Enantioselective Synthesis of Dialkylated *N*-Heterocycles by Palladium-Catalyzed Allylic Alkylation

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Materials and Methods

Unless otherwise stated, reactions were performed in flame-dried glassware under an argon or nitrogen atmosphere using dry, deoxygenated solvents. Solvents were dried by passage through an activated alumina column under argon.[1] Reaction progress was monitored by thin-layer chromatography (TLC) or Agilent 1290 UHPLC-LCMS. TLC was performed using E. Merck silica gel 60 F254 precoated glass plates (0.25 mm) and visualized by UV fluorescence quenching, *p*-anisaldehyde, $KMnO_4$ or ninhydrin staining. Silicycle Silia*Flash*® P60 Academic Silica gel (particle size 40–63 nm) was used for flash chromatography. Melting points were measured with BÜCHI Melting Point B-545. ^1H and ^{13}C NMR spectra were recorded on a Varian Inova 500 (500 MHz and 126 MHz, respectively) and a Varian Mercury 300 spectrometer (300 MHz and 75 MHz, respectively) and are reported in terms of chemical shift relative to $CHCl_3$ (δ 7.26 and δ 77.16, respectively). Data for ^1H NMR are reported as follows: chemical shift (δ ppm) (multiplicity, coupling constant (Hz), integration). Multiplicities are reported as follows: s = singlet, d = doublet, t = triplet, q = quartet , m = multiplet, br s = broad singlet, br d = broad doublet. Data for ^{13}C NMR are reported in terms of chemical shifts (δ ppm). IR spectra were obtained by use of a Perkin Elmer Spectrum BXII spectrometer using thin films deposited on NaCl plates and reported in frequency of absorption (cm^{-1}). Optical rotations were measured with a Jasco P-2000 polarimeter operating on the sodium D-line (589 nm), using a 100 mm path-length cell and are reported as: $[\alpha]_D^T$ (concentration in g/100 mL, solvent). Analytical SFC was performed with a Mettler SFC supercritical CO_2 analytical chromatography system utilizing Chiralpak (AD-H, AS-H or IC) or Chiralcel (OD-H, OJ-H, or OB-H) columns (4.6 mm x 25 cm) obtained from Daicel Chemical Industries, Ltd. Chiral GC was performed with an Agilent 6850 GC utilizing a G-TA (30 m x 0.25 cm) column (1.0 mL/min carrier gas flow). High resolution mass spectra (HRMS) were obtained from Agilent 6200 Series TOF with an Agilent G1978A Multimode source in electrospray ionization (ESI+), atmospheric pressure chemical ionization (APCI+), or mixed ionization mode (MM: ESI-APCI+).

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Reagents were purchased from Sigma-Aldrich, Acros Organics, Strem, or Alfa Aesar, TCI America and used as received unless otherwise stated. DIEA and Et_3N were distilled from calcium hydride immediately prior to use. MeOH was distilled from magnesium methoxide immediately prior to use. (*S*)-$(CF_3)_3$-*t*-BuPHOX[2], tris(4,4'-methoxydibenzylideneacetone)dipalladium(0) $Pd_2(pmdba)_3$[3], **SI-2**[4], **SI-3**[5], **SI-5**[6], **SI-8**[7], **SI-10**[8] and diallyl 2-methylmalonate[9] were prepared by known methods or modified methods of reported.

List of Abbreviations:

Boc – *t*-butoxycarbonyl, BOM – benzyloxymethyl, Bz – benzoyl, Cbz – benzyloxycarbonyl, dba – dibenzylideneacetone, DBU – 1,8-diazabicyclo[5.4.0]undec-7-ene, DIEA – *N*,*N*-diisopropylethylamine, DMAP – 4-(dimethylamino)pyridine, ee – enantiomeric excess, HPLC – high-performance liquid chromatography, LDA – lithium diisopropylamide, LiHMDS – lithium hexamethyldisilazide, Ms – methanesulfonyl, Piv – pivaloyl, pmdba – bis(4-methoxybenzylidene)acetone, SFC – supercritical fluid chromatography, TLC – thin-layer chromatography, THF – tetrahydrofuran, *p*-Ts – *p*-toluenesulfonyl

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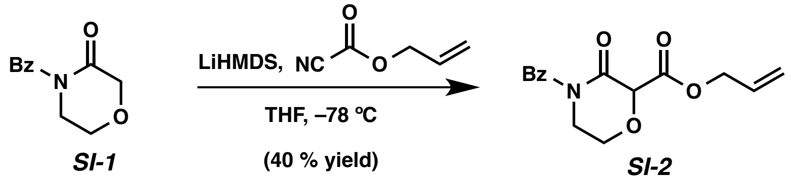
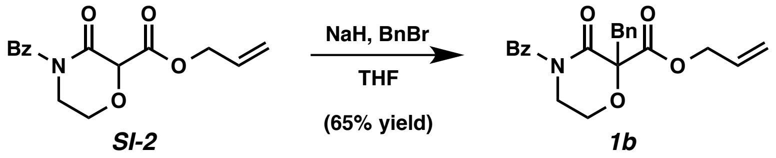
[9] Diallyl 2-methylmalonate can be prepared by esterification of 2-methyl malonic acid, see: Imao, D.; Itoi, A.; Yamazaki, A.; Shirakura, M.; Ohtoshi, R.; Ogata, K.; Ohmori, Y.; Ohta, T.; Ito, Y. *J. Org. Chem.* **2007**, *72*, 1652.

Procedures for Preparation of Substrates for Allylic Alkylation

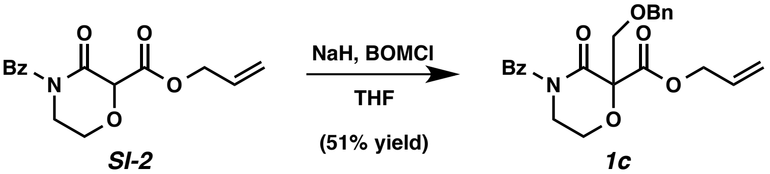


Morpholinone SI-2. To a stirred solution of LiHMDS (3.89 g, 23.3 mmol, 2.2 equiv) in THF (40 mL) was added a solution of morpholinone **SI-1** (2.17 g, 10.6 mmol, 1 equiv) in THF (30 mL) dropwise via syringe at –78 ºC. After stirring for 1 h, allyl cyanoformate (1.41 g, 12.7 mmol, 1.2 equiv) was added dropwise over 3 min at –78 ºC. After stirring at –78 ºC for 3 h, the reaction mixture was poured into a stirred mixture of saturated aqueous ammonium chloride and diethyl ether, and the biphasic mixture was stirred at ambient temperature for 5 min and extracted with diethyl ether twice. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 12→15% EtOAc in hexanes) afforded morpholinone **SI-2** (1.23 g, 4.25 mmol, 40% yield) as a colorless oil. $R_f = 0.45$ (33% EtOAc in hexanes); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.70–7.56 (m, 2H), 7.51 (m, 1H), 7.47–7.34 (m, 2H), 5.95 (ddt, *J* = 17.2, 10.4, 5.9 Hz, 1H), 5.39 (m, 1H), 5.31 (m, 1H), 4.84 (s, 1H), 4.79–4.71 (m, 2H), 4.36 (m, 1H), 4.18–3.86 (m, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 172.6, 166.5, 165.7, 134.6, 132.5, 131.0, 128.5, 128.3, 119.8, 77.4, 67.0, 62.5, 44.7; IR (Neat Film, NaCl) 2950, 1749, 1695, 1373, 1280, 1232, 1159, 1102, 1019, 988, 952, 729 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{15}H_{16}NO_5$ $[M+H]^+$: 290.1023, found 290.1026.



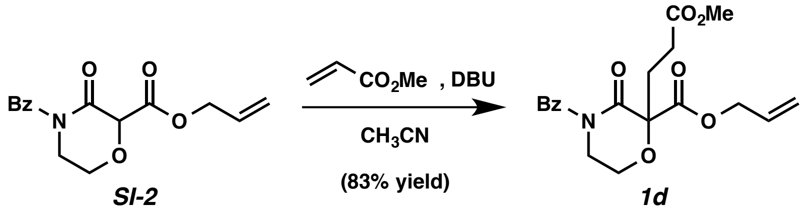
Morpholinone 1b. To a stirred suspension of NaH (48.6 mg, 55 wt%, 1.11 mmol, 1.4 equiv) in THF (2.6 mL) was added a solution of morpholinone **SI-2** (230 mg, 0.795 mmol, 1 equiv) in THF (2.0 mL) at 0 ºC. The reaction mixture was stirred at 0 ºC for 30 min before the addition of benzyl bromide (0.170 mL, 1.43 mmol, 1.8 equiv). The reaction mixture was warmed to room temperature, stirred for 12 h and poured into a stirred mixture of saturated aqueous ammonium chloride and diethyl ether. The phases

were separated, and the aqueous phase was extracted with diethyl ether twice. The combined organic layers were washed with saturated aqueous sodium bicarbonate and brine, dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 10→15% EtOAc in hexanes) afforded morpholinone **1b** (196 mg, 0.517 mmol, 65% yield) as a colorless oil. $R_f = 0.45$ (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.56–7.43 (m, 3H), 7.42–7.34 (m, 2H), 7.34–7.22 (m, 5H), 5.98 (ddt, *J* = 17.2, 10.4, 5.9 Hz, 1H), 5.42 (m, 1H), 5.35 (m, 1H), 4.81–4.73 (m, 2H), 4.28 (ddd, *J* = 12.2, 10.7, 2.8 Hz, 1H), 4.03 (ddd, *J* = 12.2, 3.8, 2.9 Hz, 1H), 3.75 (ddd, *J* = 13.2, 2.9, 2.8 Hz, 1H), 3.43 (d, *J* = 13.9 Hz, 1H), 3.31 (d, *J* = 13.9 Hz, 1H), 3.29 (ddd, *J* = 13.2, 10.7, 3.8 Hz, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 172.6, 168.6, 167.6, 135.1, 134.6, 132.2, 131.3, 131.3, 128.5, 128.3, 128.2, 127.5, 119.7, 84.5, 66.9, 62.3, 44.4, 41.6; IR (Neat Film, NaCl) 2946, 1750, 1692, 1451, 1315, 1280, 1223, 1146, 1050, 1026, 945 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{22}H_{22}NO_5$ $[M+H]^+$: 380.1492, found 380.1492.

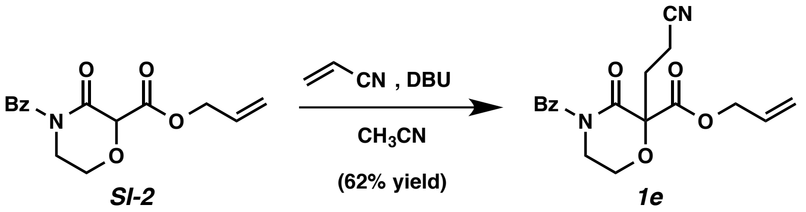


Morpholinone 1c. To a stirred suspension of NaH (45.0 mg, 55 wt%, 1.03 mmol, 1.4 equiv) in THF (2.6 mL) was added a solution of morpholinone **SI-2** (213 mg, 0.736 mmol, 1 equiv) in THF (2.6 mL) at 0 ºC. The reaction mixture was stirred at 0 ºC for 30 min before the addition of benzyloxymethyl chloride (0.184 mL, 1.32 mmol, 1.8 equiv). The reaction mixture was warmed to room temperature, stirred for 5 h and poured into a stirred mixture of saturated aqueous ammonium chloride and diethyl ether. The phases were separated and the aqueous phase was extracted with diethyl ether twice. The combined organic layers were washed with saturated aqueous sodium bicarbonate and brine, dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 15% EtOAc in hexanes) afforded morpholinone **1c** (155 mg, 0.379 mmol, 51% yield) as a white solid. $R_f = 0.48$ (33% EtOAc in hexanes); m.p. 110.4-110.7 ºC; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.68–7.61 (m, 2H), 7.52–7.43 (m, 1H), 7.40–7.24 (m, 7H), 5.91 (ddt, *J* = 17.2, 10.4, 5.8 Hz, 1H), 5.35 (m, 1H), 5.28 (m, 1H), 4.72–

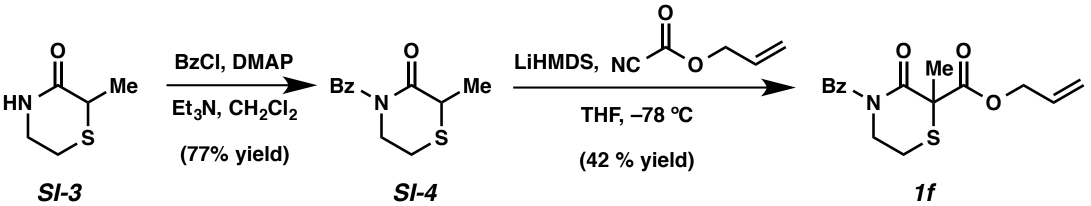
4.65 (m, 2H), 4.66–4.60 (m, 2H), 4.38 (ddd, *J* = 12.5, 9.7, 2.9 Hz, 1H), 4.30 (ddd, *J* = 12.5, 3.7, 3.7 Hz, 1H), 4.17 (d, *J* = 10.2 Hz, 1H), 4.10 (ddd, *J* = 13.2, 3.7, 2.9 Hz, 1H), 3.94 (ddd, *J* = 13.2, 9.7, 3.7 Hz, 1H), 3.92 (d, *J* = 10.2 Hz, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 172.7, 167.2, 167.0, 137.6, 134.9, 132.3, 131.1, 128.6, 128.6, 128.2, 128.0, 127.7, 119.6, 84.0, 74.3, 73.4, 66.8, 62.8, 44.7; IR (Neat Film, NaCl) 2941, 2873, 1747, 1690, 1449, 1371, 1318, 1280, 1231, 1160, 1073, 956, 727, 696 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{23}H_{24}NO_6$ [M+H]$^+$: 410.1598, found 410.1598.



Morpholinone 1d. To a stirred solution of morpholinone **SI-2** (213 mg, 0.736 mmol, 1 equiv) in CH_3CN (4.5 mL) was added methyl acrylate (0.159 mL, 1.77 mmol, 2.0 equiv) and DBU (6.6 μL, 0.044 mmol, 0.05 equiv) at room temperature. After stirring at room temperature for 12 h, the reaction mixture was diluted with ethyl acetate (20 mL). The resulting mixture was washed with 1 M HCl, saturated aqueous sodium bicarbonate and brine, dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 20→25% EtOAc in hexanes) afforded morpholinone **1d** (274 mg, 0.730 mmol, 83% yield) as a colorless oil. R_f = 0.42 (33% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.69–7.62 (m, 2H), 7.52 (m, 1H), 7.42–7.38 (m, 2H), 5.98 (ddt, *J* = 17.2, 10.4, 6.0 Hz, 1H), 5.42 (m, 1H), 5.34 (m, 1H), 4.77–4.75 (m, 2H), 4.27 (ddd, *J* = 12.3, 10.4, 3.2 Hz, 1H), 4.13 (ddd, *J* = 12.3, 4.0, 3.1 Hz, 1H), 4.00 (ddd, *J* = 13.2, 10.4, 4.0 Hz, 1H), 3.88 (ddd, *J* = 13.2, 3.2, 3.1 Hz, 1H), 3.65 (s, 3H), 2.56–2.34 (m, 4H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.0, 173.0, 168.4, 167.9, 134.9, 132.4, 131.0, 128.5, 128.3, 120.1, 83.2, 67.1, 61.9, 51.9, 45.1, 30.8, 28.6; IR (Neat Film, NaCl) 2951, 1737, 1690, 1448, 1369, 1280, 1226, 1177, 1153, 1072, 944, 727, 694 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{19}H_{22}NO_7$ [M+H]$^+$: 376.1391, found 376.1393.

