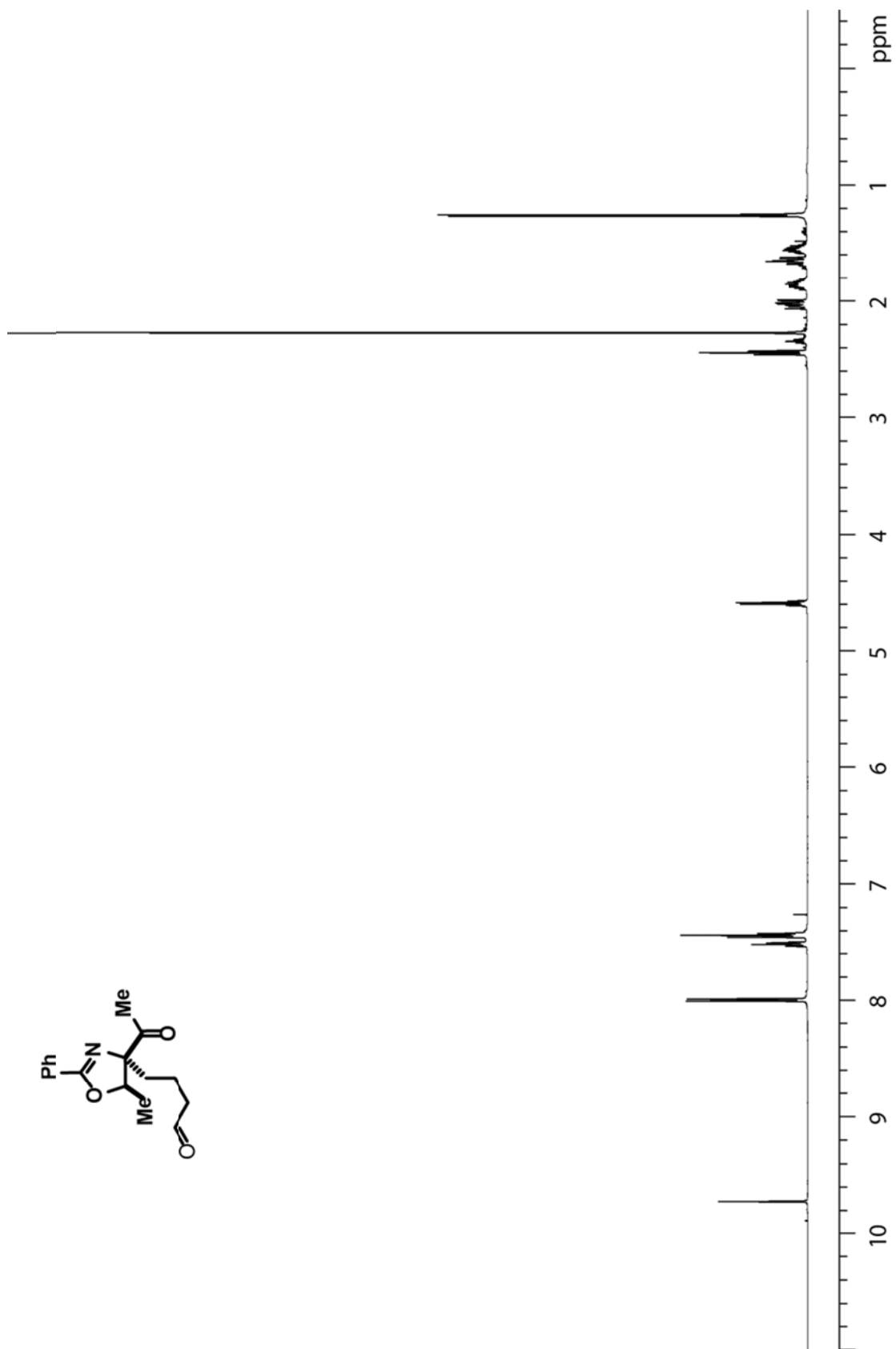
### 3. Representative $^1\text{H}$ NMR and $^{13}\text{C}$ NMR

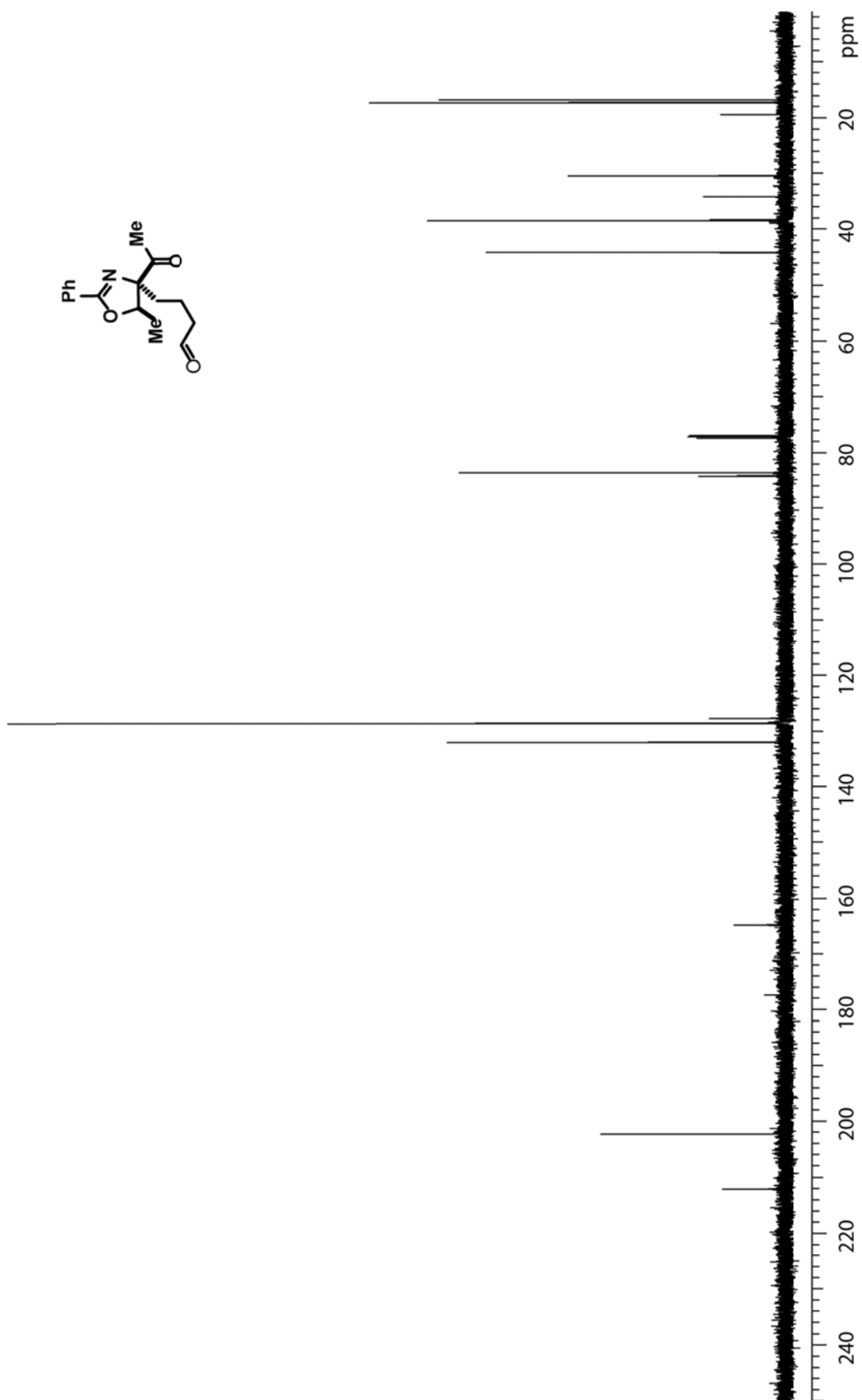




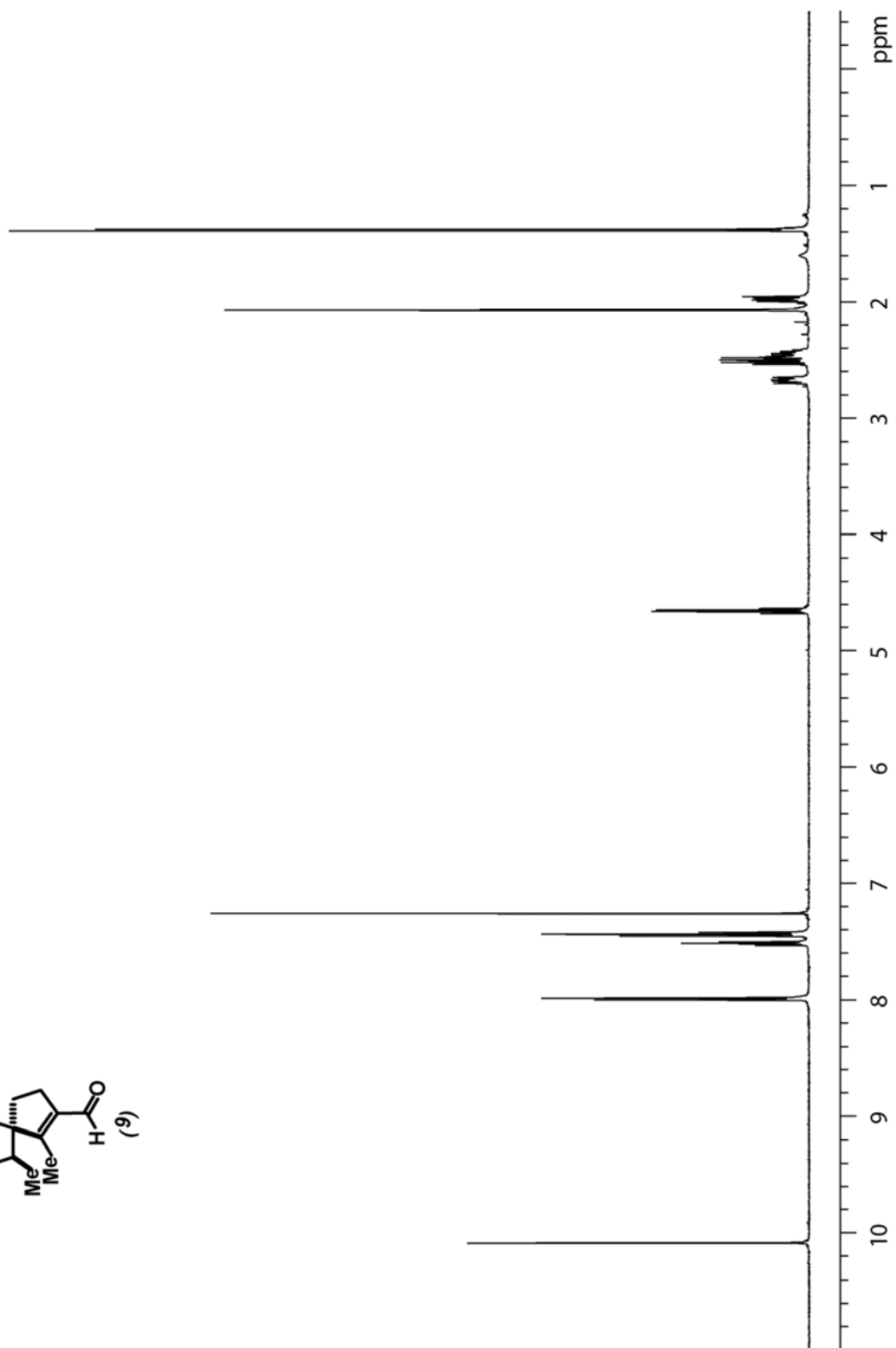
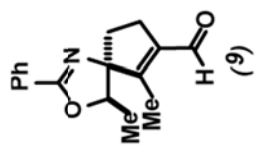