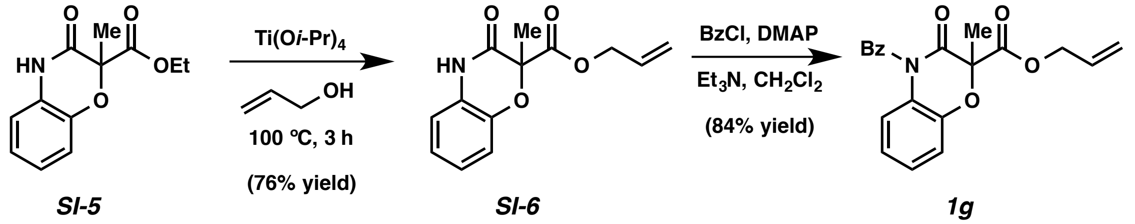


Morpholinone 1e. To a stirred solution of morpholinone **SI-2** (250 mg, 0.864 mmol, 1 equiv) in CH_3CN (4.3 mL) was added acrylonitrile (0.113 mL, 1.73 mmol, 2.0 equiv) and DBU (6.4 μL, 0.043 mmol, 0.05 equiv) at room temperature. After stirring at room temperature for 8 h, the reaction mixture was diluted with ethyl acetate (30 mL). The resulting mixture was washed with 1 M HCl, saturated aqueous sodium bicarbonate and brine, dried over Na_2SO_4, filtered, and concentrated *in vacuo*. Flash column chromatography (SiO_2, 20→25% EtOAc in hexanes) afforded morpholinone **1e** (182 mg, 0.532 mmol, 62% yield) as a white solid. $R_f = 0.41$ (33% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.67–7.64 (m, 2H), 7.54 (m, 1H), 7.44–7.39 (m, 2H), 5.99 (ddt, *J* = 17.1, 10.4, 6.0 Hz, 1H), 5.46–5.36 (m, 2H), 4.81–4.78 (m, 2H), 4.32 (ddd, *J* = 12.4, 10.4, 3.1 Hz, 1H), 4.18 (ddd, *J* = 12.4, 4.0, 3.1 Hz, 1H), 4.04 (ddd, *J* = 13.4, 10.4, 4.0 Hz, 1H), 3.89 (ddd, *J* = 13.4, 3.1, 3.1 Hz, 1H), 2.60–2.36 (m, 4H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 172.8, 167.7, 167.3, 134.6, 132.7, 130.7, 128.5, 128.4, 120.6, 118.8, 76.9, 67.5, 62.0, 45.1, 31.2, 12.1; IR (Neat Film, NaCl) 3062, 2950, 2894, 2248, 1746, 1692, 1600, 1462, 1449, 1372, 1280, 1221, 1155, 1070, 943, 796, 727, 694 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{18}H_{19}N_2O_5$ $[M+H]^+$: 343.1288, found 343.1290.



Thiomorpholinone SI-4. To a stirred solution of morpholinone **SI-3** (1.02 g, 7.77 mmol, 1 equiv), DMAP (47.4 mg, 0.389 mmol, 0.05 equiv) and Et_3N (2.48 mL, 17.9 mmol, 2.3 equiv) in CH_2Cl_2 (24 mL) was added benzoyl chloride (0.994 mL, 8.55 mmol, 1.1 equiv) at 0 ºC. The reaction mixture was warmed to room temperature gradually and stirred for 20 h. After full consumption of the starting material as indicated by TLC analysis, the reaction mixture was diluted with ethyl acetate (30 mL) and washed with 1 M HCl, saturated aqueous sodium bicarbonate and brine. The organic layers were dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 10→15% EtOAc in hexanes) afforded thiomorpholinone **SI-4** (1.40 g, 5.95 mmol, 77% yield) as a yellow solid. $R_f = 0.41$ (25% EtOAc in hexanes); m.p. 94.0–94.7 ºC; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.60–7.57 (m, 2H), 7.51 (m, 1H), 7.44–7.39 (m, 2H), 4.81 (ddd, *J* = 14.3, 5.0, 3.3 Hz, 1H), 3.86 (q, *J* = 6.7 Hz, 1H), 3.72 (ddd, *J* = 14.3, 11.8, 4.1 Hz, 1H), 3.19–3.06 (m, 2H), 1.38 (d, *J* = 6.6 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.4, 172.6, 136.0, 132.0, 128.3, 128.2, 43.9, 37.2, 27.2, 14.4; IR (Neat Film, NaCl) 2932, 1683, 1373, 1318, 1279, 1130, 991, 878 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{12}H_{14}NO_2S$ $[M+H]^+$: 236.0740, found 236.0737.

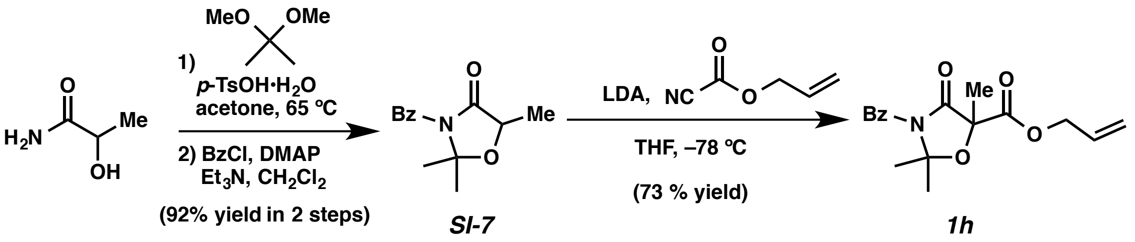
Thiomorpholinone 1f. To a stirred solution of LiHMDS (277 mg, 1.66 mmol, 1.3 equiv) in THF (5 mL) was added a solution of thiomorpholinone **SI-4** (300 mg, 1.27 mmol, 1 equiv) in THF (3 mL) dropwise via syringe at –78 ºC. After stirring for 1 h, allyl cyanoformate (169 mg, 1.52 mmol, 1.2 equiv) was added dropwise over 3 min at –78 ºC. After stirring at –78 ºC for 3 h, the reaction mixture was poured into a stirred mixture of saturated aqueous ammonium chloride and diethyl ether, and the biphasic mixture was stirred at ambient temperature for 5 min and extracted with diethyl ether twice. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 5→8% EtOAc in hexanes) afforded morpholinone **1f** (172 mg, 0.539 mmol, 42% yield) as a yellow oil. $R_f = 0.48$ (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.74–7.68 (m, 2H), 7.50 (m, 1H), 7.42–7.38 (m, 2H), 5.98 (m, 1H), 5.44 (m, 1H), 5.35 (m, 1H), 4.77 (br d, *J* = 5.9 Hz, 2H), 4.55 (m, 1H), 3.84 (ddd, *J* = 14.3, 8.5, 3.6 Hz, 1H), 3.27 (ddd, *J* = 13.0, 6.9, 3.6 Hz, 1H), 3.00 (ddd, *J* = 13.0, 8.5, 4.5 Hz, 1H), 1.66 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.3, 171.0, 169.1, 135.6, 132.2, 131.1, 128.3, 128.2, 120.0, 67.2, 52.8, 46.8, 26.5, 22.2; IR (Neat Film, NaCl) 2939, 1743, 1681, 1691, 1449, 1378, 1314, 1265, 1220, 1109, 990, 884 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{16}H_{18}NO_4S$ $[M+H]^+$: 320.0951, found 320.0957.



Benzomorpholinone SI-6. To a solution of benzomorpholinone **SI-5** (300 mg, 1.28 mmol, 1 equiv) in allyl alcohol (3.0 mL) was added Ti(O*i*-Pr)$_4$ (0.076 mL, 0.260 mmol, 0.2 equiv) at room temperature. After stirring at 100 ºC for 3 h, the reaction mixture was diluted with ethyl acetate (50 mL) and washed with 1 M HCl, saturated aqueous sodium bicarbonate and brine. The organic layers were dried over Na$_2$SO$_4$, filtered, and concentrated in vacuo. Flash column chromatography (SiO$_2$, 7→15% EtOAc in hexanes) afforded thiomorpholinone **SI-6** (239 mg, 0.976 mmol, 76% yield) as a white solid. R$_f$ = 0.40 (33% EtOAc in hexanes); m.p. 82.3–84.1 ºC; ^{1}H NMR (500 MHz, CDCl$_3$) δ 7.09–6.94 (m, 3H), 6.79 (m, 1H), 5.76 (m, 1H), 5.23–5.13 (m, 2H), 4.66–4.54 (m, 2H), 1.88 (s, 3H); ^{13}C NMR (126 MHz, CDCl$_3$) δ 168.3, 164.8, 143.0, 131.1, 126.2, 124.6, 123.2, 118.8, 117.5, 116.0, 81.3, 66.7, 20.8; IR (Neat Film, NaCl) 3235, 1744, 1698, 1614, 1502, 1379, 1232, 1123, 968, 751 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{13}H_{14}NO_4$ [M+H]$^+$: 248.0917, found 248.0907.

Benzomorpholinone 1g. To a stirred solution of benzomorpholinone **SI-6** (150 mg, 0.607 mmol, 1 equiv), DMAP (7.4 mg, 0.061 mmol, 0.10 equiv) and Et$_3$N (0.127 mL, 0.911 mmol, 1.5 equiv) in CH$_2$Cl$_2$ (3 mL) was added benzoyl chloride (0.084 mL, 0.728 mmol, 1.2 equiv) at room temperature. After full consumption of the starting material as indicated by TLC analysis, the reaction mixture was diluted with diethyl ether (30 mL) (30 mL) and washed with 1 M HCl, saturated aqueous sodium bicarbonate and brine. The organic layers were dried over Na$_2$SO$_4$, filtered, and concentrated in vacuo. Flash column chromatography (SiO$_2$, 10→13% EtOAc in hexanes) afforded benzomorpholinone **1g** (180 mg, 0.512 mmol, 84% yield) as a colorless oil. R$_f$ = 0.19 (10% EtOAc in hexanes); ^{1}H NMR (500 MHz, CDCl$_3$) δ 8.01–7.98 (m, 2H), 7.64 (ddt, *J* = 7.8, 7.1, 1.3 Hz, 1H), 7.51–7.47 (m, 2H), 7.18 (m, 1H), 7.11 (ddd, *J* = 8.1, 7.3, 1.5 Hz, 1H), 6.99 (ddd, *J* = 8.1, 7.3, 1.5 Hz, 1H), 6.90 (ddd, *J* = 8.1, 1.5, 0.4 Hz, 1H), 5.78 (ddt, *J*

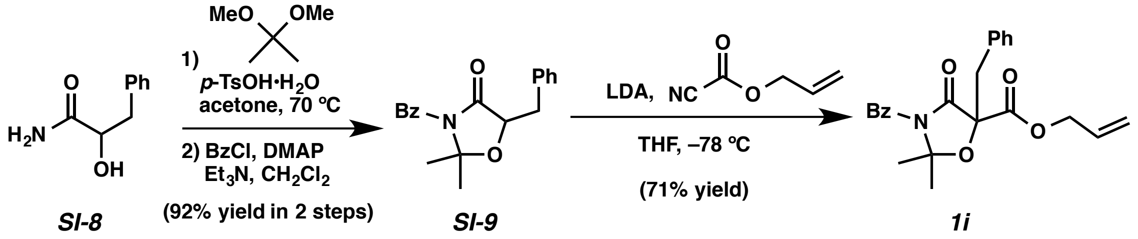
= 17.2, 10.5, 5.8 Hz, 1H), 5.27–5.21 (m, 2H), 4.65–4.63 (m, 2H), 1.87 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 171.8, 168.5, 163.8, 144.3, 134.6, 133.6, 130.9, 130.3, 129.1, 127.2, 125.8, 123.7, 119.6, 118.6, 118.3, 81.6, 66.9, 20.5; IR (Neat Film, NaCl) 3070, 1726, 1708, 1496, 1338, 1282, 1240, 1123 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{20}H_{18}NO_5$ $[M+H]^+$: 352.1179, found 352.1163.



Oxazolidinone SI-7. To a suspension of lactamide (2.50 g, 28.1 mmol, 1 equiv) and 2,2-dimethoxypropane (8.76 mL, 84.2 mmol, 3.0 equiv) in acetone (30 mL) was added *p*-toluenesulfonic acid monohydrate (53.0 mg, 0.280 mmol, 0.01 equiv) at room temperature. The reaction mixture was warmed to 65 ºC and stirred for 2 h. After full consumption of the starting material as indicated by TLC analysis, the reaction mixture was queched with Et_3N and concentrated in vacuo. The residue was used for the next reaction without further purification.

To a stirred solution of the crude acetonide, DMAP (189 mg, 1.54 mmol, 0.05 equiv) and Et_3N (5.87 mL, 42.2 mmol, 1.5 equiv) in CH_2Cl_2 (60 mL) was added benzoyl chloride (3.57 mL, 30.9 mmol, 1.1 equiv) at 0 ºC. After full consumption of the starting material as indicated by TLC analysis, the reaction mixture was diluted with diethyl ether (30 mL) (30 mL) and washed with 1 M HCl, saturated aqueous sodium bicarbonate and brine. The organic layers were dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 10→15% EtOAc in hexanes) afforded oxazolidinone **SI-7** (6.02 g, 25.8 mmol, 92% yield in 2 steps) as a white solid. R_f = 0.41 (15% EtOAc in hexanes); m.p. 66.7–67.1 ºC; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.61–7.52 (m, 3H), 7.47–7.41 (m, 2H), 4.42 (q, *J* = 6.7 Hz, 1H), 1.78 (s, 3H), 1.77 (s, 3H), 1.51 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.3, 169.7, 134.4, 132.7, 129.1, 128.3, 95.8, 72.0, 26.8, 25.2, 17.5; IR (Neat Film, NaCl) 1756, 1684, 1309, 1292, 1282, 1156, 835 cm^{-1}.

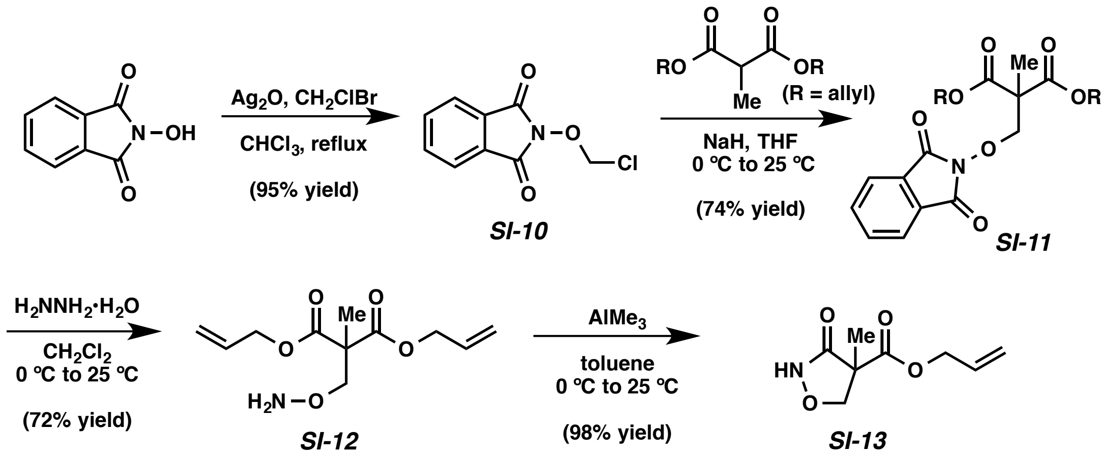
Oxazolidinone 1h. To a stirred solution of *N*,*N*-diisopropylamine (0.830 mL, 5.93 mmol, 1.3 equiv) in THF (15 mL) was added *n*-BuLi (2.83 mL, 2.3 M solution in hexanes, 5.47 mmol, 1.2 equiv) dropwise via syringe at –78 ºC. After stirring at 0 ºC for 20 min, a solution of oxazolidinone **SI-7** (1.00 g, 4.56 mmol, 1 equiv) in THF (10 mL) was added dropwise over 10 min at –78 ºC. After stirring at –78 ºC for 30 min, allyl cyanoformate (659 mg, 5.93 mmol, 1.3 equiv) was added dropwise over 3 min at –78 ºC. After stirring at –78 ºC for 2 h, the reaction mixture was poured into a stirred mixture of saturated aqueous ammonium chloride and diethyl ether, and the biphasic mixture was stirred at ambient temperature for 5 min and extracted with diethyl ether twice. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 5→7% EtOAc in hexanes) afforded oxazolidinone **1h** (1.06 g, 3.34 mmol, 73% yield) as a white solid. $R_f = 0.42$ (15% EtOAc in hexanes); m.p. 95.0–95.7 ºC; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.62–7.53 (m, 3H), 7.44–7.39 (m, 2H), 5.95 (ddt, *J* = 17.2, 10.4, 5.8 Hz, 1H), 5.40 (m, 1H), 5.32 (m, 1H), 4.78–4.69 (m, 2H), 1.84 (s, 3H), 1.82 (s, 3H), 1.70 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 169.4, 169.2, 168.5, 134.2, 132.7, 131.2, 128.9, 128.3, 119.7, 97.0, 81.4, 67.0, 29.3, 26.7, 21.9; IR (Neat Film, NaCl) 2991, 1762, 1736, 1690, 1373, 1323, 1279, 1241, 1178, 1127, 994, 951, 834 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{17}H_{20}NO_5$ $[M+H]^+$: 318.1336, found 318.1333.



Oxazolidinone SI-9. To a solution of amide **SI-8** (800 mg, 4.48 mmol, 1 equiv) and 2,2-dimethoxypropane (1.78 mL, 14.5 mmol, 3.0 equiv) in acetone (10 mL) was added *p*-toluenesulfonic acid monohydrate (9.2 mg, 0.048 mmol, 0.01 equiv) at room temperature. The reaction mixture was warmed to 70 ºC and stirred for 12 h. After full consumption of the starting material as indicated by TLC analysis, the reaction mixture was queched with Et_3N and concentrated in vacuo. The residue was used for the next reaction without further purification.

To a stirred solution of the crude acetonide, DMAP (29.6 mg, 0.242 mmol, 0.05 equiv) and Et_3N (1.10 mL, 7.26 mmol, 1.5 equiv) in CH_2Cl_2 (20 mL) was added benzoyl chloride (0.615 mL, 5.32 mmol, 1.1 equiv) at 0 ºC. After full consumption of the starting material as indicated by TLC analysis, the reaction mixture was diluted with diethyl ether (30 mL) and washed with 1 M HCl, saturated aqueous sodium bicarbonate and brine. The organic layers were dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 7→10% EtOAc in hexanes) afforded oxazolidinone **SI-9** (1.47 g, 4.78 mmol, 98% yield in 2 steps) as a colorless oil. $R_f = 0.42$ (10% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.50 (m, 1H), 7.41–7.29 (m, 7H), 7.11–7.07 (m, 2H), 4.66 (dd, *J* = 4.9, 3.8 Hz, 1H), 3.23 (dd, *J* = 14.5, 3.8 Hz, 1H), 3.11 (dd, *J* = 14.5, 4.9 Hz, 1H), 1.76 (s, 3H), 1.60 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 171.8, 169.8, 134.3, 132.7, 131.6, 130.9, 129.1, 128.3, 128.1, 127.2, 96.0, 76.3, 37.3, 26.1, 25.9; IR (Neat Film, NaCl) 1755, 1688, 1382, 1304, 1284, 1242, 1210, 1138 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{19}H_{20}NO_3$ $[M+H]^+$: 310.1438, found 310.1426.

Oxazolidinone 1i. To a stirred solution of LiHMDS (232 mg, 1.39 mmol, 1.4 equiv) in THF (3 mL) was added a solution of oxazolidinone **SI-9** (307 mg, 0.992 mmol, 1 equiv) in THF (2 mL) dropwise via syringe at –78 ºC. After stirring for 1 h, allyl cyanoformate (132 mg, 1.19 mmol, 1.2 equiv) was added dropwise over 3 min at –78 ºC. After stirring at –78 ºC for 2.5 h, the reaction mixture was poured into a stirred mixture of saturated aqueous ammonium chloride and diethyl ether, and the biphasic mixture was stirred at ambient temperature for 5 min and extracted with diethyl ether twice. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 5→7% EtOAc in hexanes) afforded oxazolidinone **1i** (279 mg, 0.709 mmol, 71% yield) as a colorless oil. $R_f = 0.42$ (10% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.52 (m, 1H), 7.39–7.31 (m, 7H), 7.16–7.13 (m, 2H), 5.95 (ddt, *J* = 17.2, 10.4, 5.9 Hz, 1H), 5.40 (m, 1H), 5.30 (m, 1H), 4.79–4.70 (m, 2H), 3.41 (d, *J* = 14.2 Hz, 1H), 3.34 (d, *J* = 14.2 Hz, 1H), 1.81 (s, 3H), 1.38 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 169.2, 168.4, 167.2, 134.1, 134.0, 132.6, 131.9, 131.1, 128.9, 128.3, 128.1, 127.8, 119.9, 97.2, 85.2, 67.1, 40.7, 27.7, 27.1; IR (Neat Film, NaCl) 1754, 1692, 1309, 1278, 1235, 1156, 1039 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{23}H_{24}NO_5$ $[M+H]^+$: 394.1649, found 394.1647.



***N*-Chloromethoxyphthalimide (SI-10).**[10] *N*-Hydroxyphthalimide (1.06 g, 6.47 mmol, 3.0 equiv) and CH_2ClBr (4.2 mL, 64.7 mmol, 10 equiv) in $CHCl_3$ (50 mL) were heated at reflux for 30 min, then Ag_2O (0.50 g, 2.16 mmol, 1 equiv) was added with vigorous stirring. The suspension was stirred at 75 ºC for 18 h under the dark and the reaction mixture was filtrated. The filtrate was concentrated in vacuo. Flash column chromatography (SiO_2, 10→20% EtOAc in hexanes) afforded *N*-chloromethoxyphthalimide (**SI-10**) (433 mg, 2.05 mmol, 95% yield) as a white solid. R_f = 0.46 (33% EtOAc in hexanes); m.p. 112.9–114.0 ºC; ^1H NMR (300 MHz, $CDCl_3$) δ 7.95–7.75 (m, 4H), 5.88 (s, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 162.9, 135.0, 129.0, 124.1, 83.8; IR (Neat Film, NaCl) 1724, 1126, 1018, 1000, 874 cm^{-1}.

Malonate SI-11. To a stirred suspension of NaH (397 mg, 60 wt%, 9.92 mmol, 1.5 equiv) in THF (20 mL) was added diallyl 2-methylmalonate (1.97 g, 9.92 mmol, 1.5 equiv) at 0 ºC. The reaction mixture was stirred at 0 ºC for 15 min, and then a solution of *N*-chloromethoxyphthalimide (**SI-10**) (1.40 g, 6.62 mmol, 1 equiv) was added dropwise over 15 min at 0 ºC. The reaction mixture was warmed to room temperature, stirred for 8

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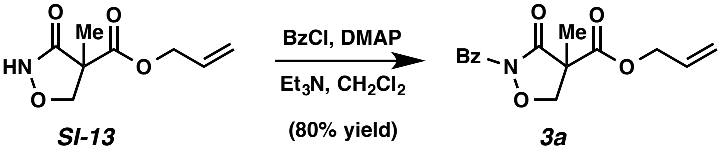
[10] (a) Calder, A; A. R. Forrester, A.R.; Thomson, R. H. *J. Chem. Soc. (C)* **1969**, 512. (b) Kirkup, M. P.; Shankar, B. B.; McCombie, S.; Ganguly, A. K.; McPhail, A. T. *Tetrahedron Lett.* **1989**, *30*, 6809.

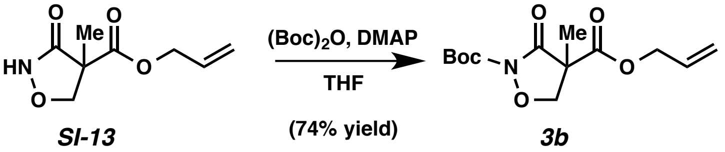
h and poured into a stirred mixture of 1 M HCl and diethyl ether. The phases were separated and the aqueous phase was extracted with ethyl acetate twice. The combined organic layers were washed with saturated aqueous sodium bicarbonate and brine, dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 15→20% EtOAc in hexanes) malonate **SI-11** (1.82 g, 4.87 mmol, 74% yield) as a colorless oil. R_f = 0.22 (20% EtOAc in hexanes); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.84–7.72 (m, 4H), 5.98–5.84 (m, 2H), 5.36–5.20 (m, 4H), 4.72–4.65 (m, 4H), 4.62 (s, 2H), 1.78 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 169.1, 163.0, 134.6, 131.6, 129.1, 123.7, 118.8, 79.8, 66.5, 54.5, 18.1; IR (Neat Film, NaCl) 2946, 1792, 1736, 1467, 1379, 1287, 1249, 1188, 1125, 1021, 1002 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{19}H_{20}NO_7$ $[M+H]^+$: 374.1234, found 374.1228.

Alkoxyamine SI-12. To a stirred solution of malonate **SI-11** (1.82 g, 4.87 mmol, 1 equiv) in CH_2Cl_2 (25 mL) was added hydrazine monohydrate (0.260 mL, 5.36 mmol, 1.1 equiv) at 0 ºC. The reaction mixture was warmed to room temperature, stirred for 20 h and filtered. The filtrate was concentrated in vacuo. Flash column chromatography (SiO_2, 15→20% EtOAc in hexanes) afforded alkoxyamine **SI-12** (850 mg, 3.49 mmol, 72% yield) as a colorless oil. R_f = 0.24 (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.92–5.84 (m, 2H), 5.34–5.29 (m, 2H), 5.24–5.21 (m, 2H), 4.64–4.62 (m, 6H), 4.12 (s, 2H), 1.53 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 170.4, 131.8, 118.4, 78.4, 66.0, 54.6, 18.3; IR (Neat Film, NaCl) 2943, 1732, 1454, 1248, 1213, 1120, 1020, 988, 935 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{11}H_{18}NO_5$ $[M+H]^+$: 244.1179, found 244.1175.

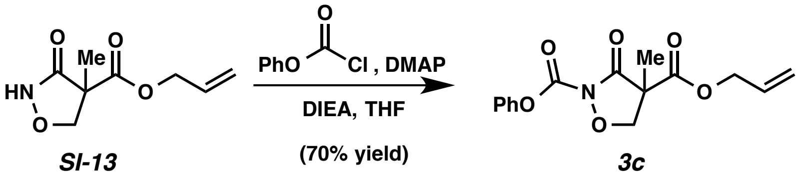
Isoxazolidinone SI-13. To a stirred solution of alkoxyamine **SI-12** (850 mg, 3.49 mmol, 1 equiv) in toluene (35 mL) was added trimethylaluminum (3.5 mL, 2.0 M solution in toluene, 6.98 mmol, 2.0 equiv) dropwise at 0 ºC. The reaction mixture was warmed to room temperature, stirred for 6 h, and poured into a stirred mixture of 1 M HCl and diethyl ether. The phases were separated and the aqueous phase was extracted with ethyl acetate twice. The combined organic layers were washed with brine, dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 20→40% EtOAc in hexanes) afforded isoxazolidinone **SI-13** (633 mg, 3.42 mmol, 98% yield) as a colorless oil. R_f = 0.22 (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.91 (m, 1H), 5.35 (m, 1H), 5.26 (m, 1H), 4.81 (d, *J* = 8.8 Hz, 1H), 4.71–4.69 (m, 2H), 4.17 (d, *J* = 8.8 Hz, 1H), 1.55 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 172.7, 169.5, 131.4, 118.9, 78.3, 66.7, 53.7, 17.7; IR (Neat Film, NaCl) 3182, 3087, 1739, 1704, 1453, 1275, 1215, 1137, 1037, 934 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_8H_{12}NO_4$ $[M+H]^+$: 186.0761, found 186.0755.



Isoxazolidinone 3a. To a stirred solution of isoxazolidinone **SI-13** (68.0 mg, 0.367 mmol, 1 equiv), DMAP (22.4 mg, 0.184 mmol, 0.50 equiv) and Et_3N (0.127 mL, 0.911 mmol, 2.5 equiv) in CH_2Cl_2 (2 mL) was added benzoyl chloride (0.064 mL, 0.551 mmol, 1.5 equiv) at room temperature. After full consumption of the starting material as indicated by TLC analysis, the reaction mixture was diluted with diethyl ether (30 mL) and washed with 1 M HCl, saturated aqueous sodium bicarbonate and brine. The organic layers were dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 15→20% EtOAc in hexanes) afforded isoxazolidinone **3a** (82.5 mg, 0.295 mmol, 80% yield) as a colorless oil. R_f = 0.25 (20% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.76–7.73 (m, 2H), 7.59 (m, 1H), 7.48–7.43 (m, 2H), 5.92 (ddt, *J* = 17.2, 10.5, 5.7 Hz, 1H), 5.39–5.28 (m, 2H), 4.92 (d, *J* = 9.0 Hz, 1H), 4.74–4.71 (m, 2H), 4.28 (d, *J* = 9.0 Hz, 1H), 1.61 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 168.6, 167.6, 163.8, 133.3, 131.8, 131.1, 129.9, 128.2, 119.4, 76.5, 67.1, 55.2, 17.5; IR (Neat Film, NaCl) 2942, 1769, 1741, 1703, 1450, 1273, 1138, 996 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{15}H_{16}NO_5$ $[M+H]^+$: 290.1023, found 290.1013.

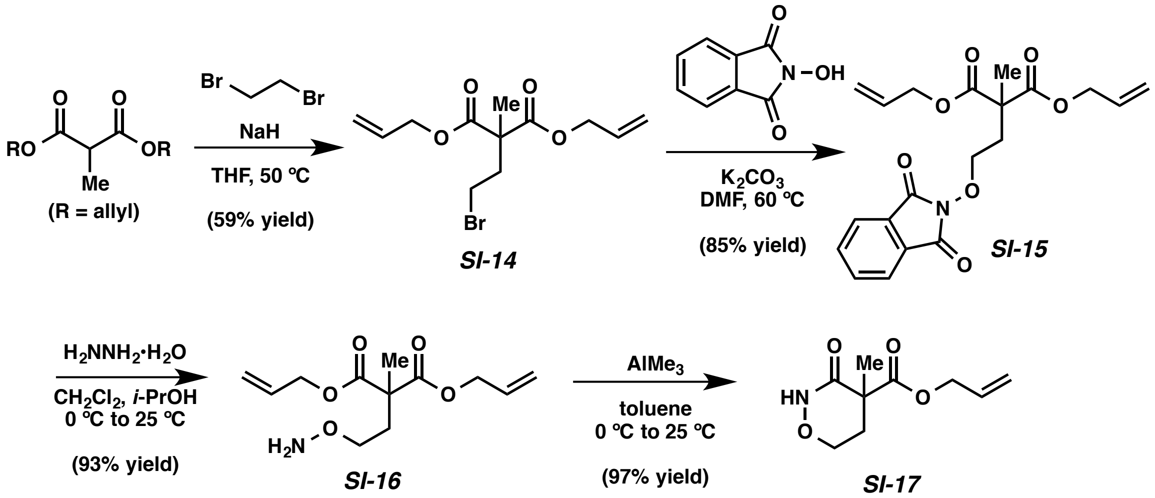


Isoxazolidinone 3b. To a stirred solution of isoxazolidinone **SI-13** (150 mg, 0.810 mmol, 1 equiv) and DMAP (19.8 mg, 0.162 mmol, 0.20 equiv) in THF (4 mL) was added $(Boc)_2O$ (229 mg, 1.05 mmol, 1.3 equiv) at room temperature. After full consumption of the starting material as indicated by TLC analysis, the reaction mixture was concentrated in vacuo. Flash column chromatography (SiO_2, 10→15% EtOAc in hexanes) afforded isoxazolidinone **3b** (170 mg, 0.596 mmol, 74% yield) as a colorless oil. R_f = 0.35 (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.90 (m, 1H), 5.34 (m, 1H), 5.26 (m, 1H), 4.79 (d, J = 8.9 Hz, 1H), 4.70–4.68 (m, 2H), 4.14 (d, J = 8.9 Hz, 1H), 1.58 (s, 3H), 1.57 (s, 9H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 168.7, 166.0, 146.2, 131.2, 119.1, 85.7, 76.1, 66.9, 55.0, 28.1, 17.6; IR (Neat Film, NaCl) 2984, 1791, 1748, 1458, 1371, 1291, 1157, 1107, 987, 946, 842, 752 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{13}H_{23}N_2O_6$ $[M+NH_4]^+$: 303.1551, found 303.1539.



Isoxazolidinone 3c. To a stirred solution of isoxazolidinone **SI-13** (150 mg, 0.810 mmol, 1 equiv), DMAP (10.0 mg, 0.081 mmol, 0.10 equiv) and DIEA (0.353 mL, 2.03 mmol, 2.5 equiv) in CH_2Cl_2 (4 mL) was added phenyl chloroformate (0.132 mL, 1.05 mmol, 1.3 equiv) at 0 ºC. After full consumption of the starting material as indicated by TLC analysis, the reaction mixture was diluted with diethyl ether (30 mL) and washed with 1 M HCl, saturated aqueous sodium bicarbonate and brine. The organic layers were dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 15→20% EtOAc in hexanes) afforded isoxazolidinone **3c** (172 mg, 0.563 mmol, 70% yield) as a colorless oil. R_f = 0.22 (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.44–7.39 (m, 2H), 7.31–7.22 (m, 3H), 5.95 (m, 1H), 5.38 (m, 1H), 5.30 (m, 1H), 4.91 (d, J = 9.0 Hz, 1H), 4.75–4.73 (m, 2H), 4.28 (d, J = 9.0 Hz, 1H), 1.65 (s, 3H);

^{13}C NMR (126 MHz, CDCl$_3$) δ 168.4, 166.1, 150.1, 146.0, 131.1, 129.7, 126.7, 121.3, 119.4, 76.7, 67.1, 54.9, 17.6; IR (Neat Film, NaCl) 1802, 1761, 1315, 1220, 1192, 1138, 980, 936 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{15}H_{16}NO_6$ [M+H]$^+$: 306.0972, found 306.0959.