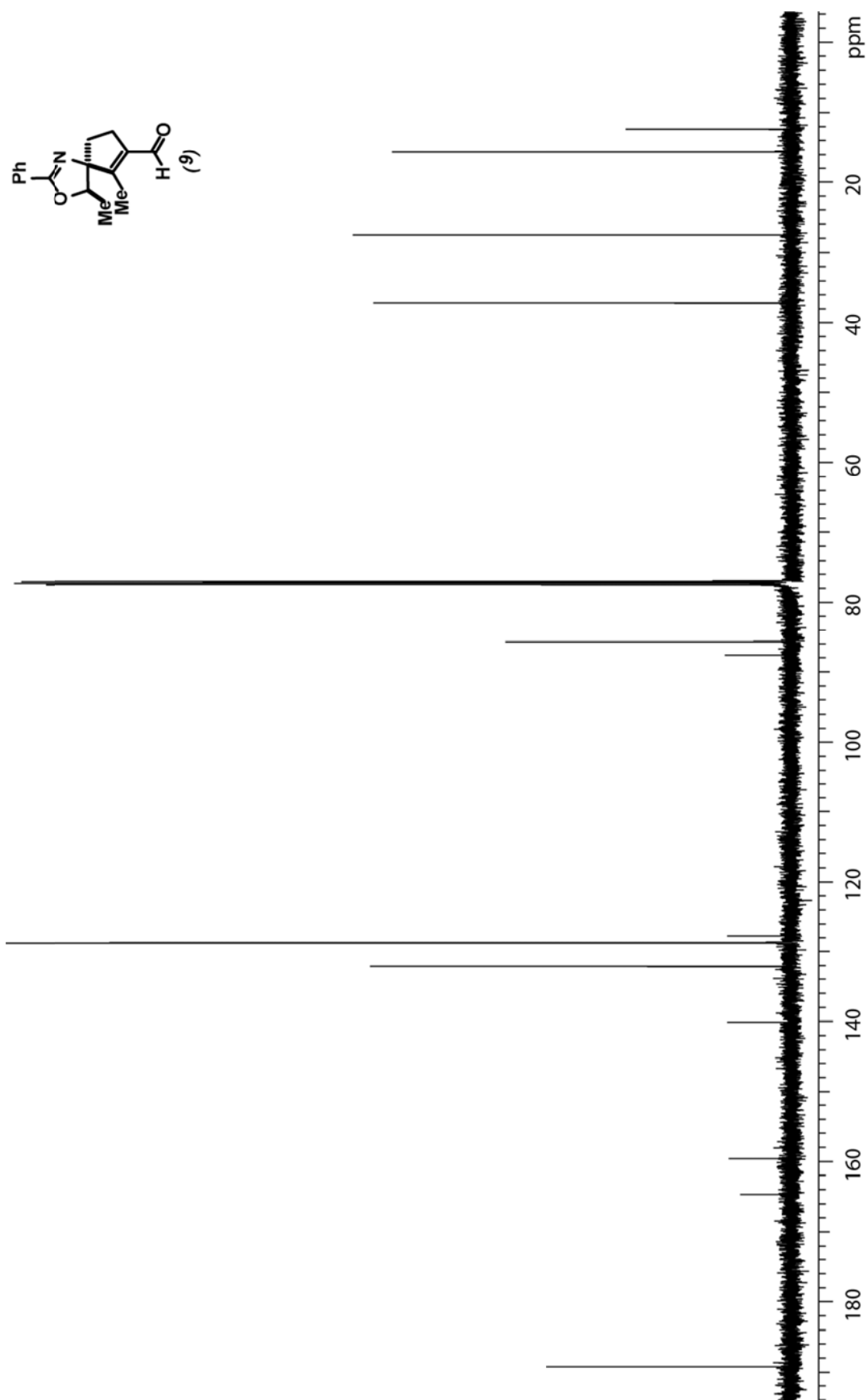


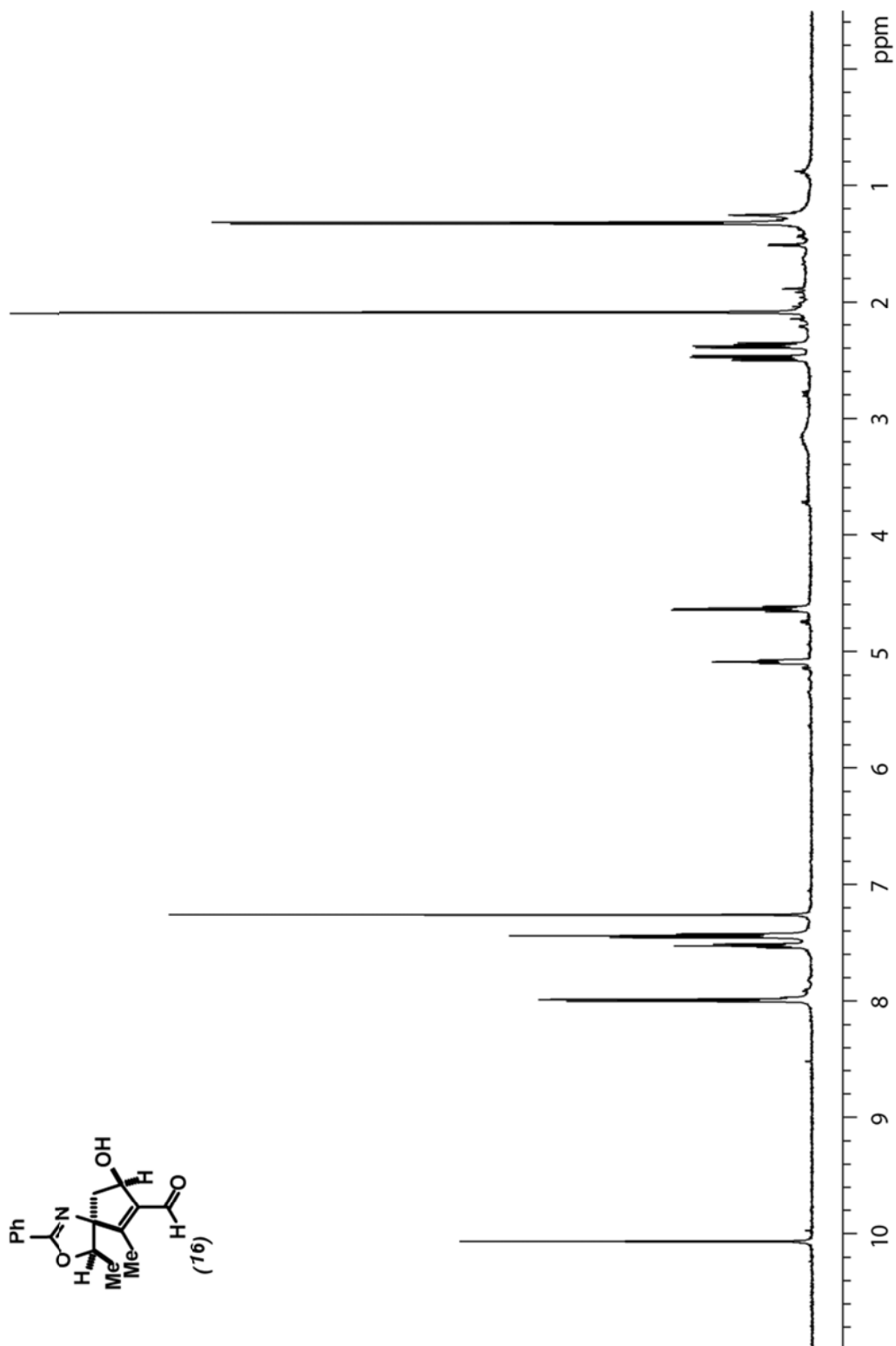
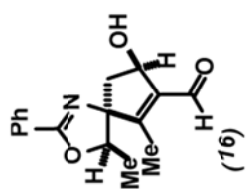


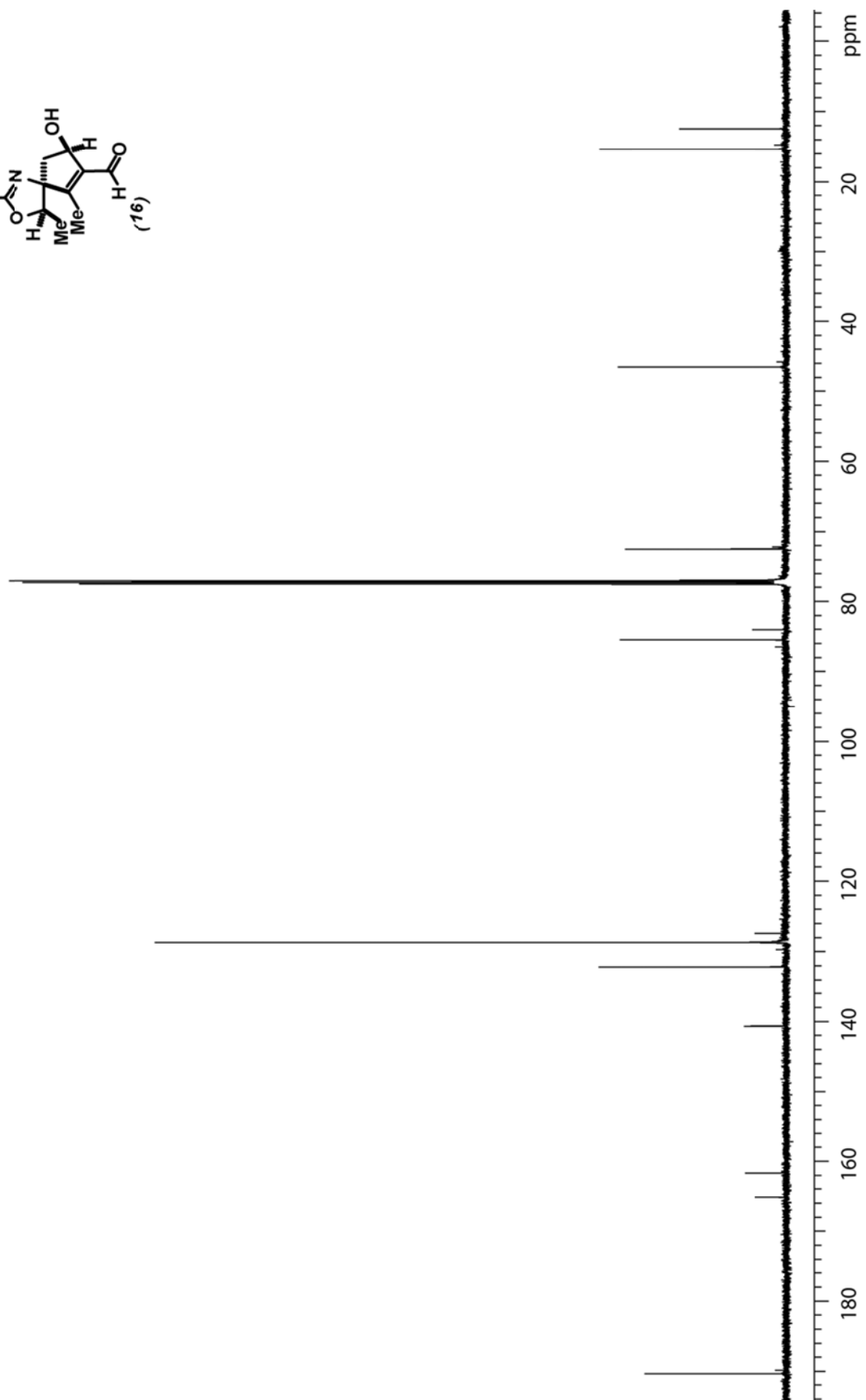
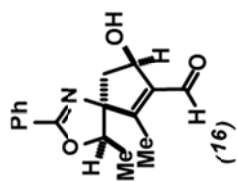


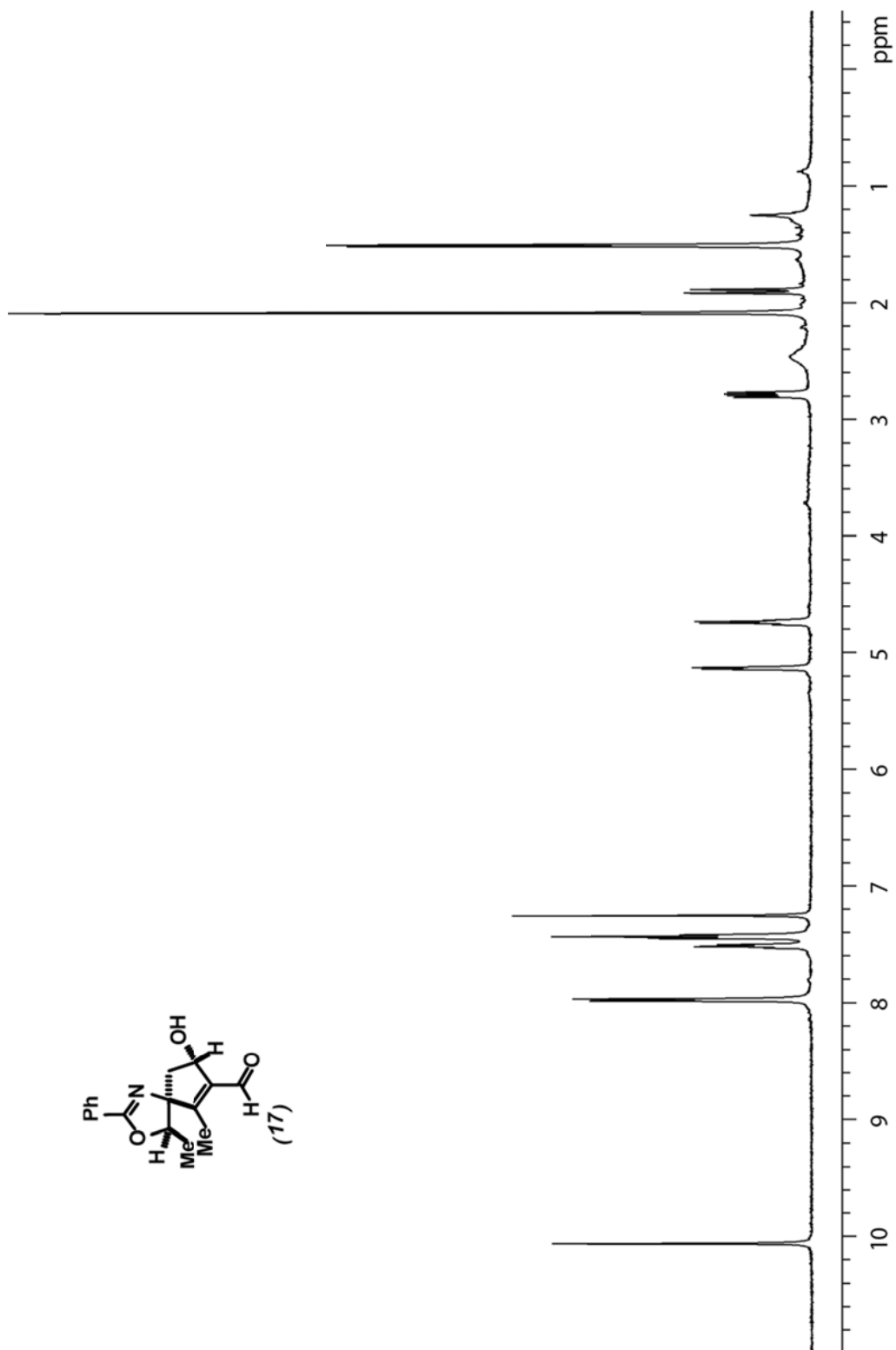


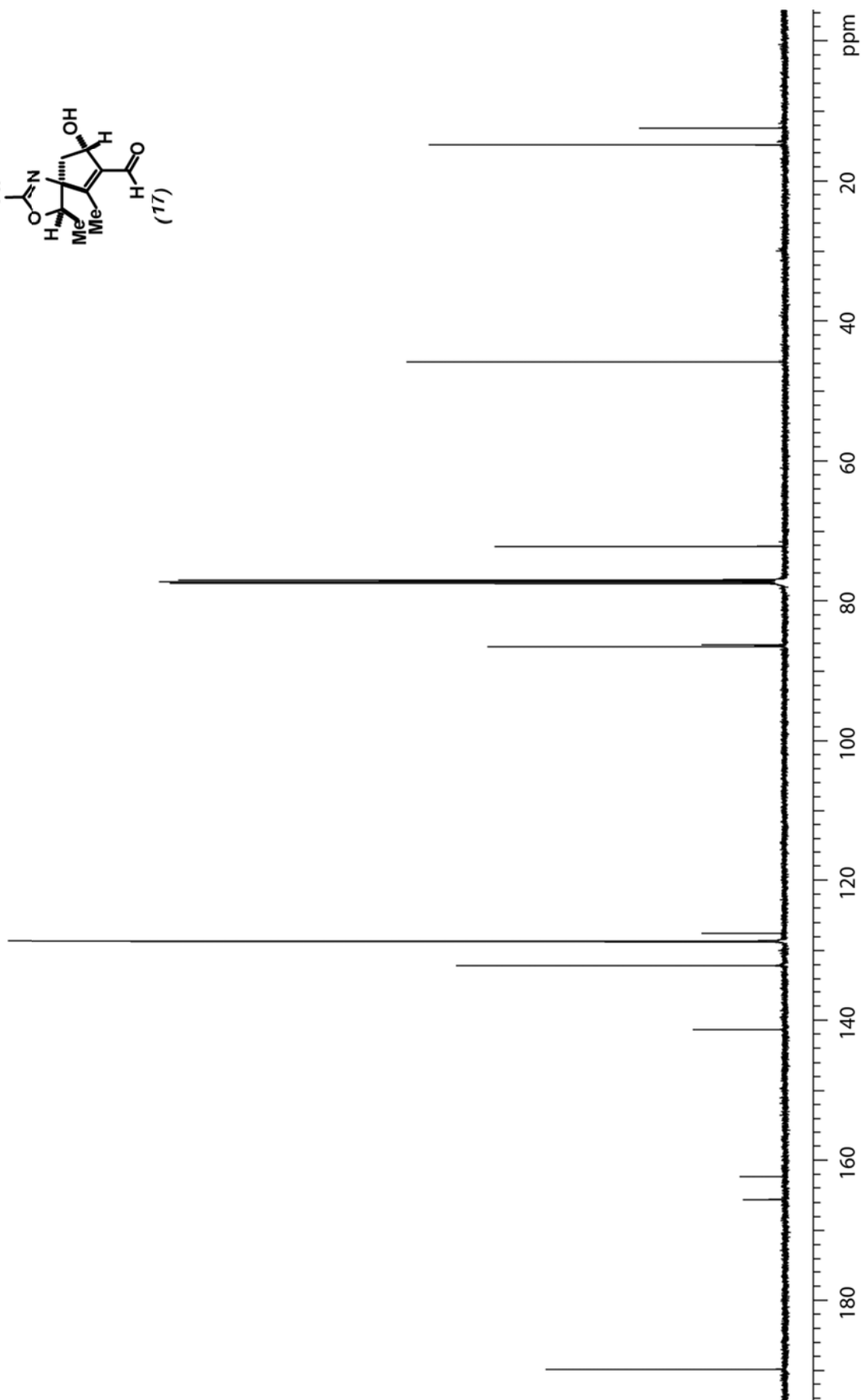
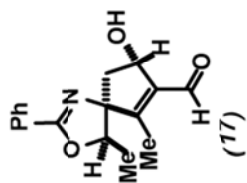