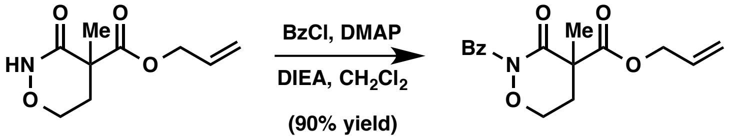


Malonate (SI-14). To a stirred suspension of NaH (1.23 g, 55 wt%, 28.3 mmol, 1.4 equiv) in THF (100 mL) was added diallyl 2-methylmalonate (4.00 g, 20.2 mmol, 1 equiv) at room temperature. The reaction mixture was stirred at room temperature for 20 min, and then 1,2-dibromoethane (11.4 mL, 60.5 mmol, 3.0 equiv) was added at 0 ºC. The reaction mixture was warmed to 50 ºC, stirred for 12 h and poured into a stirred mixture of 1 M HCl and diethyl ether. The phases were separated and the aqueous phase was extracted with diethyl ether. The combined organic layers were washed with saturated aqueous sodium bicarbonate and brine, dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 3% EtOAc in hexanes) malonate **SI-14** (3.66 g, 12.0 mmol, 59% yield) as a colorless oil. $R_f = 0.60$ (10% EtOAc in hexanes); ^{1}H NMR (500 MHz, CDCl$_3$) δ 5.88 (ddt, *J* = 17.2, 10.4, 5.7 Hz, 2H), 5.34–5.21 (m, 4H), 4.67–4.58 (m, 4H), 3.41–3.35 (m, 2H), 2.50–2.42 (m, 2H), 1.48 (s, 3H); ^{13}C NMR (126 MHz, CDCl$_3$) δ 170.9, 131.6, 118.9, 66.3, 54.1, 39.4, 27.1, 20.4; IR (Neat Film, NaCl) 2987, 2944, 1731, 1451, 1384, 1259, 1217, 1166, 1114, 986, 935 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{12}H_{18}O_4Br$ [M+H]$^+$: 305.0383, found 305.0382.

Malonate SI-15. To a solution of malonate **SI-14** (3.65 g, 11.9 mmol, 1 equiv) and *N*-hydroxyphthalimide (2.34 g, 14.4 mmol, 1.2 equiv) in DMF (50 mL) was added K_2CO_3 (2.14 g, 15.5 mmol, 1.3 equiv) at room temperature. The reaction mixture was warmed to 60 ºC and stirred for 12 h. After full consumption of the starting material as indicated by TLC analysis, the reaction mixture was diluted with ethyl acetate (100 mL) and washed with 1 M HCl, saturated aqueous sodium bicarbonate and brine. The organic layers were dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 20→25% EtOAc in hexanes) afforded malonate **SI-15** (3.90 g, 10.1 mmol, 85% yield) as a colorless oil. R_f = 0.29 (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.85–7.71 (m, 4H), 5.90–5.85 (m, 2H), 5.32–5.21 (m, 4H), 4.63–4.60 (m, 4H), 4.31 (t, *J* = 6.9 Hz, 2H), 2.44 (t, *J* = 6.9 Hz, 2H), 1.59 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 171.3, 163.5, 134.6, 131.7, 129.2, 123.7, 118.7, 75.0, 66.2, 52.5, 34.1, 20.5; IR (Neat Film, NaCl) 2948, 1790, 1732, 1467, 1374, 1240, 1188, 1124, 992, 935, 878 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{20}H_{22}NO_7$ $[M+H]^+$: 388.1391, found 388.1387.

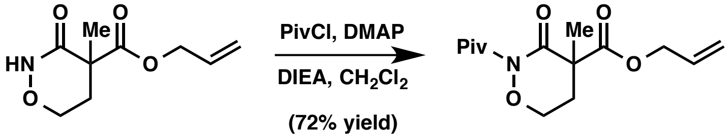
Alkoxyamine SI-16. To a stirred solution of malonate **SI-15** (3.87 g, 10.0 mmol, 1 equiv) in CH_2Cl_2 (45 mL) and *i*-PrOH (5 mL) was added hydrazine monohydrate (0.485 mL, 10.0 mmol, 1.0 equiv) at 0 ºC. The reaction mixture was warmed to room temperature, stirred for 15 h and filtered. The filtrate was concentrated in vacuo. Flash column chromatography (SiO_2, 20→35% EtOAc in hexanes) afforded alkoxyamine **SI-16** (2.39 g, 9.29 mmol, 93% yield) as a colorless oil. R_f = 0.19 (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.93–5.84 (m, 2H), 5.34–5.29 (m, 2H), 5.24–5.21 (m, 2H), 4.62–4.60 (m, 4H), 3.76 (t, *J* = 6.3 Hz, 2H), 2.22 (t, *J* = 6.3 Hz, 2H), 1.48 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 171.9, 131.9, 118.5, 71.8, 66.0, 52.3, 34.3, 20.3; IR (Neat Film, NaCl) 2943, 1732, 1589, 1453, 1382, 1298, 1237, 1141, 1117, 995, 934 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{12}H_{20}NO_5$ $[M+H]^+$: 258.1263, found 258.1333.

1,2-Oxazinan-3-one SI-17. To a stirred solution of alkoxyamine **SI-16** (2.24 g, 8.71 mmol, 1 equiv) in toluene (87 mL) was added trimethylaluminum (8.71 mL, 2.0 M solution in toluene, 14.7 mmol, 2.0 equiv) dropwise at 0 ºC. The reaction mixture was warmed to room temperature, stirred for 4 h, and poured into a stirred mixture of 1 M HCl and diethyl ether. The phases were separated and the aqueous phase was extracted with ethyl acetate twice. The combined organic layers were washed with brine, dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 40→50% EtOAc in hexanes) afforded 1,2-oxazinan-3-one **SI-17** (1.68 mg, 8.43 mmol, 97% yield) as a white solid. R_f = 0.26 (33% EtOAc in hexanes); m.p. 32.6–33.3 ºC; ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.94–5.86 (m, 1H), 5.37–5.23 (m, 2H), 4.69–4.63 (m, 2H), 4.17 (ddd, *J* = 10.5, 8.8, 6.7 Hz, 1H), 4.05 (ddd, *J* = 10.5, 8.8, 4.7 Hz, 1H), 2.86 (ddd, *J* = 13.5, 8.8, 4.7 Hz, 1H), 1.84 (ddd, *J* = 13.5, 8.8, 6.7 Hz, 1H), 1.50 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.4, 171.5, 131.7, 118.5, 69.0, 66.3, 48.7, 33.3, 20.0; IR (Neat Film, NaCl) 3192, 2942, 1740, 1683, 1455, 1383, 1272, 1225, 1146, 979, 938 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_9H_{14}NO_4$ $[M+H]^+$: 200.0917, found 200.0920.



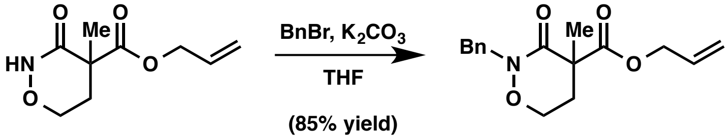
1,2-Oxazinan-3-one 3d. To a stirred solution of 1,2-oxazinan-3-one **SI-17** (448 mg, 2.25 mmol, 1 equiv), DMAP (82.5 mg, 0.675 mmol, 0.30 equiv) and DIEA (0.980 mL, 5.63 mmol, 2.5 equiv) in CH_2Cl_2 (11.3 mL) was added benzoyl chloride (0.338 mL, 2.92 mmol, 1.3 equiv) at 0 ºC. The reaction mixture was warmed to room temperature, stirred for 4 h, and poured into a stirred mixture of 1 M HCl and diethyl ether. The phases were separated and the aqueous phase was extracted with ethyl acetate twice. The combined organic layers were washed with saturated aqueous sodium bicarbonate and brine. The organic layers were dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 20→30% EtOAc in hexanes) afforded 1,2-oxazinan-3-one **3d** (628 mg, 2.07 mmol, 90% yield) as a colorless oil. R_f = 0.49 (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.69–7.64 (m, 2H), 7.55 (m, 1H), 7.45–7.41 (m, 2H), 5.94 (ddt, *J* = 17.2, 10.4, 5.7 Hz, 1H), 5.37 (m, 1H), 5.29 (m, 1H), 4.77–4.66 (m, 2H), 4.39–4.24 (m, 2H), 3.03 (ddd, *J* = 13.5, 9.9, 5.1 Hz, 1H), 1.90 (ddd, *J* = 13.5, 9.4, 6.4 Hz, 1H), 1.45 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 170.8, 170.7, 167.0, 133.5, 132.8, 131.5, 129.4, 128.2, 119.2, 69.8, 66.7, 51.4, 32.5, 19.7; IR (Neat Film, NaCl)

2942, 1732, 1705, 1450, 1270, 1205, 1142, 981, 922, 716 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{16}H_{18}NO_5$ [M+H]$^+$: 304.1179, found 304.1176.



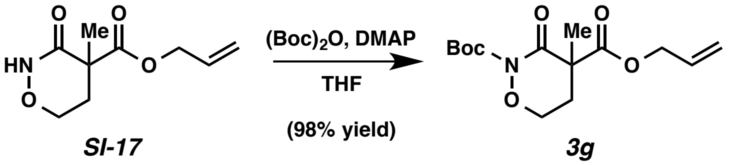
SI-17 **3e**

1,2-Oxazinan-3-one 3e. To a stirred solution of 1,2-oxazinan-3-one **SI-17** (200 mg, 1.00 mmol, 1 equiv), DMAP (12.0 mg, 0.100 mmol, 0.10 equiv) and DIEA (0.435 mL, 2.51 mmol, 2.5 equiv) in CH_2Cl_2 (5.0 mL) was added pivaloyl chloride (0.213 mL, 1.31 mmol, 1.3 equiv) at 0 ºC. The reaction mixture was warmed to room temperature, stirred for 3 h, and poured into a stirred mixture of 1 M HCl and diethyl ether. The phases were separated and the aqueous phase was extracted with ethyl acetate twice. The combined organic layers were washed with saturated aqueous sodium bicarbonate and brine. The organic layers were dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 15→20% EtOAc in hexanes) afforded 1,2-oxazinan-3-one **3e** (205 mg, 0.723 mmol, 72% yield) as a white solid. R_f = 0.26 (25% EtOAc in hexanes); m.p. 79.8–80.2 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.86 (m, 1H), 5.33–5.19 (m, 2H), 4.69–4.53 (m, 2H), 4.26 (ddd, *J* = 10.8, 10.0, 6.6 Hz, 1H), 4.08 (ddd, *J* = 10.8, 9.5, 4.6 Hz, 1H), 2.93 (ddd, *J* = 13.5, 10.0, 4.6 Hz, 1H), 1.85 (ddd, *J* = 13.5, 9.5, 6.6 Hz, 1H), 1.47 (s, 3H), 1.27 (s, 9H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 175.9, 171.0, 170.0, 131.4, 119.0, 69.3, 66.5, 50.8, 41.5, 31.9, 26.4, 19.8; IR (Neat Film, NaCl) 2980, 1763, 1734, 1273, 1235, 1195, 1137, 1116 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{14}H_{22}NO_5$ [M+H]$^+$: 284.1492, found 284.1493.

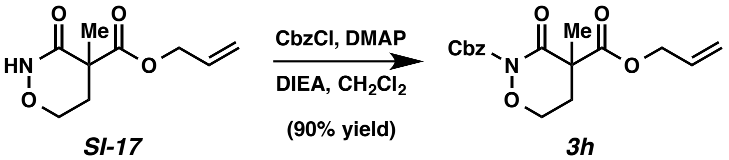


SI-17 **3f**

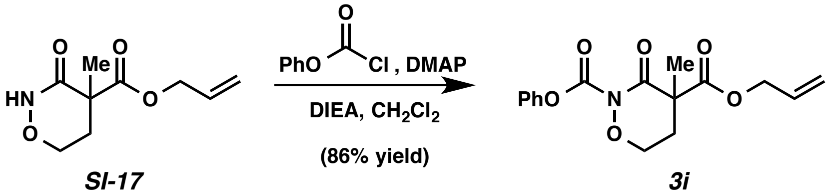
1,2-Oxazinan-3-one 3f. To a stirred solution of 1,2-oxazinan-3-one **SI-17** (200 mg, 1.00 mmol, 1 equiv) and K_2CO_3 (350 mg, 2.51 mmol, 2.5 equiv) in THF (5.0 mL) was added benzyl bromide (0.192 mL, 2.00 mmol, 2.0 equiv) at room temperature. The reaction mixture was warmed to 50 ºC, stirred for 24 h, and quenched with 1 M HCl. The phases were separated, and the aqueous phase was extracted with ethyl acetate twice. The combined organic layers were washed with saturated aqueous sodium bicarbonate and brine. The organic layers were dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 15→20% EtOAc in hexanes) afforded 1,2-oxazinan-3-one **3f** (246 mg, 0.850 mmol, 85% yield) as a colorless oil. R_f = 0.30 (25% EtOAc in hexanes); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.38–7.27 (m, 5H), 5.79 (m, 1H), 5.31–5.16 (m, 2H), 4.77 (s, 2H), 4.63–4.50 (m, 2H), 4.03 (m, 1H), 3.85 (ddd, *J* = 10.5, 9.3, 4.6 Hz, 1H), 2.81 (ddd, *J* = 13.7, 9.3, 4.6 Hz, 1H), 1.79 (ddd, *J* = 13.7, 9.3, 6.8 Hz, 1H), 1.49 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.7, 171.5, 135.8, 131.7, 128.6, 128.5, 127.9, 118.5, 68.4, 66.2, 49.8, 49.1, 33.6, 20.2; IR (Neat Film, NaCl) 2980, 1763, 1734, 1273, 1235, 1195, 1137, 1116 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{16}H_{20}NO_4$ $[M+H]^+$: 290.1387, found 290.1387.



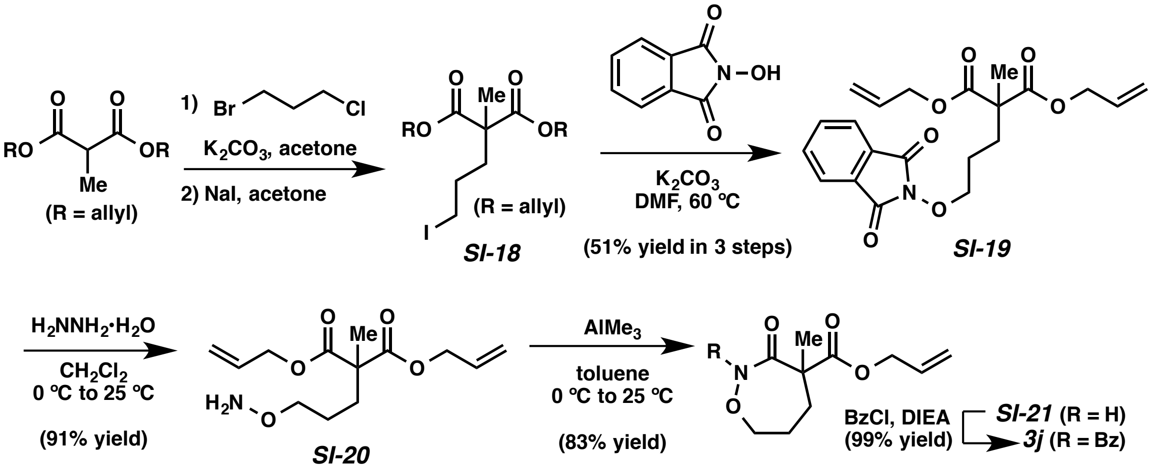
1,2-Oxazinan-3-one 3g. To a stirred solution of 1,2-oxazinan-3-one **SI-17** (150 mg, 0.753 mmol, 1 equiv) and DMAP (18.4 mg, 0.151 mmol, 0.20 equiv) in THF (3.7 mL) was added $(Boc)_2O$ (214 mg, 0.979 mmol, 1.3 equiv) at room temperature. After full consumption of the starting material as indicated by TLC analysis, the reaction mixture was concentrated in vacuo. Flash column chromatography (SiO_2, 15→20% EtOAc in hexanes) afforded 1,2-oxazinan-3-one **3g** (220 mg, 0.735 mmol, 98% yield) as a white solid. R_f = 0.44 (33% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.87 (ddt, *J* = 17.2, 10.5, 5.6 Hz, 1H), 5.30 (m, 1H), 5.23 (m, 1H), 4.69–4.58 (m, 2H), 4.24 (ddd, *J* = 10.9, 9.8, 6.7 Hz, 1H), 4.12 (ddd, *J* = 10.9, 9.5, 4.4 Hz, 1H), 2.91 (ddd, *J* = 13.5, 9.8, 4.4 Hz, 1H), 1.84 (ddd, *J* = 13.5, 9.5, 6.7 Hz, 1H), 1.56 (s, 9H), 1.47 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 170.8, 169.6, 148.2, 131.6, 118.7, 85.1, 69.1, 66.4, 51.4, 32.1, 28.2, 19.8; IR (Neat Film, NaCl) 2983, 1786, 1744, 1281, 1254, 1212, 1154, 1129 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{14}H_{21}NO_6Na$ $[M+Na]^+$: 322.1261, found 322.1248.