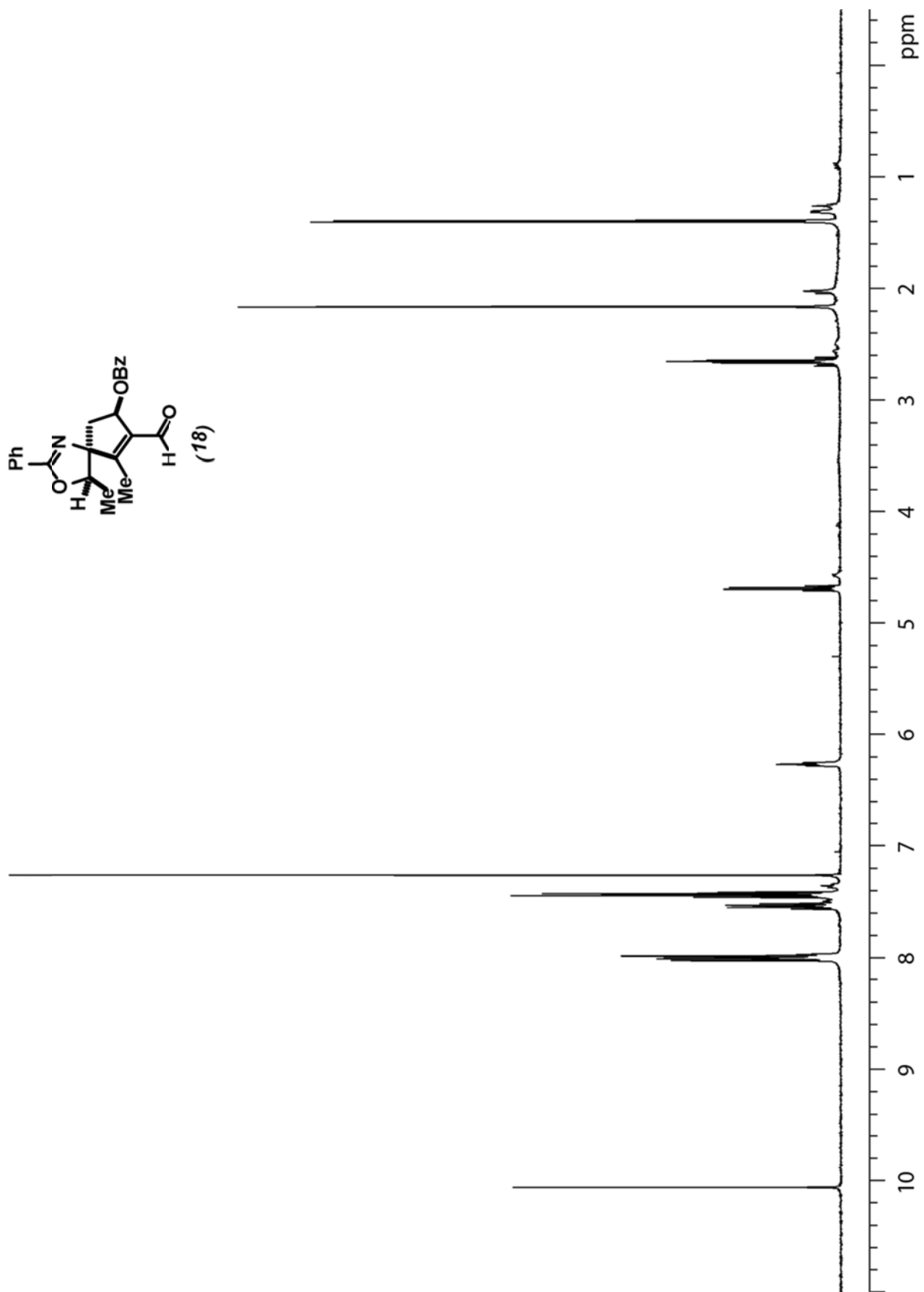


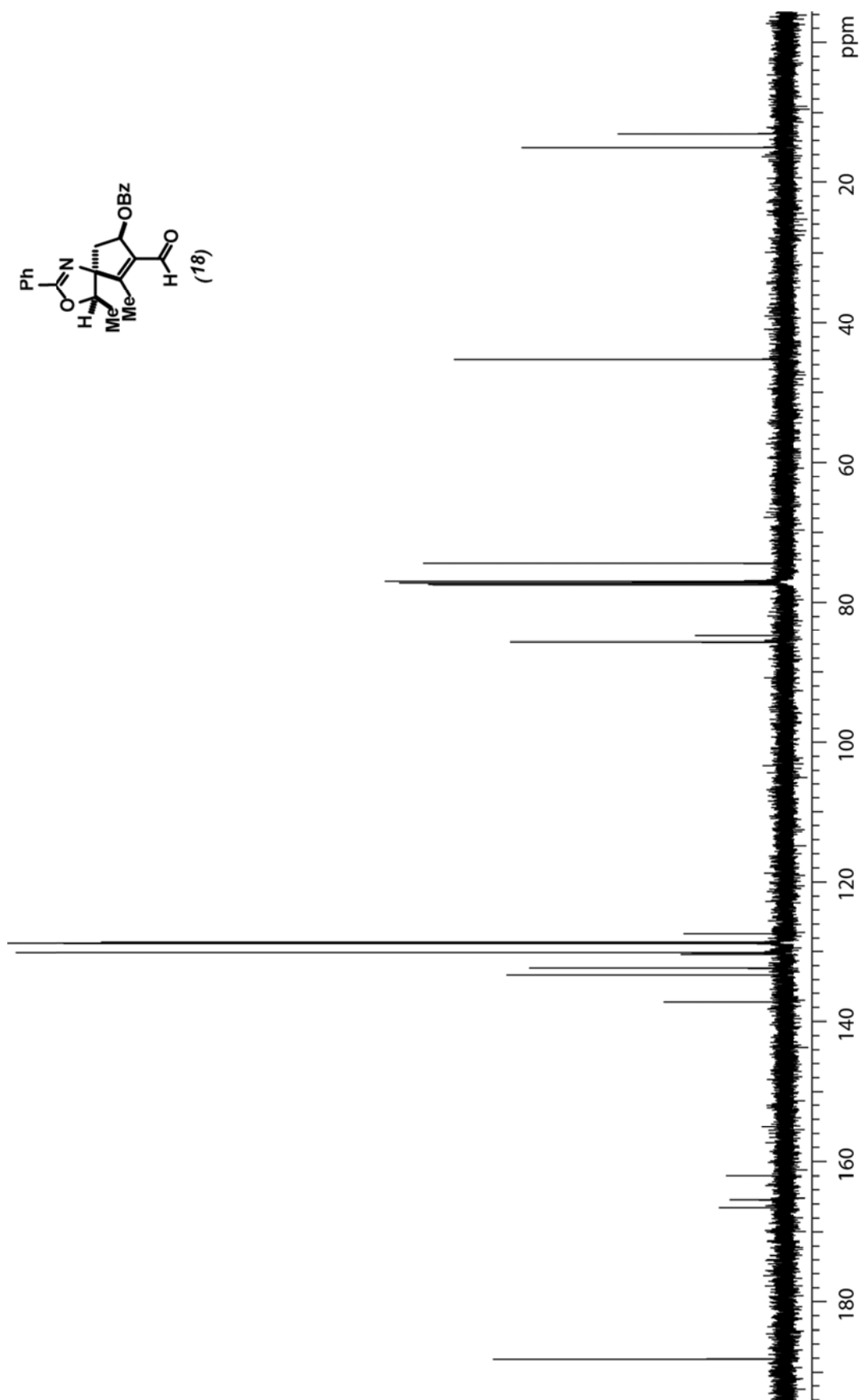




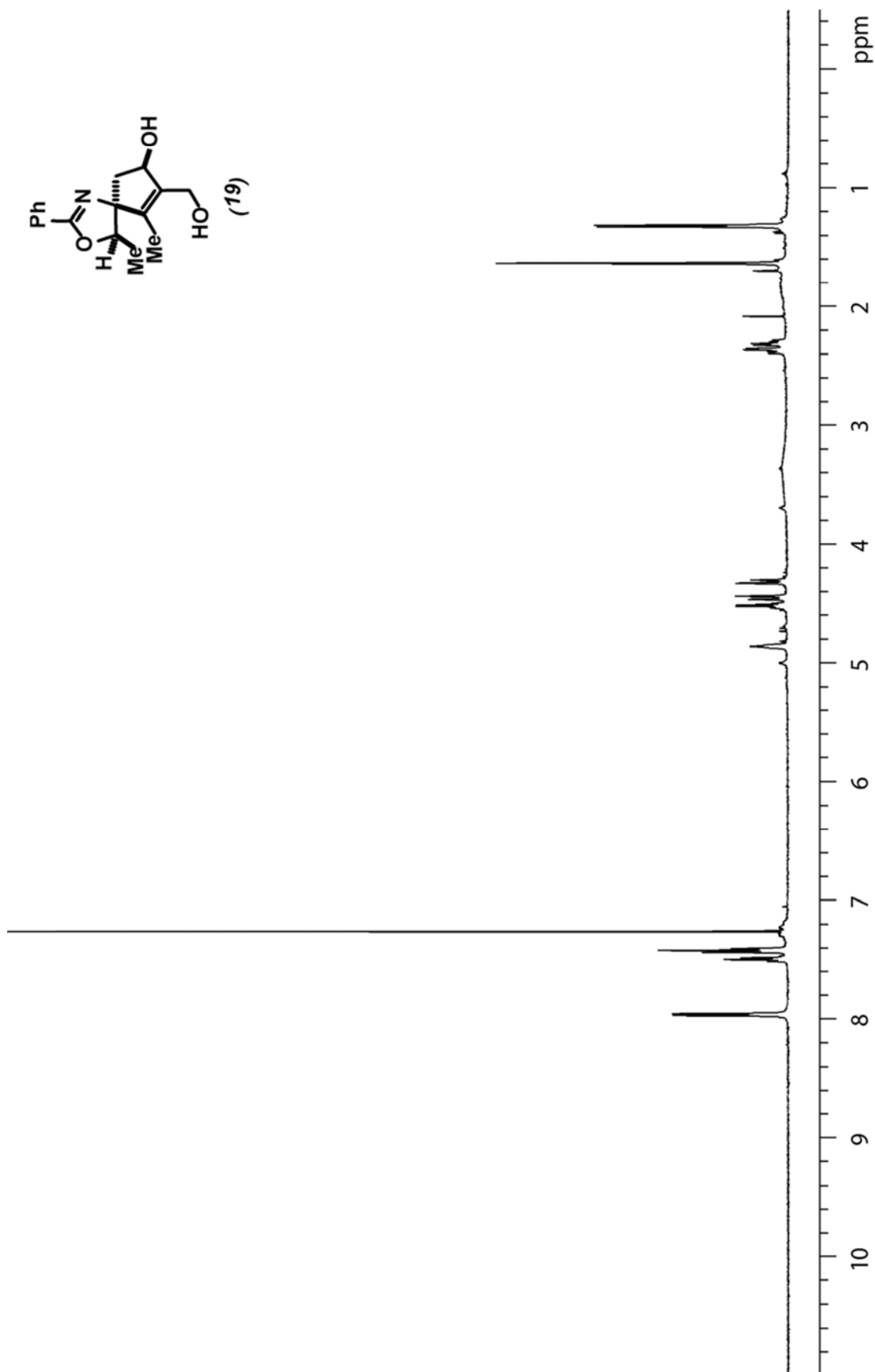


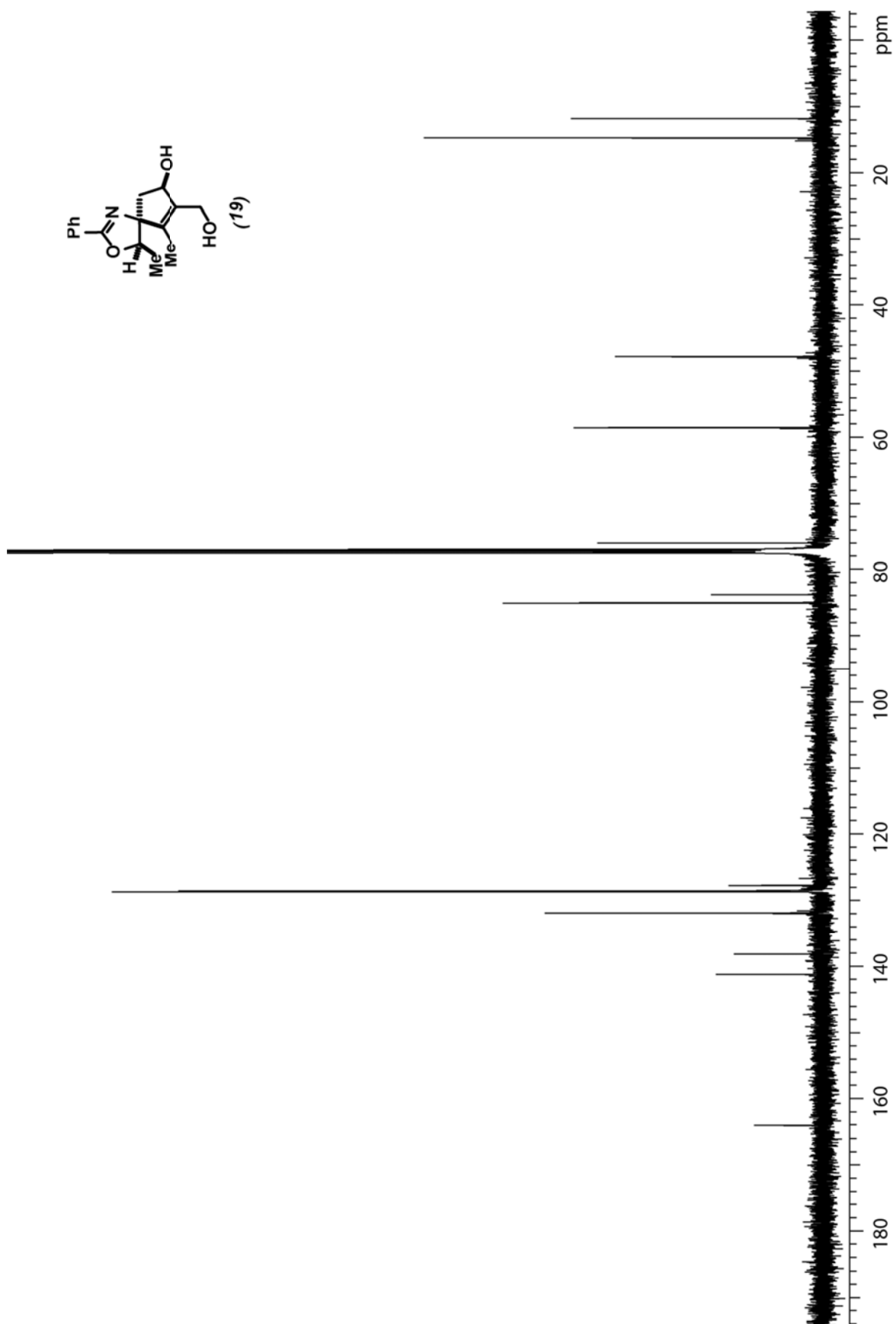


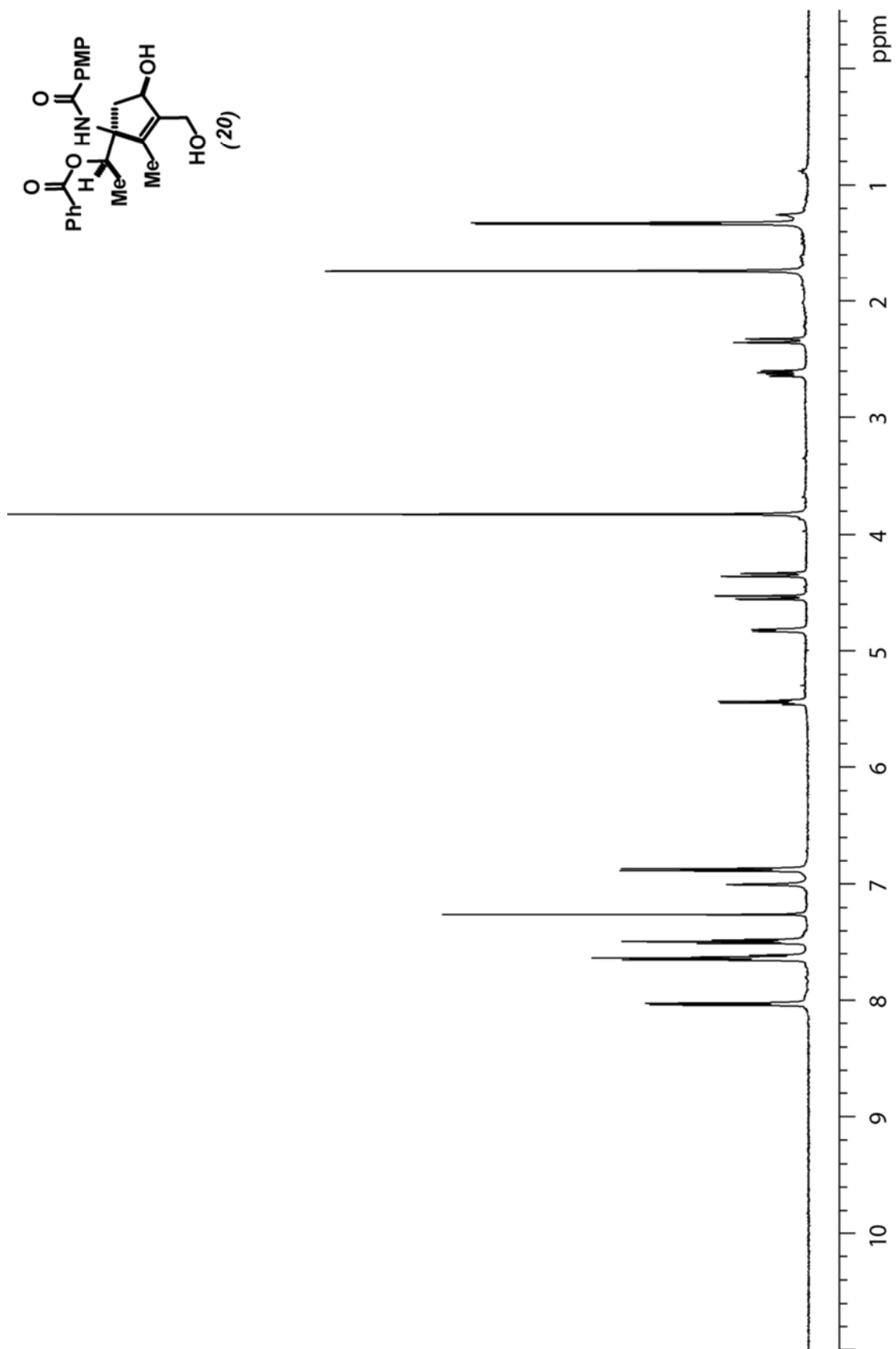


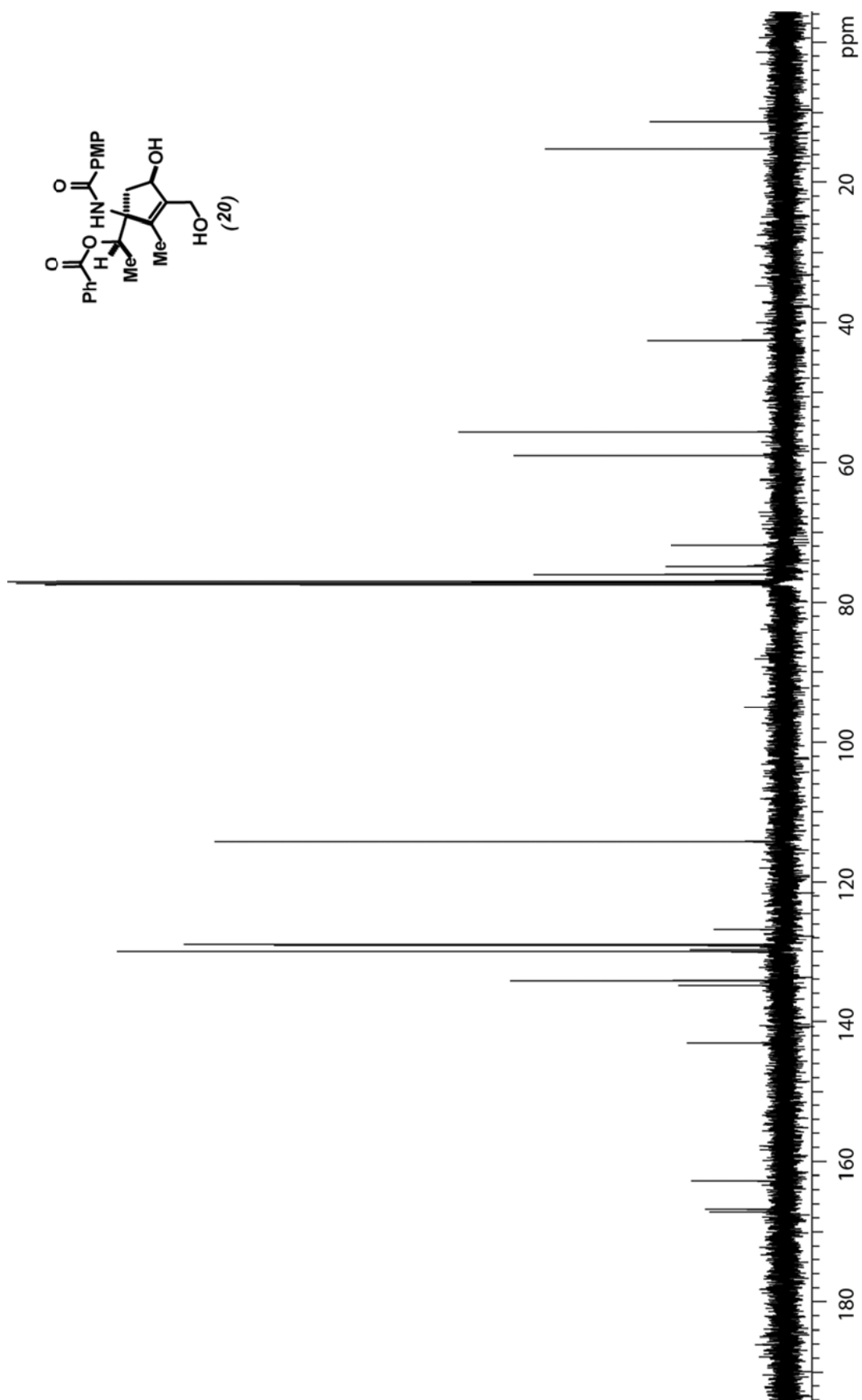


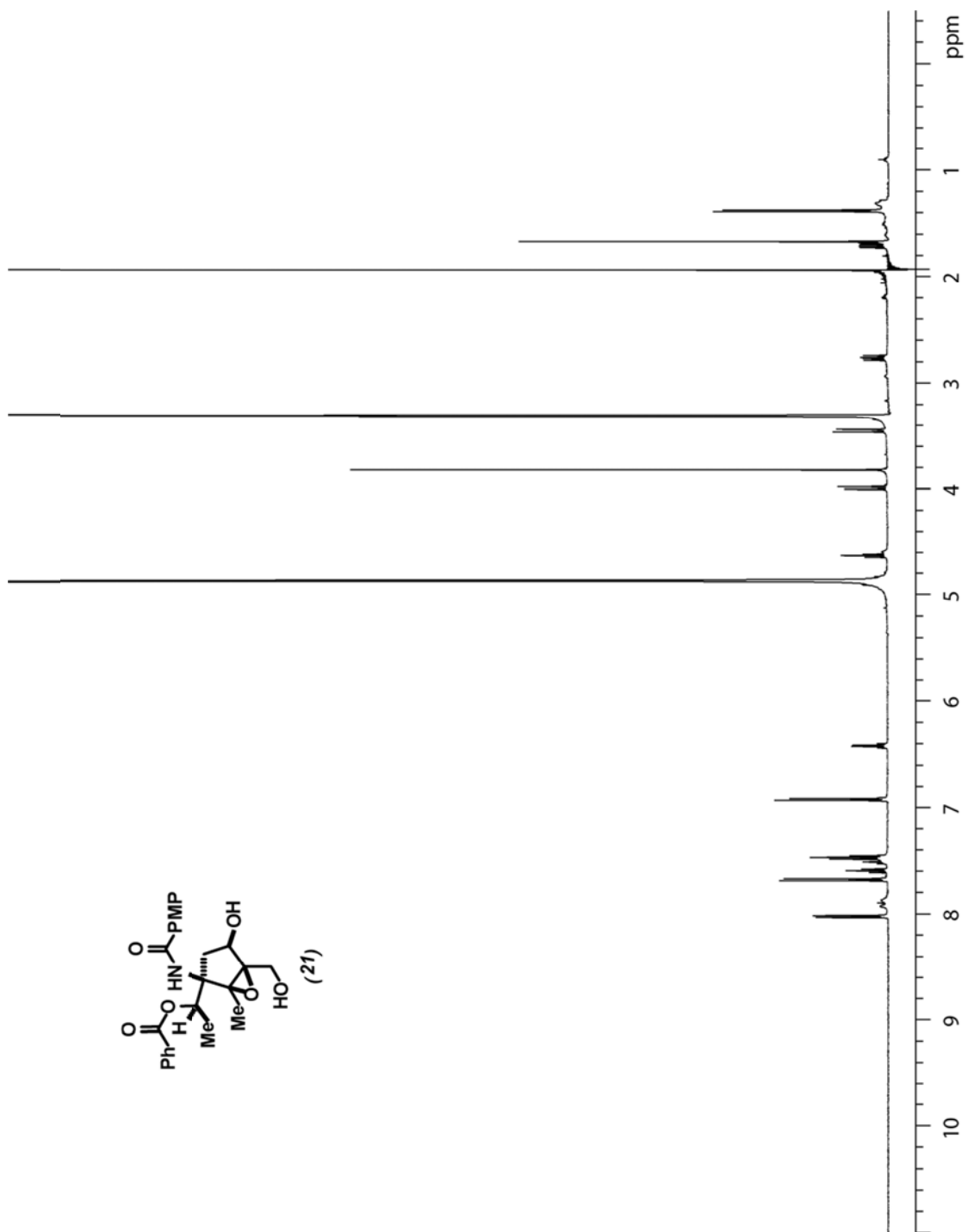


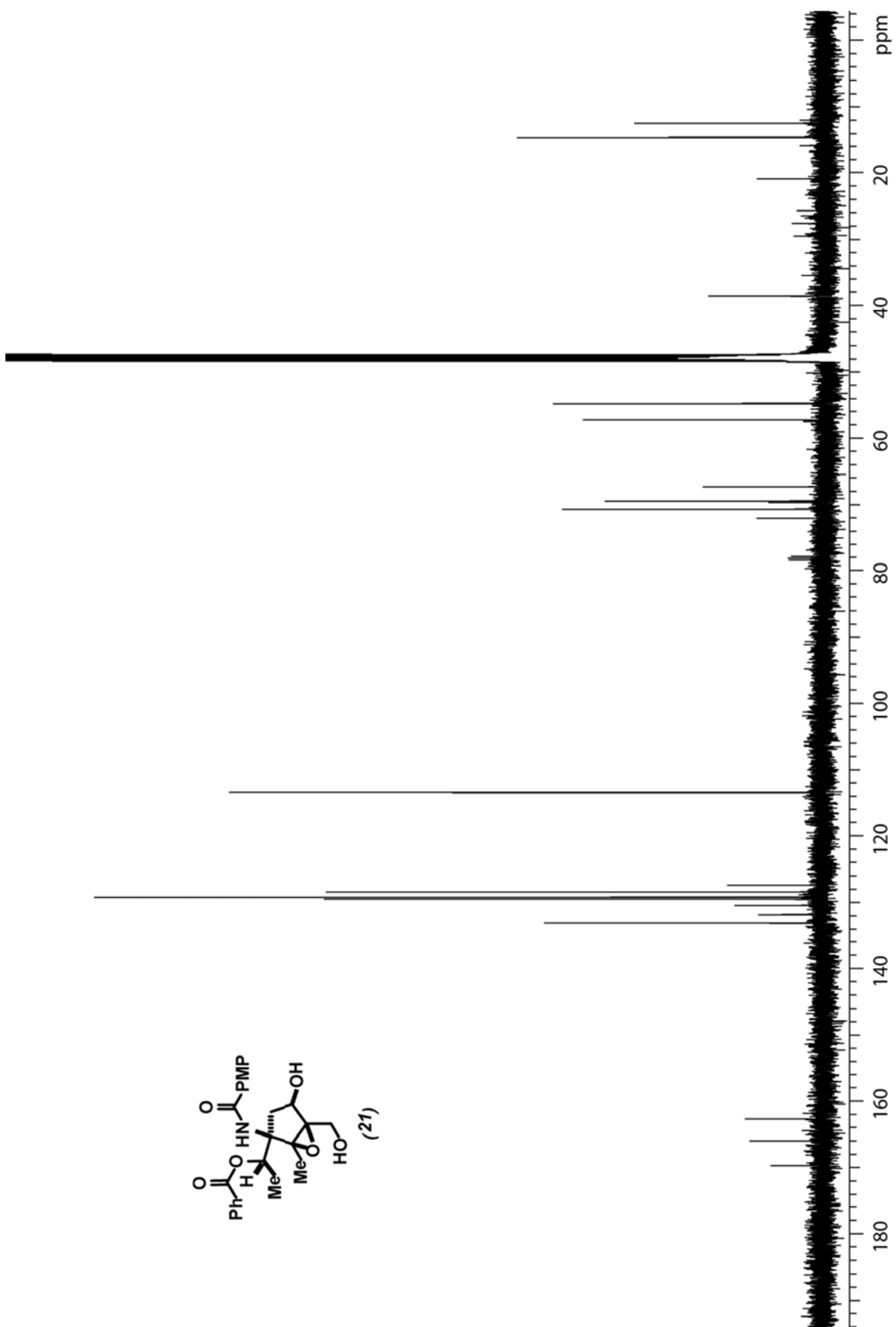
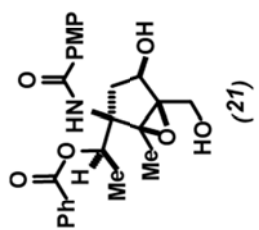


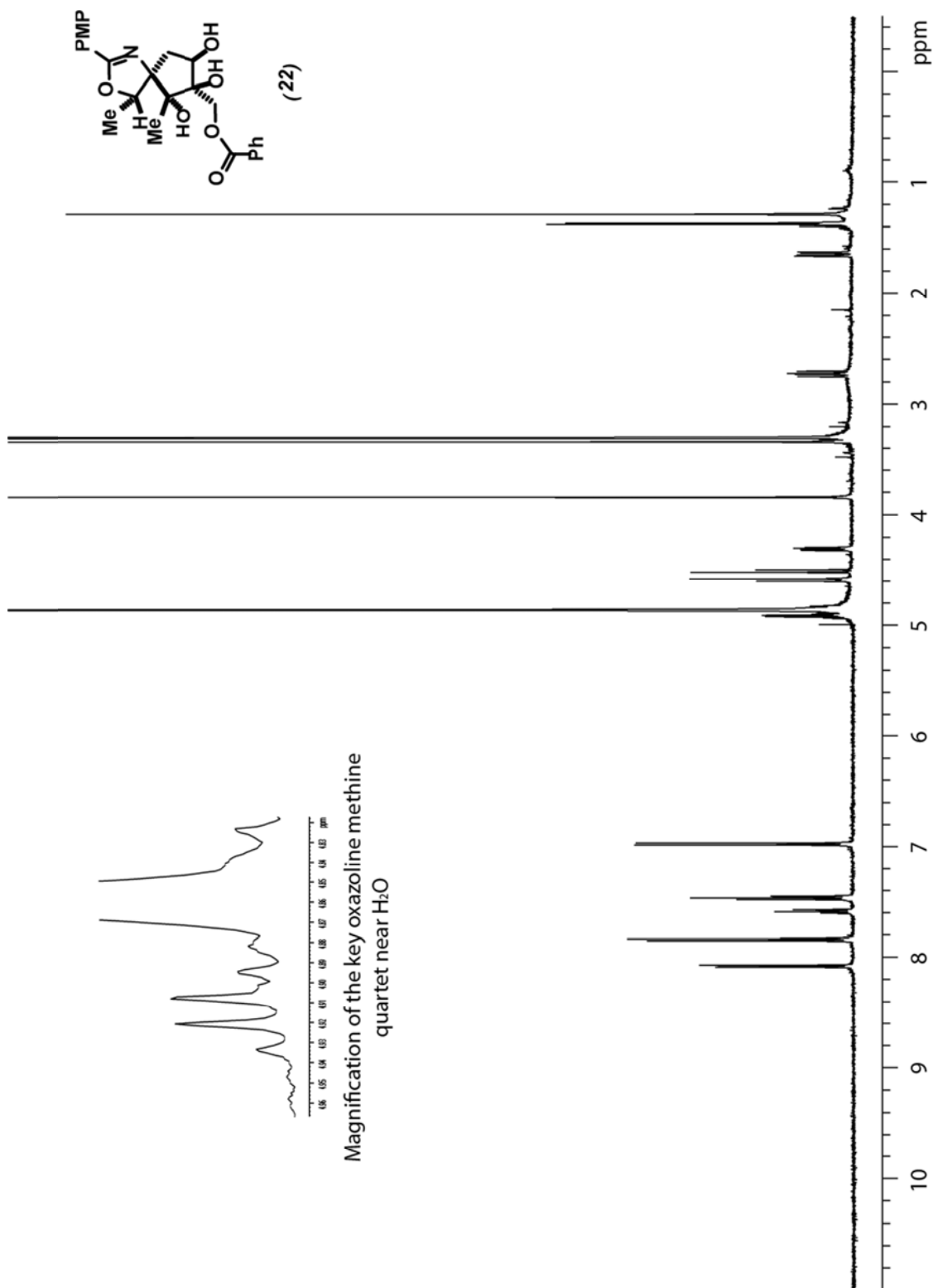


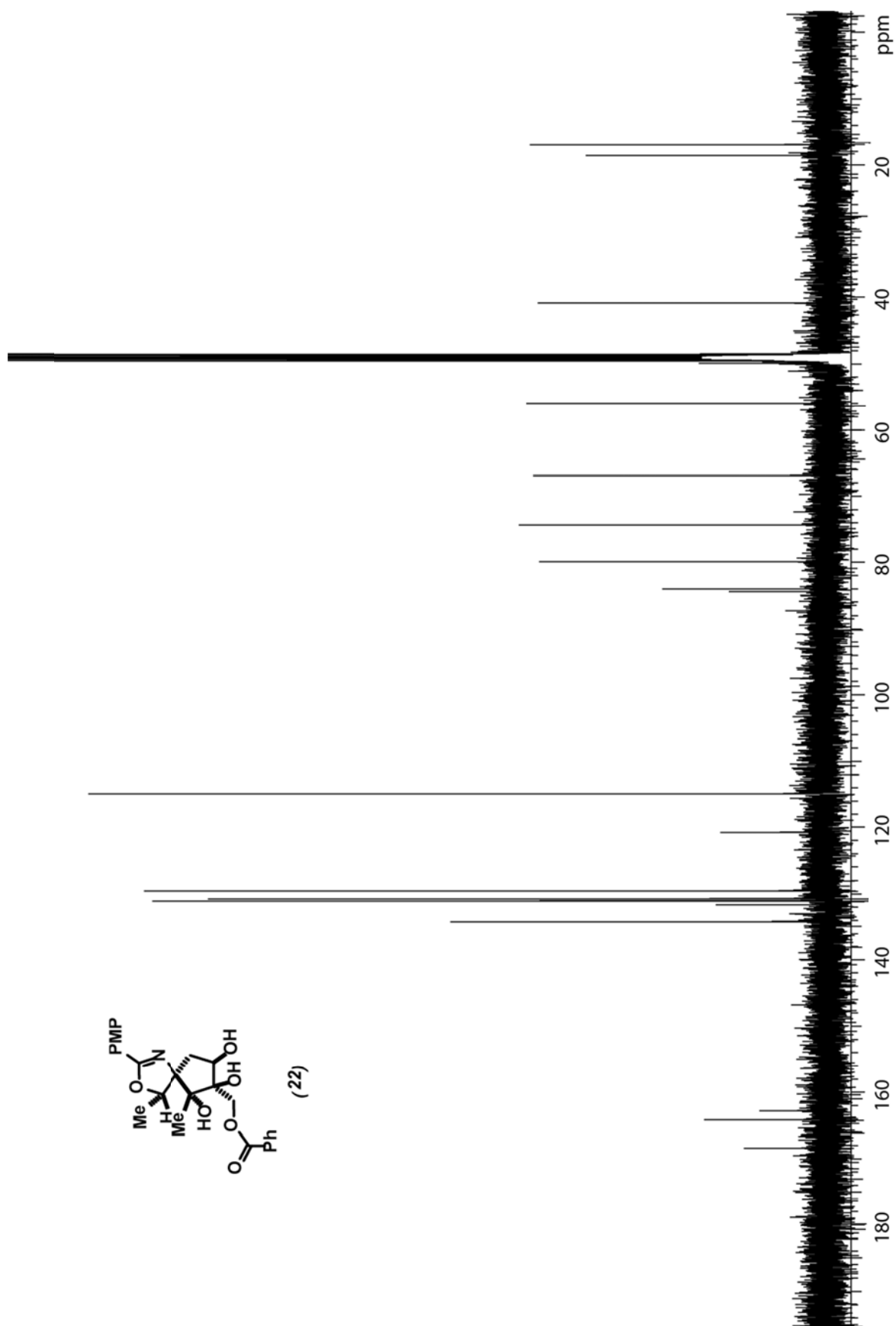










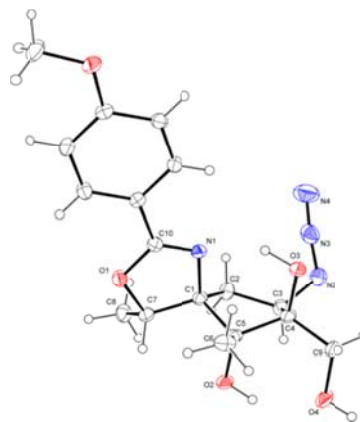




## Crystal Structure Report for Compound 15

### Experimental:

A colorless plate-shaped crystal 0.38 x 0.25 x 0.05 mm in size was mounted on a glass fiber with traces of viscous oil and then transferred to a Nonius KappaCCD diffractometer equipped with Mo K $\alpha$  radiation ( $\lambda = 0.71073 \text{ \AA}$ ). Ten frames of data were collected at 150(1) K with an oscillation range of 1 deg/frame and an exposure time of 20 sec/frame. [REF1] Indexing and unit cell refinement based on all observed reflection from those ten frames, indicated a monoclinic  $P$  lattice. A total of 4028 reflections ( $\Theta_{\max} = 27.49^\circ$ ) were indexed, integrated and corrected for Lorentz, polarization and absorption effects using DENZO-SMN and SCALEPAC. [REF 2] Post refinement of the unit cell gave  $a = 9.3688(3) \text{ \AA}$ ,  $b = 10.2321(2) \text{ \AA}$ ,  $c = 9.9800(3) \text{ \AA}$ ,  $\beta = 110.4465(14)$ , and  $V = 896.43(4) \text{ \AA}^3$ . Axial photographs and systematic absences were consistent with the compound having crystallized in the monoclinic space group  $P2_1$ .



The structure was solved by a combination of direct methods and heavy atom using SIR 97. [REF 3]

All of the non-hydrogen atoms were refined with anisotropic displacement coefficients. Hydrogen atoms were either located and refined isotropically or assigned isotropic displacement coefficients  $U(H) = 1.2U(C)$  or  $1.5U(C_{\text{methyl}})$ , and their coordinates were allowed to ride on their respective carbons using SHELXL97. [REF 4] The weighting scheme employed was  $w = 1/[\sigma^2(F_o^2) + (0.04P)^2 + 0.1358P]$  where  $P = (F_o^2 + 2F_c^2)/3$ . The refinement converged to  $R1 = 0.0336$ ,  $wR2 = 0.0744$ , and  $S = 1.038$  for 1807 reflections with  $1 > 2\sigma(I)$ , and  $R1 = 0.0479$ ,  $wR2 = 0.0816$ , and  $S = 1.038$  for 2171 unique reflections and 252 parameters. [REF 5] The maximum  $\Delta/\sigma$  in the final cycle of the least-squares was 0, and the residual peaks on the final difference-Fourier map ranged from -0.161 to 0.178 e/ $\text{\AA}^3$ . Scattering factors were taken from the International Tables for Crystallography, Volume C. [REF 6, REF 7]

REF 1 COLLECT Data Collection Software. Nonius B.V. 1998.

REF 2 Otwinowski, Z.; Minor, W., "Processing of X-ray Diffraction Data Collected in Oscillation Mode", Methods Enzymol. 1997, 276, 307-326.

REF 3 SIR97 (Release 1.02) - A program for automatic solution and refinement of crystal structure. A. Altomare, M.C. Burla, M. Camalli, G. Cascarano, C. Giacovazzo, A. Guagliardi, A.G. G. Molteni, G. Polidori, and R. Spagna.

REF 4 SHELX97 [Includes SHELXS97, SHELXL97, CIFTAB ] - Sheldrick, G. M. (1997). Programs for Crystal Structure Analysis (Release 97-2). University of Göttingen, Germany.

REF 5  $R1 = \Sigma ( || F_o | - | F_c | | ) / \Sigma | F_o |$ ,  $wR2 = [ \Sigma (w(F_o^2 - F_c^2)^2) / \Sigma (F_o^2)^2 ]^{1/2}$ , and  $S = \text{Goodness-of-fit}$  on  $F^2 = [ \Sigma ( w(F_o^2 - F_c^2)^2 / (n-p) ) ]^{1/2}$ , where  $n$  is the number of reflections and  $p$  is the number of parameters refined.

REF 6 Maslen, E. N.; Fox, A. G.; O'Keefe, M. A., International Tables for Crystallography: Mathematical, Physical and Chemical Tables, Vol. C, Chapter 6, Wilson, A. J. C., Ed.; Kluwer, Dordrecht, The Netherlands, 1992; pp. 476-516.

REF 7 Creagh, D. C.; McAuley, W. J., International Tables for Crystallography: mathematical, Physical and Chemical tables, Vol. C, Chapter 4 Wilson, A. J. C., Ed.; Kluwer, Dordrecht, The Netherlands, 1992; pp. 206-222.

REF8 ORTEP3 for Windows - L. J. Farrugia, *J. Appl. Crystallogr.* **1997**, 30, 565.

REF9 WinGX A Windows Program for Crystal Structure Analysis. L. J. Farrugia, University of Glasgow, Glasgow, 1998.

Table 1. Crystal data and structure refinement for rel009.

Identification code

rel009

Empirical formula	C17 H22 N4 O5	
Formula weight	362.39	
Temperature	150(1) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	<i>P</i> 2 <sub>1</sub>	
Unit cell dimensions	a = 9.3688(3) Å	α = 90°.
	b = 10.2321(2) Å	β = 110.4465(14)°.
	c = 9.9800(3) Å	γ = 90°.
Volume	896.43(4) Å <sup>3</sup>	
Z	2	
Density (calculated)	1.343 Mg/m <sup>3</sup>	
Absorption coefficient	0.100 mm <sup>-1</sup>	
F(000)	384	
Crystal size	0.38 x 0.25 x 0.05 mm <sup>3</sup>	
Theta range for data collection	2.18 to 27.49°.	
Index ranges	-12 ≤ h ≤ 12, -13 ≤ k ≤ 12, -12 ≤ l ≤ 12	
Reflections collected	4028	
Independent reflections	2171 [R(int) = 0.0207]	
Completeness to theta = 27.49°	99.8 %	
Absorption correction	Multi-scan	
Max. and min. transmission	0.9950 and 0.9628	
Refinement method	Full-matrix least-squares on F <sup>2</sup>	
Data / restraints / parameters	2171 / 1 / 252	
Goodness-of-fit on F <sup>2</sup>	1.038	
Final R indices [I > 2σ(I)]	R1 = 0.0336, wR2 = 0.0744	
R indices (all data)	R1 = 0.0479, wR2 = 0.0816	
Extinction coefficient	0.040(4)	
Largest diff. peak and hole	0.178 and -0.161 e.Å <sup>-3</sup>	

Table 2. Atomic coordinates ( $\times 10^4$ ) and equivalent isotropic displacement parameters ( $\text{\AA}^2 \times 10^3$ ) for rel009.  $U(\text{eq})$  is defined as one third of the trace of the orthogonalized  $U^{ij}$  tensor.

	x	y	z	U(eq)
O(1)	920(2)	1190(2)	9489(2)	37(1)
O(2)	895(2)	-2334(2)	9505(3)	60(1)
O(3)	3027(2)	-1482(2)	8503(2)	34(1)
O(4)	4387(2)	1808(2)	7078(2)	34(1)
O(5)	1510(2)	7417(2)	4951(2)	36(1)
N(1)	2991(2)	2077(2)	8488(2)	27(1)
N(2)	2862(3)	403(2)	12218(2)	47(1)
N(3)	3075(3)	1579(3)	12445(2)	50(1)
N(4)	3264(4)	2637(3)	12793(3)	77(1)
C(1)	3615(2)	744(2)	8826(2)	26(1)
C(2)	4327(3)	553(3)	10461(2)	34(1)
C(3)	3089(3)	-119(2)	10922(3)	34(1)
C(4)	1622(3)	-69(2)	9593(3)	32(1)
C(5)	2276(2)	-239(2)	8370(2)	28(1)
C(6)	1122(3)	-54(3)	6884(3)	39(1)
C(7)	384(3)	-1031(2)	9588(3)	44(1)
C(8)	4678(3)	602(2)	7937(2)	30(1)
C(9)	6367(3)	509(3)	8763(3)	39(1)
C(10)	3427(2)	2545(2)	7508(2)	27(1)
C(11)	2957(2)	3813(2)	6808(2)	26(1)
C(12)	1842(2)	4541(2)	7110(2)	29(1)
C(13)	1399(3)	5743(2)	6485(2)	29(1)
C(14)	2064(2)	6243(2)	5543(2)	29(1)
C(15)	3180(3)	5540(2)	5249(2)	33(1)
C(16)	3618(3)	4323(3)	5879(2)	32(1)
C(17)	2177(3)	8008(3)	4030(3)	52(1)

Table 3. Bond lengths [ $\text{\AA}$ ] and angles [ $^\circ$ ] for rel009.

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O(1)-C(4)	1.435(3)
O(1)-H(1)	0.99(4)
O(2)-C(7)	1.430(3)
O(2)-H(2)	0.88(4)
O(3)-C(5)	1.437(3)
O(3)-H(3)	0.88(4)
O(4)-C(10)	1.353(3)
O(4)-C(8)	1.473(3)
O(5)-C(14)	1.359(3)
O(5)-C(17)	1.415(3)
N(1)-C(10)	1.277(3)
N(1)-C(1)	1.476(3)
N(2)-N(3)	1.227(3)
N(2)-C(3)	1.482(3)
N(3)-N(4)	1.132(4)
C(1)-C(2)	1.545(3)
C(1)-C(5)	1.547(3)
C(1)-C(8)	1.555(3)
C(2)-C(3)	1.550(3)
C(2)-H(2A)	0.9900
C(2)-H(2B)	0.9900
C(3)-C(4)	1.542(3)
C(3)-H(3A)	1.0000
C(4)-C(7)	1.520(3)
C(4)-C(5)	1.555(3)
C(5)-C(6)	1.511(3)
C(6)-H(6A)	0.9800
C(6)-H(6B)	0.9800
C(6)-H(6C)	0.9800
C(7)-H(7A)	0.9900
C(7)-H(7B)	0.9900
C(8)-C(9)	1.510(3)
C(8)-H(8)	1.0000
C(9)-H(9A)	0.9800

C(9)-H(9B)	0.9800
C(9)-H(9C)	0.9800
C(10)-C(11)	1.466(3)
C(11)-C(16)	1.385(3)
C(11)-C(12)	1.399(3)
C(12)-C(13)	1.377(3)
C(12)-H(12)	0.9500
C(13)-C(14)	1.394(3)
C(13)-H(13)	0.9500
C(14)-C(15)	1.382(3)
C(15)-C(16)	1.391(3)
C(15)-H(15)	0.9500
C(16)-H(16)	0.9500
C(17)-H(17A)	0.9800
C(17)-H(17B)	0.9800
C(17)-H(17C)	0.9800

C(4)-O(1)-H(1)	109(2)
C(7)-O(2)-H(2)	111(2)
C(5)-O(3)-H(3)	104(2)
C(10)-O(4)-C(8)	106.95(16)
C(14)-O(5)-C(17)	118.2(2)
C(10)-N(1)-C(1)	108.32(18)
N(3)-N(2)-C(3)	116.8(2)
N(4)-N(3)-N(2)	172.7(3)
N(1)-C(1)-C(2)	110.40(18)
N(1)-C(1)-C(5)	108.53(17)
C(2)-C(1)-C(5)	103.61(18)
N(1)-C(1)-C(8)	103.74(16)
C(2)-C(1)-C(8)	117.69(18)
C(5)-C(1)-C(8)	112.74(18)
C(1)-C(2)-C(3)	106.13(18)
C(1)-C(2)-H(2A)	110.5
C(3)-C(2)-H(2A)	110.5
C(1)-C(2)-H(2B)	110.5
C(3)-C(2)-H(2B)	110.5