1,2-Oxazinan-3-one 3h. To a stirred solution of 1,2-oxazinan-3-one **SI-17** (200 mg, 1.00 mmol, 1 equiv), DMAP (12.0 mg, 0.100 mmol, 0.10 equiv) and DIEA (0.435 mL, 2.51 mmol, 2.5 equiv) in CH_2Cl_2 (5.0 mL) was added benzyl chloroformate (0.184 mL, 1.31 mmol, 1.3 equiv) at 0 ºC. The reaction mixture was warmed to room temperature, stirred for 3 h, and poured into a stirred mixture of 1 M HCl and diethyl ether. The phases were separated and the aqueous phase was extracted with ethyl acetate twice. The combined organic layers were washed with saturated aqueous sodium bicarbonate and brine. The organic layers were dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 20→30% EtOAc in hexanes) afforded 1,2-oxazinan-3-one **3h** (300 mg, 0.899 mmol, 90% yield) as a colorless oil. $R_f = 0.80$ (50% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.45–7.32 (m, 5H), 5.85 (ddt, *J* = 17.3, 10.5, 5.7 Hz, 1H), 5.38–5.18 (m, 4H), 4.68–4.58 (m, 2H), 4.26 (ddd, *J* = 10.9, 9.8, 6.8 Hz, 1H), 4.14 (ddd, *J* = 10.9, 9.5, 4.4 Hz, 1H), 2.92 (ddd, *J* = 13.6, 9.8, 4.4 Hz, 1H), 1.84 (ddd, *J* = 13.6, 9.5, 6.8 Hz, 1H), 1.48 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 170.5, 169.4, 149.7, 134.9, 131.4, 128.8, 128.7, 128.4, 118.9, 69.4, 69.2, 66.5, 51.4, 31.9, 19.8; IR (Neat Film, NaCl) 2946, 1789, 1340, 1456, 1380, 1270, 1212, 1149, 1129, 978, 939, 753 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{17}H_{20}NO_6$ $[M+H]^+$: 334.1285, found 334.1276.



1,2-Oxazinan-3-one 3i. To a stirred solution of 1,2-oxazinan-3-one **SI-17** (200 mg, 1.00 mmol, 1 equiv), DMAP (12.0 mg, 0.100 mmol, 0.10 equiv) and DIEA (0.435 mL, 2.51 mmol, 2.5 equiv) in CH_2Cl_2 (5.0 mL) was added phenyl chloroformate (0.164 mL, 1.31 mmol, 1.3 equiv) at 0 ºC. The reaction mixture was warmed to room temperature, stirred for 3 h, and poured into a stirred mixture of 1 M HCl and diethyl ether. The phases were separated and the aqueous phase was extracted with ethyl acetate twice. The combined organic layers were washed with saturated aqueous sodium bicarbonate and brine. The organic layers were dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 15→20% EtOAc in hexanes) afforded 1,2-oxazinan-3-one **3i** (276 mg, 0.864 mmol, 86% yield) as a white solid. R_f = 0.22 (25% EtOAc in hexanes); m.p. 98.0–98.3 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.43–7.38 (m, 2H), 7.29–7.20 (m, 3H), 5.91 (ddt, *J* = 17.2, 10.5, 5.7 Hz, 1H), 5.35 (m, 1H), 5.26 (m, 1H), 4.74–4.64 (m, 2H), 4.38–4.26 (m, 2H), 2.99 (ddd, *J* = 13.7, 9.7, 4.4 Hz, 1H), 1.94 (ddd, *J* = 13.7, 9.5, 6.9 Hz, 1H), 1.54 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 170.4, 169.3, 150.3, 148.0, 131.4, 129.7, 126.5, 121.4, 119.0, 69.6, 66.6, 51.5, 31.9, 19.8; IR (Neat Film, NaCl) 1797, 1757, 1739, 1294, 1268, 1218, 1187, 1163, 1145, 935, 745 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{16}H_{18}NO_6$ $[M+H]^+$: 320.1129, found 320.1120.



Malonate SI-19. To a stirred suspension of K_2CO_3 (4.40 g, 31.8 mmol, 2.0 equiv) and diallyl 2-methylmalonate (3.15 g, 15.9 mmol, 1 equiv) in acetone (32 mL) was added 1-bromo-3-chloropropane (2.36 mL, 23.8 mmol, 1.5 equiv) at room temperature. The reaction mixture was stirred at 70 °C for 24 h, filtered, and concentrated in vacuo. The residue was used for the next reaction without further purification.

To a solution of the crude alkyl chloride in acetone (45 mL) was added sodium iodide (4.77 g, 31.8 mmol, 2.0 equiv) at room temperature. The reaction mixture was stirred at 70 °C for 24 h, diluted with ether, filtered, and concentrated in vacuo.

To a solution of the crude malonate **SI-18** and *N*-hydroxyphthalimide (2.13 g, 13.1 mmol) in DMF (30 mL) was added K_2CO_3 (2.11 g, 15.3 mmol) at room temperature.

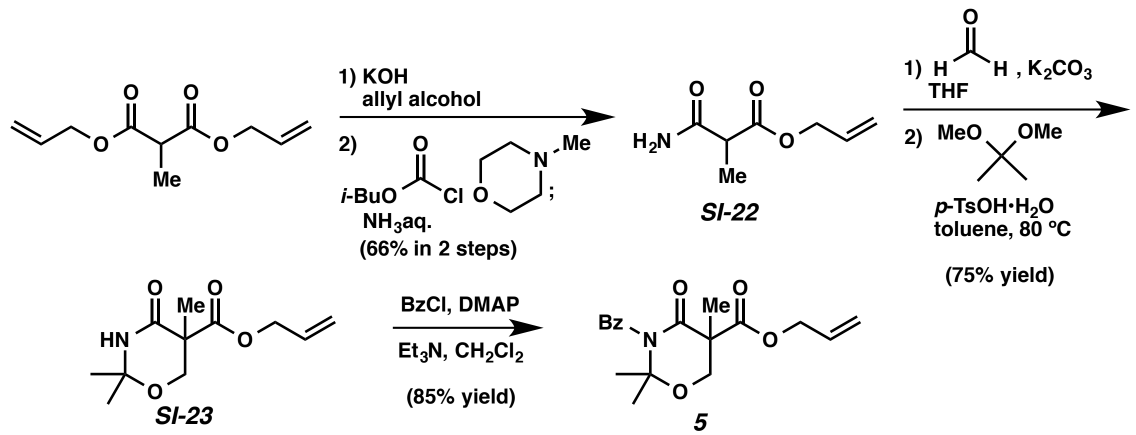
The reaction mixture was warmed to 60 ºC and stirred for 6 h. After full consumption of the starting material as indicated by TLC analysis, the reaction mixture was diluted with ethyl acetate (100 mL) and washed with 1 M HCl, saturated aqueous sodium bicarbonate and brine. The organic layers were dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 15→25% EtOAc in hexanes) afforded malonate **SI-19** (3.27 g, 8.15 mmol, 51% yield in 3 steps) as a colorless oil. R_f = 0.19 (20% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.86–7.81 (m, 2H), 7.77–7.72 (m, 2H), 5.93–5.84 (m, 2H), 5.34–5.28 (m, 2H), 5.24–5.20 (m, 2H), 4.67–4.59 (m, 4H), 4.20 (t, *J* = 6.5 Hz, 2H), 2.14–2.10 (m, 2H), 1.83–1.76 (m, 2H), 1.49 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 171.7, 163.6, 134.5, 131.8, 129.2, 123.6, 118.6, 78.4, 66.0, 53.7, 32.1, 23.7, 20.3; IR (Neat Film, NaCl) 2946, 1790, 1731, 1467, 1375, 1230, 1188, 1124, 981 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{21}H_{24}NO_7$ $[M+H]^+$: 402.1547, found 402.1536.

Alkoxyamine SI-20. To a stirred solution of malonate **SI-19** (3.15 g, 7.85 mmol, 1 equiv) in CH_2Cl_2 (35 mL) was added hydrazine monohydrate (0.438 mL, 9.02 mmol, 1.15 equiv) at 0 ºC. The reaction mixture was warmed to room temperature, stirred for 7 h and filtered. The filtrate was concentrated in vacuo. Flash column chromatography (SiO_2, 20→40% EtOAc in hexanes) afforded alkoxyamine **SI-20** (1.93 g, 7.11 mmol, 91% yield) as a colorless oil. R_f = 0.38 (33% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.92–5.83 (m, 2H), 5.33–5.28 (m, 2H), 5.22 (dq, *J* = 10.5, 1.4 Hz, 2H), 4.63–4.60 (m, 4H), 3.65 (t, *J* = 6.3 Hz, 2H), 1.96–1.91 (m, 2H), 1.59–1.52 (m, 2H), 1.45 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 171.8, 131.9, 118.4, 75.5, 65.8, 53.7, 32.3, 23.5, 20.1; IR (Neat Film, NaCl) 2944, 1732, 1463, 1382, 1272, 1230, 1190, 1119, 984, 935 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{13}H_{22}NO_5$ $[M+H]^+$: 272.1492, found 272.1488.

1,2-Oxazepan-3-one SI-21. To a stirred solution of alkoxyamine **SI-20** (1.35 g, 4.92 mmol, 1 equiv) in toluene (25 mL) was added trimethylaluminum (4.92 mL, 2.0 M solution in toluene, 9.85 mmol, 2.0 equiv) dropwise at 0 ºC. The reaction mixture was warmed to room temperature, stirred for 36 h, and poured into a stirred mixture of 1 M

HCl and diethyl ether. The phases were separated and the aqueous phase was extracted with ethyl acetate twice. The combined organic layers were washed with brine, dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 20→30% EtOAc in hexanes) afforded 1,2-oxazepan-3-one **SI-21** (874 mg, 4.10 mmol, 83% yield) as a white solid. R_f = 0.42 (33% EtOAc in hexanes); m.p. 79.2–80.6 ºC; ^1H NMR (500 MHz, $CDCl_3$) δ 8.18 (s, 1H), 5.89 (ddt, *J* = 17.2, 10.6, 5.6 Hz, 1H), 5.32 (m, 1H), 5.22 (m, 1H), 4.69–4.61 (m, 2H), 4.16 (m, 1H), 3.82 (ddd, *J* = 11.9, 10.3, 3.4 Hz, 1H), 2.34–2.22 (m, 2H), 1.82–1.64 (m, 2H), 1.46 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 176.4, 172.0, 132.0, 118.3, 76.4, 65.8, 51.9, 31.8, 25.5, 24.1; IR (Neat Film, NaCl) 3184, 3065, 1733, 1662, 1451, 1258, 1217, 1140, 1084, 970, 920 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{10}H_{16}NO_4$ $[M+H]^+$: 214.1074, found 214.1070.

1,2-Oxazepan-3-one 3j. To a stirred solution of 1,2-oxazepan-3-one **SI-21** (300 mg, 1.41 mmol, 1 equiv), DMAP (17.0 mg, 0.141 mmol, 0.10 equiv) and DIEA (0.614 mL, 3.53 mmol, 2.5 equiv) in CH_2Cl_2 (7.0 mL) was added benzoyl chloride (0.197 mL, 1.69 mmol, 1.2 equiv) at 0 ºC. The reaction mixture was stirred at 0 ºC for 1 h, poured into a stirred mixture of 1 M HCl and diethyl ether. The phases were separated and the aqueous phase was extracted with ethyl acetate twice. The combined organic layers were washed with saturated aqueous sodium bicarbonate and brine. The organic layers were dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 20% EtOAc in hexanes) afforded 1,2-oxazepan-3-one **3j** (443 mg, 1.40 mmol, 99% yield) as a colorless oil. R_f = 0.50 (33% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 7.65–7.61 (m, 2H), 7.53 (m, 1H), 7.44–7.40 (m, 2H), 5.96 (ddt, *J* = 17.4, 10.4, 5.9 Hz, 1H), 5.38 (m, 1H), 5.28 (m, 1H), 4.76–4.67 (m, 2H), 4.31 (ddd, *J* = 12.0, 7.3, 4.8 Hz, 1H), 4.20 (ddd, *J* = 12.0, 7.1, 4.3 Hz, 1H), 2.50 (ddd, *J* = 14.5, 8.5, 4.8 Hz, 1H), 2.20 (m, 1H), 1.85 (m, 1H), 1.62 (ddd, *J* = 14.5, 7.8, 4.6 Hz, 1H), 1.44 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 172.5, 171.6, 168.3, 134.2, 132.4, 131.9, 128.7, 128.2, 119.1, 76.4, 66.3, 53.7, 31.2, 24.5, 23.9; IR (Neat Film, NaCl) 2940, 1722, 1704, 1449, 1261, 1226, 1212, 1138, 993, 928 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{17}H_{20}NO_5$ $[M+H]^+$: 318.1336, found 318.1339.



Amide SI-22. To a solution of diallyl 2-methylmalonate (2.00 g, 10.1 mmol, 1 equiv) in allyl alcohol (10 mL) was added a solution of KOH (623 mg, 11.1 mmol, 1.1 equiv) in allyl alcohol (10 mL) at room temperature. After full consumption of the starting material as indicated by TLC analysis, the reaction mixture was queched with 1 M HCl and the aqueous phase was extracted with CH_2Cl_2 three times. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated in vacuo. The residue was used for the next reaction without further purification.

To a solution of the crude acid in diethyl ether (30 mL) was added *N*-methylmorpholine (1.17 mL, 10.6 mmol, 1.05 equiv) and isobutyl chloroformate (1.45 mL, 10.6 mmol, 1.05 equiv) at 0 °C. After stirring at 0 °C for 10 min, the reaction mixture was filtered and the filtrate was poured into a stirred solution of aqueous ammonia (2.2 mL, 26 wt%, 30.3 mmol, 3.0 equiv) in THF (10 mL) at 0 °C. After 10 min, the reaction mixture was diluted with CH_2Cl_2 and the phases were separated. The aqueous phase was extracted with CH_2Cl_2 three times. The combined organic layers were washed with brine, dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 40→60% EtOAc in hexanes) afforded amide **SI-22** (1.05 g, 6.68 mmol, 60% yield in 2 steps) as a white solid. $R_f = 0.23$ (50% EtOAc in hexanes); m.p. 53.9–54.3 °C; ^1H NMR (500 MHz, $CDCl_3$) δ 5.91 (ddt, $J = 17.3, 10.5, 5.8$ Hz, 1H), 5.38–5.22 (m, 2H), 4.67–4.60 (m, 2H), 3.36 (q, $J = 7.3$ Hz, 1H), 1.47 (d, $J = 7.3$ Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 171.9, 171.3, 131.5, 119.1, 66.3, 46.7, 15.1; IR (Neat Film, NaCl) 3425, 3332, 3198, 1735, 1672, 1615, 1456, 1397, 1260, 1185, 1096, 932 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_7H_{12}NO_3$ $[M+H]^+$: 158.0812, found 158.0814.

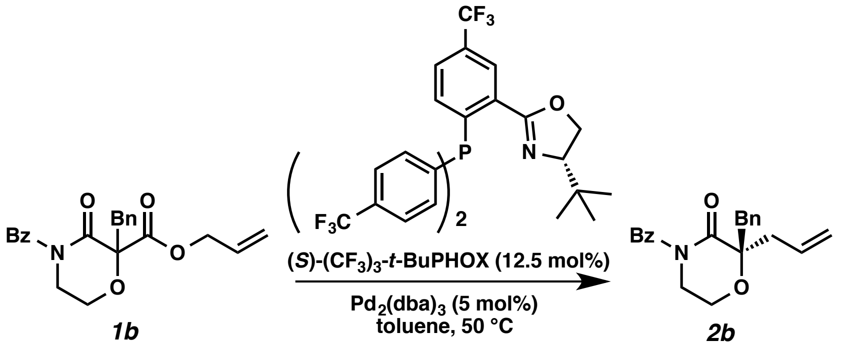
1,3-Oxazinan-4-one SI-23. To a solution of amide **SI-22** (455 mg, 2.89 mmol, 1 equiv) in THF (6 mL) was added K_2CO_3 (79.9 mg, 0.578 mmol, 0.20 equiv) and formaldehyde (0.352 mL, 37% aqueous solution, 4.34 mmol, 1.5 equiv) at room temperature. After full consumption of the starting material as indicated by TLC analysis, the reaction mixture was diluted with ethyl acetate (50 mL), dried over Na_2SO_4, filtered, and concentrated in vacuo. The residue was used for the next reaction without further purification.

To a solution of the crude alcohol in toluene (9 mL) added 2,2-dimethoxypropane (3.5 mL, 28.9 mmol, 10 equiv) and *p*-toluenesulfonic acid monohydrate (27.6 mg, 0.145 mmol, 0.05 equiv) at room temperature. After stirring at 80 ºC for 12 h, the reaction mixture was diluted with ethyl acetate (30 mL), washed with saturated aqueous sodium bicarbonate and brine, dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 50% EtOAc in hexanes) afforded 1,3-oxazinan-4-one **SI-23** (494 mg, 2.17 mmol, 75% yield in 2 steps) as a white solid. R_f = 0.54 (66% EtOAc in hexanes); m.p. 30.6–31.2 ºC; ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.90 (s, 1H), 5.90 (ddt, *J* = 17.3, 10.5, 5.6 Hz, 1H), 5.38–5.18 (m, 2H), 4.73–4.59 (m, 2H), 4.23 (d, *J* = 11.7 Hz, 1H), 3.76 (d, *J* = 11.7 Hz, 1H), 1.48 (s, 3H), 1.45 (s, 3H), 1.44 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 171.4, 169.0, 131.7, 118.6, 86.2, 67.2, 66.3, 50.9, 29.1, 27.7, 17.7; IR (Neat Film, NaCl) 3198, 1735, 1672, 1412, 1370, 1245, 1201, 1127, 1082 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{11}H_{18}NO_4$ $[M+H]^+$: 228.1230, found 228.1232.

1,3-Oxazinan-4-one 5. To a stirred solution of 1,3-oxazinan-4-one **SI-23** (366 mg, 1.61 mmol, 1 equiv), DMAP (19.7 mg, 0.161 mmol, 0.10 equiv) and Et_3N (0.561 mL, 4.03 mmol, 2.5 equiv) in CH_2Cl_2 (8.0 mL) was added benzoyl chloride (0.224 mL, 1.61 mmol, 1.2 equiv) at 0 ºC. The reaction mixture was warmed to room temperature, stirred for 48 h, and diluted with diethyl ether (50 mL). The organic layers were washed with 1 M HCl, saturated aqueous sodium bicarbonate and brine, dried over Na_2SO_4, filtered, and concentrated in vacuo. Flash column chromatography (SiO_2, 10% EtOAc in hexanes) afforded 1,3-oxazinan-4-one **5** (455 mg, 1.37 mmol, 85% yield) as a white solid. R_f = 0.40 (25% EtOAc in hexanes); m.p. 67.0–67.4 ºC; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.88–

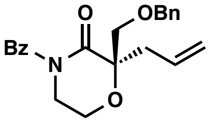
7.82 (m, 2H), 7.53 (m, 1H), 7.45–7.37 (m, 2H), 5.98 (ddt, *J* = 17.2, 10.4, 5.8 Hz, 1H), 5.44–5.28 (m, 2H), 4.81–4.67 (m, 2H), 4.40 (d, *J* = 12.1 Hz, 1H), 3.96 (d, *J* = 12.1 Hz, 1H), 1.84 (s, 3H), 1.69 (s, 3H), 1.47 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 175.2, 171.1, 170.3, 136.0, 132.8, 131.5, 128.6, 128.6, 119.4, 93.1, 66.8, 66.7, 52.2, 27.3, 26.8, 18.1; IR (Neat Film, NaCl) 2988, 2940, 1738, 1701, 1685, 1450, 1389, 1322, 1263, 1247, 1163, 1141, 1084, 978, 816, 718 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{18}H_{22}NO_5$ $[M+H]^+$: 332.1492, found 332.1485.

General Procedure for Palladium-Catalyzed Allylic Alkylation



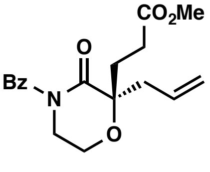
In a nitrogen-filled glove box, $Pd_2(dba)_3$ (4.6 mg, 0.005 mmol, 5 mol%) and (*S*)-$(CF_3)_3$-*t*-BuPHOX (7.4 mg, 0.0125 mmol, 12.5 mol%) were added to a 20 mL scintillation vial equipped with a magnetic stirring bar. The vial was then charged with toluene (2.0 mL) and stirred at 25 °C for 30 min, generating a yellow solution. To the above preformed catalyst solution was added a solution of **1b** (37.9 mg, 0.10 mmol, 1 equiv) in toluene (1.0 mL). The vial was sealed and stirred at 50 °C until **1b** was fully consumed by TLC analysis. The reaction mixture was concentrated in vacuo. Flash column chromatography (SiO_2, 10% EtOAc in hexanes) afforded morpholinone **2b** (31.8 mg, 94.8 mmol, 95% yield) as a colorless oil. 99% ee, $[\alpha]_D^{25}$ +85.9 (*c* 1.15, $CHCl_3$); R_f = 0.63 (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.50 (m, 1H), 7.42–7.34 (m, 3H), 7.34–7.23 (m, 6H), 5.94 (ddt, *J* = 16.9, 10.3, 7.2 Hz, 1H), 5.25–5.16 (m, 2H), 4.01 (ddd, *J* = 12.2, 7.0, 3.1 Hz, 1H), 3.85 (ddd, *J* = 12.2, 6.3, 3.2 Hz, 1H), 3.77 (ddd, *J* = 13.0, 6.3, 3.1 Hz, 1H), 3.50 (ddd, *J* = 13.0, 7.0, 3.2 Hz, 1H), 3.21 (d, *J* = 13.7 Hz, 1H), 2.93 (d, *J* = 13.7 Hz, 1H), 2.75 (m, 1H), 2.45 (m, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.0, 172.7, 136.1, 135.9, 132.3, 131.8, 131.0, 128.3, 128.1, 128.0, 127.2, 119.7, 83.7, 60.8, 45.1, 43.7, 43.2; IR (Neat Film, NaCl) 3062, 3029, 2976, 2927, 1686, 1462, 1448 1369, 1300, 1282, 1220, 1091, 1023, 923, 726, 700 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{21}H_{22}NO_3$ $[M+H]^+$: 336.1594, found 336.1594; SFC conditions: 10% MeOH, 3.0 mL/min, Chiralpak AD-H column, λ = 254 nm, t_R (min): major = 3.67, minor = 5.93.

Spectroscopic Data for alkylation products



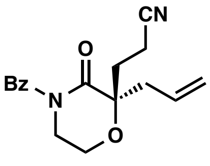
2c

Morpholinone 2c. Flash column chromatography (SiO_2, 15% EtOAc in hexanes) afforded morpholinone **2c** (80% yield) as a colorless oil. 99% ee, $[\alpha]_D^{25}$ –22.4 (*c* 1.37, $CHCl_3$); R_f = 0.42 (33% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 7.64–7.57 (m, 2H), 7.46 (m, 1H), 7.40–7.26 (m, 7H), 5.85 (ddt, *J* = 16.8, 10.4, 7.2 Hz, 1H), 5.19–5.10 (m, 2H), 4.62 (d, *J* = 12.0 Hz, 1H), 4.57 (d, *J* = 12.0 Hz, 1H), 4.44 (ddd, *J* = 12.1, 7.2, 4.0 Hz, 1H), 4.07 (ddd, *J* = 12.1, 5.1, 3.6 Hz, 1H), 4.00 – 3.90 (m, 2H), 3.89 (d, *J* = 9.5 Hz, 1H), 3.63 (d, *J* = 9.5 Hz, 1H), 2.58 (m, 1H), 2.38 (m, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.3, 172.1, 137.8, 135.6, 131.9, 131.7, 128.6, 128.4, 128.1, 127.9, 127.7, 119.7, 82.9, 77.6, 74.1, 62.0, 45.6, 40.1; IR (Neat Film, NaCl) 3062, 3029, 3894, 3863, 1686, 1462, 1449, 1371, 1325, 1283, 1226, 1116, 1088, 923, 728, 696 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{22}H_{24}NO_4$ $[M+H]^+$: 366.1700, found 366.1703; SFC conditions: 5% MeOH, 3.0 mL/min, Chiralpak AD-H column, λ = 254 nm, t_R (min): major = 5.91, minor = 6.73.



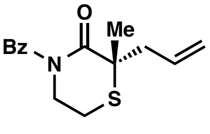
2d

Morpholinone 2d. Flash column chromatography (SiO_2, 20→25% EtOAc in hexanes) afforded morpholinone **2d** (60% yield) as a colorless oil. 99% ee, $[\alpha]_D^{25}$ +24.6 (*c* 1.15, $CHCl_3$); R_f = 0.25 (25% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 7.59–7.46 (m, 3H), 7.44–7.36 (m, 2H), 5.86 (ddt, *J* = 16.9, 10.4, 7.2 Hz, 1H), 5.24–5.14 (m, 2H), 4.08 (ddd, *J* = 12.4, 7.0, 3.6 Hz, 1H), 4.02 (ddd, *J* = 12.4, 6.0, 3.5 Hz, 1H), 3.95 (ddd, *J* = 13.0, 7.0, 3.4 Hz, 1H), 3.89 (ddd, *J* = 13.0, 6.0, 3.6 Hz, 1H), 3.67 (s, 3H), 2.69 (m, 1H), 2.56–2.41 (m, 2H), 2.37 (ddd, *J* = 15.7, 9.4, 5.9 Hz, 1H), 2.29 (ddd, *J* = 14.3, 9.5, 5.9 Hz, 1H), 2.15–2.02 (m, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.6, 173.3, 173.0, 135.8, 132.0, 131.8, 128.3, 127.9, 119.8, 81.8, 59.8, 51.9, 45.6, 41.0, 31.7, 28.6; IR (Neat Film, NaCl) 2951, 1737, 1687, 1438, 1369, 1283, 1226, 1124, 924 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{18}H_{22}NO_5$ $[M+H]^+$: 332.1492, found 332.1494; SFC conditions: 5% MeOH, 3.0 mL/min, Chiralcel OD-H column, $\lambda = 254$ nm, t_R (min): major = 6.16, minor = 5.66.



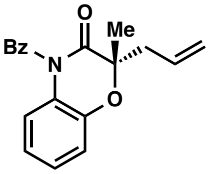
2e

Morpholinone 2e. Flash column chromatography (SiO_2, 20→25% EtOAc in hexanes) afforded morpholinone **2e** (84% yield) as a colorless oil. 99% ee, $[\alpha]_D^{25}$ +38.5 (*c* 1.24, $CHCl_3$); $R_f = 0.23$ (25% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 7.63–7.48 (m, 3H), 7.48–7.35 (m, 2H), 5.84 (ddt, *J* = 17.3, 10.2, 7.2 Hz, 1H), 5.29–5.18 (m, 2H), 4.18 (ddd, *J* = 12.9, 8.2, 3.3 Hz, 1H), 4.08–3.84 (m, 3H), 2.76 (m, 1H), 2.58–2.43 (m, 2H), 2.38 (ddd, *J* = 16.7, 9.3, 6.2 Hz, 1H), 2.28 (ddd, *J* = 14.2, 9.3, 6.2 Hz, 1H), 2.07 (ddd, *J* = 14.2, 9.3, 5.9 Hz, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.1, 172.3, 135.5, 132.2, 131.0, 128.4, 128.0, 120.5, 119.3, 80.9, 59.8, 45.6, 40.8, 32.1, 12.1; IR (Neat Film, NaCl) 3075, 2928, 2247, 1687, 1370, 1283, 1229, 1128, 1091, 926, 727, 696 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{17}H_{19}N_2O_3$ $[M+H]^+$: 299.1390, found 299.1383; SFC conditions: 3% MeOH, 2.5 mL/min, Chiralpak AS-H column, $\lambda = 254$ nm, t_R (min): major = 5.79, minor = 6.53.



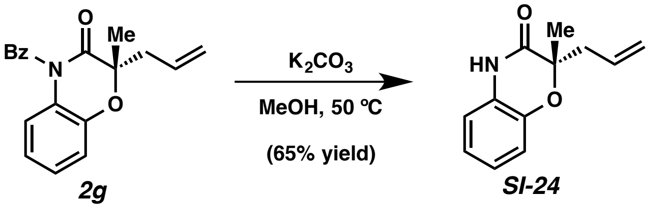
2f

Thiomorpholinone 2f. Flash column chromatography (SiO_2, 12→15% EtOAc in hexanes) afforded thiomorpholinone **2f** (79% yield) as a colorless oil. 86% ee, $[\alpha]_D^{25}$ –45.8 (*c* 1.35, $CHCl_3$); $R_f = 0.48$ (25% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 7.58–7.45 (m, 3H), 7.45–7.36 (m, 2H), 5.86 (dddd, *J* = 16.6, 10.4, 7.5, 6.8 Hz, 1H), 5.23–5.14 (m, 2H), 4.30–4.16 (m, 2H), 3.11–2.98 (m, 2H), 2.81 (m, 1H), 2.58 (m, 1H), 1.58 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 175.7, 175.5, 136.1, 132.3, 131.8, 128.5, 127.5, 119.7, 50.4, 48.9, 43.5, 25.6, 23.9; IR (Neat Film, NaCl) 3075, 2977, 2931, 2359, 1683, 1448, 1382, 1305, 1280, 1214, 1139, 986, 922, 725, 693, 666 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{15}H_{18}NO_2S$ $[M+H]^+$: 276.1053, found 276.1051; SFC conditions: 5% MeOH, 3.0 mL/min, Chiralcel OJ-H column, λ = 254 nm, t_R (min): major = 6.80, minor = 5.74.



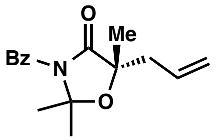
2g

Benzomorpholinone 2g. Flash column chromatography (SiO_2, 5% EtOAc in hexanes) afforded benzomorpholinone **2g** (76% yield) as a colorless oil. $[\alpha]_D^{25}$ –10.4 (*c* 0.27, $CHCl_3$); R_f = 0.31 (10% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.90–7.87 (m, 2H), 7.62 (m, 1H), 7.49–7.45 (m, 2H), 7.07 (m, 1H), 7.06 (d, *J* = 1.1 Hz, 1H), 6.96–6.88 (m, 2H), 5.89 (m, 1H), 5.22–5.14 (m, 2H), 2.76 (ddt, *J* = 14.3, 6.8, 1.3 Hz, 1H), 2.55 (ddt, *J* = 14.3, 7.6, 1.2 Hz, 1H), 1.56 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 171.8, 168.6, 143.0, 134.6, 133.4, 131.3, 130.3, 129.2, 127.4, 125.5, 122.8, 120.0, 118.5, 116.8, 80.3, 40.4, 21.5; IR (Neat Film, NaCl) 1723, 1695, 1498, 1353, 1282, 1258, 750 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{19}H_{18}NO_3$ $[M+H]^+$: 308.1281, found 308.1275.



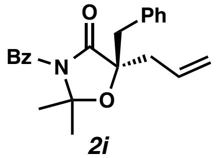
Benzomorpholinone SI-24. To a solution of **2g** (13.1 mg, 42.6 μmol, 1 equiv) in MeOH (2 mL) was added K_2CO_3 (7.1 mg, 51 μmol, 1.2 equiv) at room temperature. After stirring at 50 ºC for 8 h, the reaction mixture was filtered and the filtrate was concentrated in vacuo. Flash column chromatography (SiO_2, 20% EtOAc in hexanes) afforded benzomorpholinone **SI-24** (5.6 mg, 27.6 μmol, 65% yield) as a white solid. 95% ee, $[\alpha]_D^{25}$ –15.2 (*c* 0.21, $CHCl_3$); R_f = 0.36 (20% EtOAc in hexanes); ^{1}H NMR (500 MHz,

$CDCl_3$) δ 8.13 (s, 1H), 7.00–6.91 (m, 3H), 6.76 (m, 1H), 5.87 (dddd, *J* = 16.5, 10.8, 7.6, 6.7 Hz, 1H), 5.16–5.11 (m, 2H), 2.69 (m, 1H), 2.49 (ddt, *J* = 14.3, 7.7, 1.2 Hz, 1H), 1.52 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 169.3, 142.6, 131.7, 126.7, 124.3, 122.4, 119.5, 117.7, 115.1, 80.5, 41.0, 21.8; IR (Neat Film, NaCl) 3206, 3077, 2982, 2919, 1687, 1611, 1502, 1379, 1279, 750 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{12}H_{14}NO_2$ $[M+H]^+$: 204.1019, found 204.1016; SFC conditions: 5% IPA, 3.0 mL/min, Chiralcel OJ-H column, λ = 210 nm, t_R (min): major = 4.18, minor = 4.64.



2h

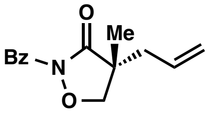
Oxazolidinone 2h. Flash column chromatography (SiO_2, 7→10% EtOAc in hexanes) afforded oxazolidinone **2h** (82% yield) as a colorless oil. 96% ee, $[\alpha]_D^{25}$ +68.2 (*c* 1.05, $CHCl_3$); R_f = 0.47 (15% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.58–7.52 (m, 3H), 7.41 (ddt, *J* = 7.8, 6.6, 1.1 Hz, 2H), 5.94 (m, 1H), 5.29–5.20 (m, 2H), 2.54–2.44 (m, 2H), 1.83 (s, 3H), 1.76 (s, 3H), 1.46 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.4, 169.6, 134.7, 132.4, 132.4, 128.8, 128.1, 119.8, 95.1, 81.1, 43.7, 29.2, 27.7, 25.1; IR (Neat Film, NaCl) 2985, 1753, 1689, 1371, 1336, 1304, 1284, 1210, 1181, 997 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{16}H_{20}NO_3$ $[M+H]^+$: 274.1438, found 274.1434; SFC conditions: 2% IPA, 3.0 mL/min, Chiralcel OJ-H column, λ = 254 nm, t_R (min): major = 5.59, minor = 3.96.



2i

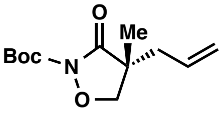
Oxazolidinone 2i. Flash column chromatography (SiO_2, 5→7% EtOAc in hexanes) afforded oxazolidinone **2i** (75% yield) as a colorless oil. 92% ee, $[\alpha]_D^{25}$ +46.9 (*c* 1.03, $CHCl_3$); R_f = 0.35 (10% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.52 (m, 1H), 7.40–7.29 (m, 7H), 7.24–7.20 (m, 2H), 5.98 (m, 1H), 5.30–5.22 (m, 2H), 3.04 (d, *J* = 14.4 Hz, 1H), 3.01 (d, *J* = 14.4 Hz, 1H), 2.63–2.50 (m, 2H), 1.82 (s, 3H), 1.45 (s, 3H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 173.2, 169.6, 135.7, 134.7, 132.3, 132.0, 131.5, 128.7, 128.2, 128.0, 127.3, 120.0, 95.5, 84.4, 43.0, 42.9, 29.1, 27.6; IR (Neat Film, NaCl) 1750, 1688, 1346, 1303, 1282 1125, 922 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{22}H_{24}NO_3$ $[M+H]^+$: 350.1751, found 350.1751; SFC conditions: 5% MeOH, 3.0 mL/min, Chiralcel OJ-H column, λ = 254 nm, t_R (min): major = 3.51, minor = 4.44.



4a

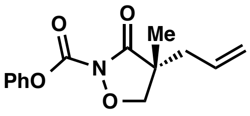
Isoxazolidinone 4a. Flash column chromatography (SiO_2, 15→20% EtOAc in hexanes) afforded isoxazolidinone **4a** (95% yield) as a colorless oil. 73% ee, $[\alpha]_D^{25}$ –33.5 (*c* 1.05, $CHCl_3$); R_f = 0.34 (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.73–7.70 (m, 2H), 7.57 (m, 1H), 7.47–7.42 (m, 2H), 5.79 (ddt, *J* = 16.8, 10.2, 7.4 Hz, 1H), 5.24–5.17 (m, 2H), 4.40 (d, *J* = 8.7 Hz, 1H), 4.16 (d, *J* = 8.7 Hz, 1H), 2.48 (m, 1H), 2.38 (m, 1H), 1.33 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.0, 164.0, 133.0, 132.2, 131.7, 129.8, 128.1, 120.3, 76.7, 47.5, 39.4, 19.7; IR (Neat Film, NaCl) 1758, 1696, 1449, 1276, 1230, 1144, 993 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{14}H_{16}NO_3$ $[M+H]^+$: 246.1125, found 246.1116; SFC conditions: 5% MeOH, 3.0 mL/min, Chiralcel OJ-H column, λ = 254 nm, t_R (min): major = 8.07, minor = 5.70.



4b

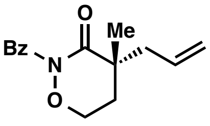
Isoxazolidinone 4b. Flash column chromatography (SiO_2, 10→15% EtOAc in hexanes) afforded isoxazolidinone **4b** (98% yield) as a colorless oil. 72% ee, $[\alpha]_D^{25}$ –27.7 (*c* 1.10, $CHCl_3$); R_f = 0.38 (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.75 (m, 1H), 5.20–5.14 (m, 2H), 4.25 (d, *J* = 8.6 Hz, 1H), 4.01 (d, *J* = 8.6 Hz, 1H), 2.45–2.33 (m, 2H), 1.57 (s, 9H), 1.27 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 171.6, 146.6, 131.9, 120.0, 85.2, 76.7, 47.2, 39.2, 28.2, 19.5; IR (Neat Film, NaCl) 2981, 1785, 1747, 1370, 1305, 1256, 1157, 1106, 990 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{12}H_{23}N_2O_4$ $[M+NH_4]^+$:

259.1652, found 259.1641; SFC conditions: 2% MeOH, 3.0 mL/min, Chiralcel OJ-H column, λ = 210 nm, *t*R (min): major = 3.54, minor = 3.89.

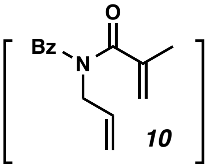


4c

Isoxazolidinone 4c. Flash column chromatography (SiO_2, 15→20% EtOAc in hexanes) afforded isoxazolidinone **4c** (95% yield) as a colorless oil. 73% ee, $[\alpha]_D^{25}$ –28.4 (*c* 1.14, $CHCl_3$); R_f = 0.32 (25% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 7.43–7.38 (m, 2H), 7.30–7.21 (m, 3H), 5.80 (ddt, *J* = 16.6, 10.4, 7.4 Hz, 1H), 5.25–5.19 (m, 2H), 4.38 (d, *J* = 8.7 Hz, 1H), 4.15 (d, *J* = 8.7 Hz, 1H), 2.53–2.40 (m, 2H), 1.36 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 171.7, 150.2, 146.2, 131.6, 129.7, 126.6, 121.4, 120.4, 77.2, 47.3, 39.3, 19.6; IR (Neat Film, NaCl) 1798, 1757, 1494, 1458, 1309, 1274, 1231, 1195, 1162, 1085, 982, 937, 746 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{14}H_{16}NO_4$ $[M+H]^+$: 262.1074, found 262.1062; SFC conditions: 5% MeOH, 3.0 mL/min, Chiralpak AD-H column, λ = 235 nm, *t*R (min): major = 6.88, minor = 8.08.



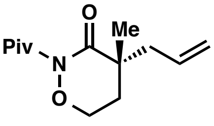
4d



10

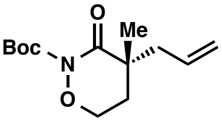
1,2-Oxazinan-3-one 4d. Flash column chromatography (SiO_2, 15→20% EtOAc in hexanes) afforded 1,2-oxazinan-3-one **4d** (29% yield) as a colorless oil and imide **10** (30% yield) as a colorless oil. 88% ee, $[\alpha]_D^{25}$ –25.8 (*c* 0.45, $CHCl_3$); R_f = 0.38 (20% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 7.64–7.50 (m, 3H), 7.44–7.39 (m, 2H), 5.81 (ddt, *J* = 16.7, 10.3, 7.4 Hz, 1H), 5.20–5.14 (m, 2H), 4.35 (t, *J* = 7.3 Hz, 2H), 2.53 (dt, *J* = 7.4, 1.2 Hz, 2H), 2.23 (dt, *J* = 13.8, 7.4 Hz, 1H), 1.94 (dt, *J* = 13.8, 7.1 Hz, 1H), 1.37 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 175.9, 167.9, 134.4, 133.2, 132.4, 129.0, 128.2, 119.5, 69.9, 43.7, 43.1, 33.3, 24.3; IR (Neat Film, NaCl) 1749, 1700, 1449, 1271, 1207, 1176, 1043, 921 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{15}H_{18}NO_3$ $[M+H]^+$: 260.1281, found 260.1275; SFC conditions: 10% IPA, 3.0 mL/min, Chiralcel OD-H column, λ = 254 nm, *t*R (min): major = 3.91, minor = 3.03.

Imide 10: ^{1}H NMR (500 MHz, CDCl$_3$) δ 7.52–7.43 (m, 3H), 7.42–7.35 (m, 2H), 5.97 (ddt, *J* = 17.2, 10.2, 6.2 Hz, 1H), 5.35–5.27 (m, 2H), 5.20 (dq, *J* = 10.2, 1.0 Hz, 1H), 5.13 (m, 1H), 4.52–4.46 (m, 2H), 1.63 (dd, *J* = 1.5, 1.0 Hz, 3H); ^{13}C NMR (126 MHz, CDCl$_3$) δ 174.6, 173.8, 143.4, 137.5, 132.5, 132.0, 128.8, 128.4, 122.2, 118.6, 48.5, 18.5; IR (Neat Film, NaCl) 1698, 1660, 1449, 1337, 1270, 1195, 1099, 930, 801, 706 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{14}H_{16}NO_2$ [M+H]$^+$: 230.1176, found 230.1165.



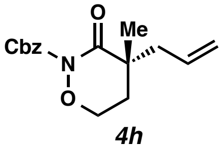
4e

1,2-Oxazinan-3-one 4e. Flash column chromatography (SiO$_2$, 10→15% EtOAc in hexanes) afforded 1,2-oxazinan-3-one **4e** (48% yield) as a colorless oil. 73% ee, $[\alpha]_D^{25}$ –26.3 (*c* 0.50, CHCl$_3$); R$_f$ = 0.29 (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, CDCl$_3$) δ 5.80 (m, 1H), 5.15–5.08 (m, 2H), 4.23–4.17 (m, 2H), 2.53–2.42 (m, 2H), 2.12 (ddd, *J* = 13.8, 8.1, 6.9 Hz, 1H), 1.86 (ddd, *J* = 13.8, 8.1, 6.8 Hz, 1H), 1.33 (s, 3H), 1.29 (s, 9H); ^{13}C NMR (126 MHz, CDCl$_3$) δ 176.7, 174.8, 133.5, 119.2, 69.3, 43.3, 43.0, 41.6, 32.5, 26.7, 24.3; IR (Neat Film, NaCl) 2975, 2935, 1753, 1708 1462, 1272, 1180, 1131, 917 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{13}H_{22}NO_3$ [M+H]$^+$: 240.1594, found 240.1591; SFC conditions: 5% IPA, 2.5 mL/min, Chiralpak AS-H column, λ = 210 nm, t_R (min): major = 7.10, minor = 6.65.



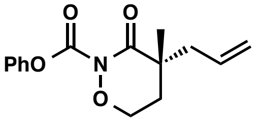
4g

1,2-Oxazinan-3-one 4g. Flash column chromatography (SiO$_2$, 10→12% EtOAc in hexanes) afforded 1,2-oxazinan-3-one **4g** (67% yield) as a colorless oil. 85% ee, $[\alpha]_D^{25}$ –25.4 (*c* 0.54, CHCl$_3$); R$_f$ = 0.47 (33% EtOAc in hexanes); ^{1}H NMR (500 MHz, CDCl$_3$) δ 5.80 (ddt, *J* = 16.8, 10.2, 7.4 Hz, 1H), 5.15–5.08 (m, 2H), 4.25–4.19 (m, 2H), 2.49–2.46 (m, 2H), 2.10 (ddd, *J* = 13.8, 8.4, 6.6 Hz, 1H), 1.86 (ddd, *J* = 13.8, 8.5, 6.7 Hz, 1H), 1.55 (s, 9H), 1.31 (s, 3H); ^{13}C NMR (126 MHz, CDCl$_3$) δ 174.3, 148.9, 133.5, 119.1, 84.5, 69.4, 43.7, 42.8, 32.7, 28.2, 24.0; IR (Neat Film, NaCl) 2979, 1744, 1775, 1370, 1281, 1255, 1217, 1156, 1124 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{13}H_{22}NO_4$ $[M+H]^+$: 256.1543, found 256.1536; SFC conditions: 1% IPA, 3.0 mL/min, Chiralcel OJ-H column, λ = 210 nm, t_R (min): major = 3.82, minor = 3.31.



4h

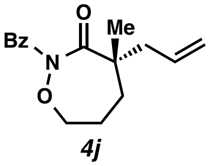
1,2-Oxazinan-3-one 4h. Flash column chromatography (SiO_2, 10→15% EtOAc in hexanes) afforded 1,2-oxazinan-3-one **4h** (89% yield) as a colorless oil. 84% ee, $[\alpha]_D^{25}$ –17.4 (*c* 1.15, $CHCl_3$); R_f = 0.24 (20% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 7.46–7.31 (m, 5H), 5.80 (ddt, *J* = 16.6, 10.2, 7.4 Hz, 1H), 5.32 (s, 2H), 5.16–5.09 (m, 2H), 4.29–4.21 (m, 2H), 2.49 (m, 2H), 2.11 (ddd, *J* = 13.8, 8.4, 6.6 Hz, 1H), 1.87 (ddd, *J* = 13.8, 8.5, 6.7 Hz, 1H), 1.33 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.1, 150.3, 135.1, 133.3, 128.8, 128.6, 128.4, 119.3, 69.7, 69.0, 43.7, 42.7, 32.5, 24.0; IR (Neat Film, NaCl) 2977, 2939, 1777, 1738, 1456, 1379, 1268, 1217, 1123, 995, 922, 753 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{16}H_{20}NO_4$ $[M+H]^+$: 290.1387, found 290.1374; SFC conditions: 5% MeOH, 3.0 mL/min, Chiralpak AD-H column, λ = 210 nm, t_R (min): major = 8.31, minor = 7.88.



4i

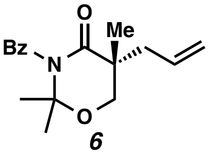
1,2-Oxazinan-3-one 4i. Flash column chromatography (SiO_2, 10→20% EtOAc in hexanes) afforded 1,2-oxazinan-3-one **4i** (70% yield) as a colorless oil. 87% ee, $[\alpha]_D^{25}$ –26.2 (*c* 0.90, $CHCl_3$); R_f = 0.31 (25% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 7.42–7.37 (m, 2H), 7.28–7.20 (m, 3H), 5.84 (ddt, *J* = 17.5, 10.3, 7.4 Hz, 1H), 5.20–5.14 (m, 2H), 4.41–4.32 (m, 2H), 2.59–2.50 (m, 2H), 2.20 (ddd, *J* = 14.6, 8.5, 6.5 Hz, 1H), 1.96 (ddd, *J* = 13.9, 8.5, 6.6 Hz, 1H), 1.40 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.2, 150.5, 148.7, 133.2, 129.6, 126.4, 121.5, 119.5, 69.8, 43.9, 42.8, 32.5, 24.0; IR (Neat Film, NaCl) 2936, 1786, 1755, 1494, 1269, 1189, 1162, 1102, 934 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{15}H_{18}NO_4$ $[M+H]^+$: 276.1230, found 276.1225; SFC conditions:

10% IPA, 2.5 mL/min, Chiralcel OJ-H column, λ = 254 nm, t_R (min): major = 9.61, minor = 7.70.



4j

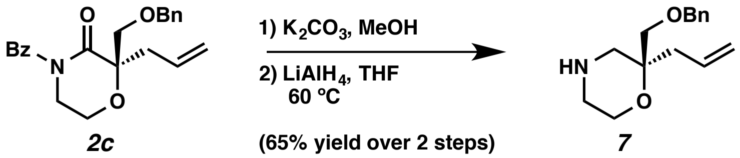
1,2-Oxazepan-3-one 4j. Flash column chromatography (SiO_2, 15% EtOAc in hexanes) afforded 1,2-oxazepan-3-one **4j** (81% yield) as a colorless oil. 93% ee, $[\alpha]_D^{25}$ –20.6 (*c* 1.00, $CHCl_3$); R_f = 0.56 (33% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 7.57–7.47 (m, 3H), 7.42–7.37 (m, 2H), 5.82 (ddt, *J* = 17.3, 10.2, 7.3 Hz, 1H), 5.20–5.13 (m, 2H), 4.36–4.04 (m, 2H), 2.68 (br s, 1H), 2.47 (dd, *J* = 13.6, 6.7 Hz, 1H), 2.14–1.71 (m, 4H), 1.32 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 178.1, 169.5, 135.1, 133.9, 132.0, 128.3, 128.3, 118.8, 77.4, 47.7, 42.8, 34.3, 25.6, 24.7; IR (Neat Film, NaCl) 2938, 1740, 1699, 1449, 1267, 1210, 1140, 997 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{16}H_{20}NO_3$ $[M+H]^+$: 274.1438, found 274.1440; SFC conditions: 5% MeOH, 3.0 mL/min, Chiralcel OJ-H column, λ = 254 nm, t_R (min): major = 5.01, minor = 4.30.



6

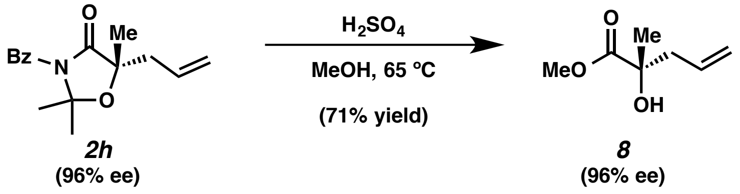
1,3-Oxazinan-4-one 6. Flash column chromatography (SiO_2, 10→15% EtOAc in hexanes) afforded 1,3-oxazinan-4-one **6** (90% yield) as a colorless oil. 94% ee, $[\alpha]_D^{25}$ –50.9 (*c* 1.53, $CHCl_3$); R_f = 0.29 (15% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 7.69–7.63 (m, 2H), 7.50 (m, 1H), 7.41 (dd, *J* = 8.4, 7.1 Hz, 2H), 5.77 (ddt, *J* = 16.6, 10.5, 7.3 Hz, 1H), 5.20–5.11 (m, 2H), 3.99 (d, *J* = 12.1 Hz, 1H), 3.74 (d, *J* = 12.1 Hz, 1H), 2.59 (m, 1H), 2.32 (m, 1H), 1.75 (s, 3H), 1.74 (s, 3H), 1.27 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 176.5, 175.7, 136.6, 132.8, 132.5, 128.6, 128.1, 119.5, 92.6, 66.7, 43.1, 40.5, 27.2, 26.9, 21.6; IR (Neat Film, NaCl) 1699, 1683, 1386, 1261, 1174, 1084 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{17}H_{22}NO_3$ $[M+H]^+$: 288.1594, found 288.1582; SFC conditions: 2% MeOH, 3.0 mL/min, Chiralcel OJ-H column, λ = 254 nm, t_R (min): major = 4.65, minor = 3.14.

Derivatization of Allylic Alkylation Products

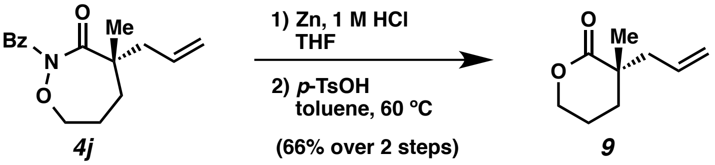


Morpholine 7. To a solution of **2c** (25.3 mg, 69.2 μmol, 1 equiv) in MeOH (0.7 mL) was added K_2CO_3 (1.9 mg, 13.8 μmol, 0.2 equiv) at room temperature. After stirring at room temperature for 2 h, the reaction mixture was filtered and the filtrate was concentrated in vacuo. The residue was used for the next reaction without further purification.

To a solution of the crude morpholinone in THF (2.0 mL) was added $LiAlH_4$ (7.9 mg, 208 μmol, 3.0 equiv) at room temperature. After stirring at 60 °C for 2 h, H_2O (8 μL), 15% aqueous NaOH (8 μL) and H_2O (24 μL) were added to the reaction mixture sequentially. The resulting mixture was diluted with diethyl ether (30 mL), dried over Na_2SO_4, filtered and the filtrate was concentrated in vacuo. Flash column chromatography (SiO_2, $CHCl_3$:MeOH:Et_2NH=94:5:1) afforded morpholine **7** (12.4 mg, 45.2 μmol, 65% yield) as a colorless oil. $[\alpha]_D^{25}$ –13.9 (*c* 0.52, $CHCl_3$); R_f = 0.35 ($CHCl_3$:MeOH:Et_2NH=94:5:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.39–7.25 (m, 5H), 5.78 (ddt, *J* = 17.4, 10.2, 7.3 Hz, 1H), 5.14–5.04 (m, 2H), 4.55 (s, 2H), 3.77–3.71 (m, 2H), 3.53 (d, *J* = 9.5 Hz, 1H), 3.47 (d, *J* = 9.5 Hz, 1H), 2.93–2.81 (m, 3H), 2.76 (d, *J* = 12.6 Hz, 1H), 2.59 (m, 1H), 2.35 (m, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 138.4, 133.3, 128.5, 127.8, 127.8, 118.2, 73.7, 73.7, 71.8, 61.8, 50.7, 45.8, 37.6; IR (Neat Film, NaCl) 2933, 2864, 1453, 1101, 1085, 737, 698 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{15}H_{22}NO_2$ $[M+H]^+$: 248.1645, found 248.1648.



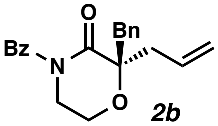
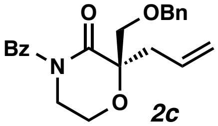
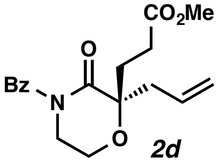
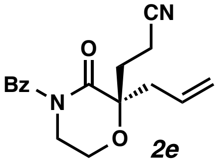
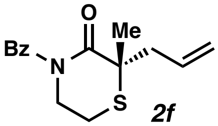
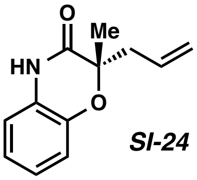
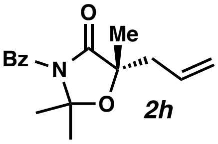
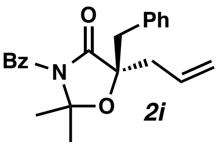
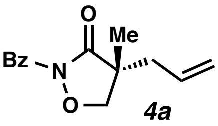
α-Hydroxyester 8. To a solution of **2h** (16.0 mg, 58.5 μmol, 1 equiv) in MeOH (4.0 mL) was added H_2SO_4 (11.5 mg, 117 μmol, 2.0 equiv) at room temperature. After stirring at 65 ºC for 48 h, the reaction mixture was quenched with saturated aqueous sodium bicarbonate and diluted with diethyl ether (30 mL). The phases were separated and the aqueous phase was extracted with diethyl ether twice. The combined organic layers were washed with brine, dried over Na_2SO_4, filtered and the filtrate was concentrated in vacuo. Flash column chromatography (SiO_2, 20→50% diethyl ether in hexanes) afforded α-hydroxyester **8** (6.0 mg, 41.6 μmol, 70% yield) as a colorless oil. 96% ee, $[\alpha]_D^{25}$ +24.2 (*c* 0.26, $CHCl_3$); R_f = 0.37 (20% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 5.76 (ddt, *J* = 16.8, 10.4, 7.3 Hz, 1H), 5.16–5.07 (m, 2H), 3.77 (s, 3H), 3.10 (s, 1H), 2.50 (m, 1H), 2.39 (m, 1H), 1.42 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 177.1, 132.5, 119.3, 74.7, 52.9, 44.9, 25.6; IR (Neat Film, NaCl) 3504, 2982, 2955, 1736, 1641, 1438, 1272, 1068 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_7H_{13}O_3$ $[M+H]^+$: 145.0865, found 145.0867; chiral GC conditions: 85 ºC isotherm, G-TA column, t_R (min): major = 7.57, minor = 7.20.

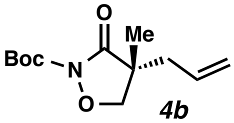
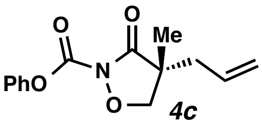
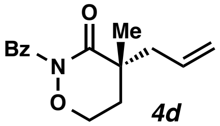
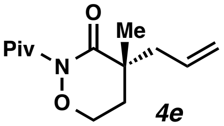
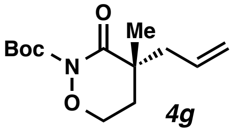
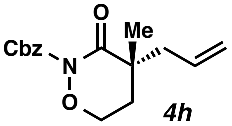
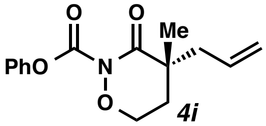
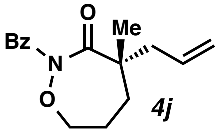
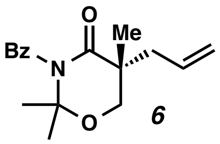
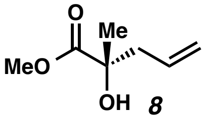


δ-Lactone 9. To a solution of **4j** (15.5 mg, 56.7 μmol, 1 equiv) in THF (1.0 mL) was added Zn (37.1 mg, 567 μmol, 10 equiv) and 1 M HCl (0.1 mL) at room temperature. After stirring at room temperature for 3 h, the reaction mixture was quenched with 1 M HCl and diluted with ethyl acetate (30 mL). The phases were separated and the aqueous phase was extracted with ethyl acetate twice. The combined organic layers were washed with brine, dried over Na_2SO_4, filtered and the filtrate was concentrated in vacuo. The residue was used for the next reaction without further purification.

To a solution of the crude alcohol in toluene (2 mL) was added p-toluenesulfonic acid monohydrate (12.9 mg, 68.0 μmol, 1.2 equiv) at room temperature. After stirring at 60 ºC for 30 min, the reaction mixture was diluted with diethyl ether (30 mL). The organic phase was washed with saturated aqueous sodium bicarbonate and brine, dried over Na_2SO_4, filtered, and the filtrate was concentrated in vacuo. Flash column chromatography (SiO_2, 20→30% diethyl ether in hexanes) afforded δ-lactone **9** (5.8 mg, 37.6 μmol, 66% yield) as a colorless oil. $[\alpha]_D^{25}$ –29.8 (*c* 0.28, $CHCl_3$); R_f = 0.36 (25% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 5.75 (dddd, *J* = 16.9, 10.2, 8.0, 6.7 Hz, 1H), 5.17–5.07 (m, 2H), 4.36 (m, 1H), 4.27 (m, 1H), 2.56 (m, 1H), 2.22 (m, 1H), 1.98–1.77 (m, 3H), 1.63 (m, 1H), 1.29 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 176.3, 133.4, 119.3, 70.6, 44.6, 42.4, 31.8, 26.5, 20.7; IR (Neat Film, NaCl) 2936, 1725, 1131 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_9H_{15}NO_2$ $[M+H]^+$: 155.1067, found 155.1068.

Methods for the Determination of Enantiomeric Excess

entry	compound	analytic conditions	ee (%)	polarimetry
1	 *2b*	SFC: 10% MeOH, 3.0 mL/min Chiralpak AD-H, λ = 254 nm t_R (min): major 3.67, minor 5.93	99	$[\alpha]_D^{25}$ +85.9 (*c* 1.15, $CHCl_3$)
2	 *2c*	SFC: 5% MeOH, 3.0 mL/min Chiralpak AD-H, λ = 254 nm t_R (min): major 5.91, minor 6.73	99	$[\alpha]_D^{25}$ –22.4 (*c* 1.37, $CHCl_3$)
3	 *2d*	SFC: 5% MeOH, 3.0 mL/min Chiralcel OD-H, λ = 254 nm t_R (min): major 6.16, minor 5.66	99	$[\alpha]_D^{25}$ +24.6 (*c* 1.15, $CHCl_3$)
4	 *2e*	SFC: 3% MeOH, 2.5 mL/min Chiralpak AS-H, λ = 254 nm t_R (min): major 5.79, minor 6.53	99	$[\alpha]_D^{25}$ +38.5 (*c* 1.24, $CHCl_3$)
5	 *2f*	SFC: 5% MeOH, 3.0 mL/min Chiralcel OJ-H, λ = 254 nm t_R (min): major 6.80, minor 5.74	86	$[\alpha]_D^{25}$ –45.8 (*c* 1.35, $CHCl_3$)
6	 *SI-24*	SFC: 5% IPA, 3.0 mL/min Chiralcel OJ-H, λ = 210 nm t_R (min): major 4.18, minor 4.64	95	$[\alpha]_D^{25}$ –15.2 (*c* 0.21, $CHCl_3$)
7	 *2h*	SFC: 2% IPA, 3.0 mL/min Chiralcel OJ-H, λ = 254 nm t_R (min): major 5.59, minor 3.96	96	$[\alpha]_D^{25}$ +68.2 (*c* 1.05, $CHCl_3$)
8	 *2i*	SFC: 5% MeOH, 3.0 mL/min Chiralcel OJ-H, λ = 254 nm t_R (min): major 3.51, minor 4.44	92	$[\alpha]_D^{25}$ +46.9 (*c* 1.03, $CHCl_3$)
9	 *4a*	SFC: 5% MeOH, 3.0 mL/min Chiralcel OJ-H, λ = 254 nm t_R (min): major 8.07, minor 5.70	73	$[\alpha]_D^{25}$ –33.5 (*c* 1.05, $CHCl_3$)

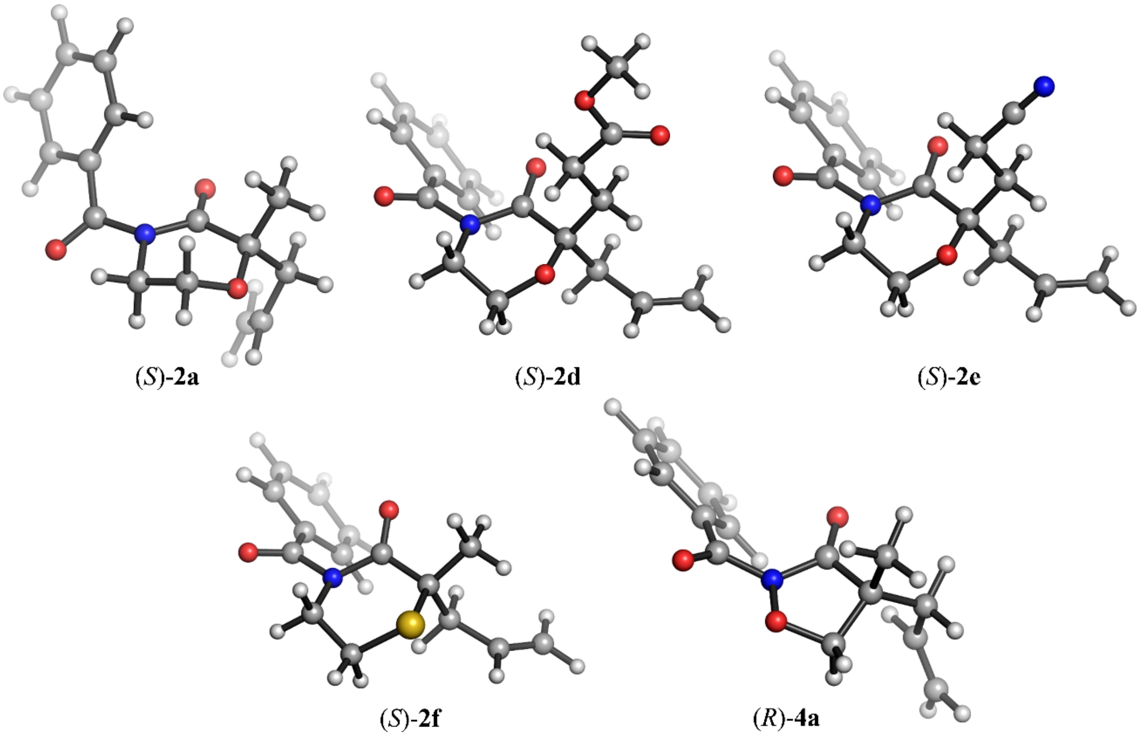
entry	compound	analytic conditions	ee (%)	polarimetry
10	 **4b**	SFC: 2% MeOH, 3.0 mL/min Chiralcel OJ-H, λ = 210 nm t_R (min): major 3.54, minor 3.89	72	$[\alpha]_D^{25}$ –27.7 (c 1.