H(2A)-C(2)-H(2B)	108.7
N(2)-C(3)-C(4)	112.5(2)
N(2)-C(3)-C(2)	116.7(2)
C(4)-C(3)-C(2)	105.35(18)
N(2)-C(3)-H(3A)	107.3
C(4)-C(3)-H(3A)	107.3
C(2)-C(3)-H(3A)	107.3
O(1)-C(4)-C(7)	104.52(17)
O(1)-C(4)-C(3)	109.9(2)
C(7)-C(4)-C(3)	115.6(2)
O(1)-C(4)-C(5)	109.89(18)
C(7)-C(4)-C(5)	115.7(2)
C(3)-C(4)-C(5)	101.23(17)
O(3)-C(5)-C(6)	111.17(19)
O(3)-C(5)-C(1)	103.16(16)
C(6)-C(5)-C(1)	115.82(19)
O(3)-C(5)-C(4)	109.92(17)
C(6)-C(5)-C(4)	114.45(18)
C(1)-C(5)-C(4)	101.38(17)
C(5)-C(6)-H(6A)	109.5
C(5)-C(6)-H(6B)	109.5
H(6A)-C(6)-H(6B)	109.5
C(5)-C(6)-H(6C)	109.5
H(6A)-C(6)-H(6C)	109.5
H(6B)-C(6)-H(6C)	109.5
O(2)-C(7)-C(4)	109.5(2)
O(2)-C(7)-H(7A)	109.8
C(4)-C(7)-H(7A)	109.8
O(2)-C(7)-H(7B)	109.8
C(4)-C(7)-H(7B)	109.8
H(7A)-C(7)-H(7B)	108.2
O(4)-C(8)-C(9)	108.45(18)
O(4)-C(8)-C(1)	103.16(16)
C(9)-C(8)-C(1)	116.87(19)
O(4)-C(8)-H(8)	109.3
C(9)-C(8)-H(8)	109.3

C(1)-C(8)-H(8)	109.3
C(8)-C(9)-H(9A)	109.5
C(8)-C(9)-H(9B)	109.5
H(9A)-C(9)-H(9B)	109.5
C(8)-C(9)-H(9C)	109.5
H(9A)-C(9)-H(9C)	109.5
H(9B)-C(9)-H(9C)	109.5
N(1)-C(10)-O(4)	117.4(2)
N(1)-C(10)-C(11)	125.0(2)
O(4)-C(10)-C(11)	117.66(18)
C(16)-C(11)-C(12)	119.1(2)
C(16)-C(11)-C(10)	121.5(2)
C(12)-C(11)-C(10)	119.40(19)
C(13)-C(12)-C(11)	120.5(2)
C(13)-C(12)-H(12)	119.8
C(11)-C(12)-H(12)	119.8
C(12)-C(13)-C(14)	119.9(2)
C(12)-C(13)-H(13)	120.0
C(14)-C(13)-H(13)	120.0
O(5)-C(14)-C(15)	124.7(2)
O(5)-C(14)-C(13)	115.1(2)
C(15)-C(14)-C(13)	120.1(2)
C(14)-C(15)-C(16)	119.7(2)
C(14)-C(15)-H(15)	120.1
C(16)-C(15)-H(15)	120.1
C(11)-C(16)-C(15)	120.7(2)
C(11)-C(16)-H(16)	119.7
C(15)-C(16)-H(16)	119.7
O(5)-C(17)-H(17A)	109.5
O(5)-C(17)-H(17B)	109.5
H(17A)-C(17)-H(17B)	109.5
O(5)-C(17)-H(17C)	109.5
H(17A)-C(17)-H(17C)	109.5
H(17B)-C(17)-H(17C)	109.5

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Symmetry transformations used to generate equivalent atoms:





Table 4. Anisotropic displacement parameters ( $\text{\AA}^2 \times 10^3$ ) for rel009. The anisotropic displacement factor exponent takes the form:  $-2\pi^2 [h^2 a^{*2} U^{11} + \dots + 2 h k a^* b^* U^{12}]$

	$U^{11}$	$U^{22}$	$U^{33}$	$U^{23}$	$U^{13}$	$U^{12}$
O(1)	38(1)	23(1)	56(1)	5(1)	26(1)	8(1)
O(2)	55(1)	22(1)	127(2)	10(1)	60(1)	3(1)
O(3)	31(1)	21(1)	52(1)	2(1)	17(1)	4(1)
O(4)	38(1)	32(1)	39(1)	10(1)	21(1)	9(1)
O(5)	42(1)	27(1)	40(1)	9(1)	15(1)	3(1)
N(1)	32(1)	21(1)	30(1)	1(1)	12(1)	1(1)
N(2)	67(2)	43(1)	43(1)	7(1)	32(1)	-1(1)
N(3)	66(2)	52(2)	40(1)	6(1)	27(1)	9(1)
N(4)	125(3)	48(2)	65(2)	-10(1)	43(2)	3(2)
C(1)	26(1)	23(1)	29(1)	2(1)	9(1)	2(1)
C(2)	30(1)	41(1)	30(1)	6(1)	9(1)	-2(1)
C(3)	38(1)	31(1)	36(1)	8(1)	17(1)	4(1)
C(4)	30(1)	20(1)	47(1)	6(1)	17(1)	6(1)
C(5)	24(1)	20(1)	40(1)	1(1)	10(1)	3(1)
C(6)	31(1)	33(1)	44(1)	-6(1)	2(1)	3(1)
C(7)	36(1)	24(1)	82(2)	7(1)	33(1)	4(1)
C(8)	34(1)	24(1)	33(1)	4(1)	13(1)	2(1)
C(9)	32(1)	41(1)	49(1)	8(1)	18(1)	7(1)
C(10)	26(1)	28(1)	26(1)	-1(1)	7(1)	0(1)
C(11)	27(1)	25(1)	24(1)	1(1)	6(1)	-2(1)
C(12)	30(1)	30(1)	30(1)	-1(1)	13(1)	-3(1)
C(13)	30(1)	26(1)	33(1)	-2(1)	11(1)	1(1)
C(14)	31(1)	24(1)	29(1)	0(1)	6(1)	-2(1)
C(15)	33(1)	36(1)	31(1)	7(1)	14(1)	-1(1)
C(16)	31(1)	36(1)	31(1)	3(1)	14(1)	5(1)
C(17)	58(2)	42(2)	64(2)	26(1)	31(2)	8(1)

Table 5. Hydrogen coordinates (  $\times 10^4$ ) and isotropic displacement parameters ( $\text{\AA}^2 \times 10^3$ ) for rel009.

	x	y	z	U(eq)
H(1)	1500(40)	1820(40)	9140(40)	79(11)
H(2)	320(40)	-2910(40)	9730(40)	79(12)
H(3)	2380(40)	-2040(40)	8640(30)	56(10)
H(2A)	4616	1407	10948	41
H(2B)	5248	-2	10706	41
H(3A)	3383	-1059	11110	28(6)
H(6A)	1638	-91	6183	58
H(6B)	625	798	6824	58
H(6C)	355	-748	6681	58
H(7A)	142	-925	10472	53
H(7B)	-553	-855	8759	53
H(8)	4350	-170	7286	36
H(9A)	6591	-323	9280	59
H(9B)	6678	1233	9447	59
H(9C)	6926	558	8099	59
H(12)	1386	4202	7752	35
H(13)	640	6232	6694	35
H(15)	3646	5887	4620	40
H(16)	4377	3837	5669	38
H(17A)	3268	8136	4544	78
H(17B)	1691	8855	3706	78
H(17C)	2031	7441	3201	78

Table 6. Torsion angles [°] for rel009.

C(3)-N(2)-N(3)-N(4)	-168(3)
C(10)-N(1)-C(1)-C(2)	133.36(19)
C(10)-N(1)-C(1)-C(5)	-113.7(2)
C(10)-N(1)-C(1)-C(8)	6.4(2)
N(1)-C(1)-C(2)-C(3)	96.6(2)
C(5)-C(1)-C(2)-C(3)	-19.4(2)
C(8)-C(1)-C(2)-C(3)	-144.6(2)
N(3)-N(2)-C(3)-C(4)	-89.5(3)
N(3)-N(2)-C(3)-C(2)	32.5(3)
C(1)-C(2)-C(3)-N(2)	-135.4(2)
C(1)-C(2)-C(3)-C(4)	-9.8(2)
N(2)-C(3)-C(4)-O(1)	46.9(3)
C(2)-C(3)-C(4)-O(1)	-81.2(2)
N(2)-C(3)-C(4)-C(7)	-71.0(3)
C(2)-C(3)-C(4)-C(7)	160.8(2)
N(2)-C(3)-C(4)-C(5)	163.10(19)
C(2)-C(3)-C(4)-C(5)	34.9(2)
N(1)-C(1)-C(5)-O(3)	169.84(17)
C(2)-C(1)-C(5)-O(3)	-72.8(2)
C(8)-C(1)-C(5)-O(3)	55.5(2)
N(1)-C(1)-C(5)-C(6)	48.2(2)
C(2)-C(1)-C(5)-C(6)	165.52(19)
C(8)-C(1)-C(5)-C(6)	-66.2(2)
N(1)-C(1)-C(5)-C(4)	-76.33(19)
C(2)-C(1)-C(5)-C(4)	41.02(19)
C(8)-C(1)-C(5)-C(4)	169.33(17)
O(1)-C(4)-C(5)-O(3)	177.99(18)
C(7)-C(4)-C(5)-O(3)	-64.0(2)
C(3)-C(4)-C(5)-O(3)	61.8(2)
O(1)-C(4)-C(5)-C(6)	-56.1(2)
C(7)-C(4)-C(5)-C(6)	62.0(3)
C(3)-C(4)-C(5)-C(6)	-172.3(2)
O(1)-C(4)-C(5)-C(1)	69.3(2)
C(7)-C(4)-C(5)-C(1)	-172.62(19)

C(3)-C(4)-C(5)-C(1)	-46.84(19)
O(1)-C(4)-C(7)-O(2)	172.7(2)
C(3)-C(4)-C(7)-O(2)	-66.4(3)
C(5)-C(4)-C(7)-O(2)	51.7(3)
C(10)-O(4)-C(8)-C(9)	-120.1(2)
C(10)-O(4)-C(8)-C(1)	4.5(2)
N(1)-C(1)-C(8)-O(4)	-6.4(2)
C(2)-C(1)-C(8)-O(4)	-128.65(19)
C(5)-C(1)-C(8)-O(4)	110.80(19)
N(1)-C(1)-C(8)-C(9)	112.5(2)
C(2)-C(1)-C(8)-C(9)	-9.8(3)
C(5)-C(1)-C(8)-C(9)	-130.3(2)
C(1)-N(1)-C(10)-O(4)	-4.0(3)
C(1)-N(1)-C(10)-C(11)	175.49(19)
C(8)-O(4)-C(10)-N(1)	-0.6(3)
C(8)-O(4)-C(10)-C(11)	179.94(18)
N(1)-C(10)-C(11)-C(16)	172.1(2)
O(4)-C(10)-C(11)-C(16)	-8.4(3)
N(1)-C(10)-C(11)-C(12)	-6.3(3)
O(4)-C(10)-C(11)-C(12)	173.2(2)
C(16)-C(11)-C(12)-C(13)	0.4(3)
C(10)-C(11)-C(12)-C(13)	178.9(2)
C(11)-C(12)-C(13)-C(14)	0.0(3)
C(17)-O(5)-C(14)-C(15)	-3.9(3)
C(17)-O(5)-C(14)-C(13)	177.5(2)
C(12)-C(13)-C(14)-O(5)	177.97(19)
C(12)-C(13)-C(14)-C(15)	-0.7(3)
O(5)-C(14)-C(15)-C(16)	-177.5(2)
C(13)-C(14)-C(15)-C(16)	1.0(3)
C(12)-C(11)-C(16)-C(15)	-0.1(3)
C(10)-C(11)-C(16)-C(15)	-178.6(2)
C(14)-C(15)-C(16)-C(11)	-0.6(3)

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Symmetry transformations used to generate equivalent atoms:

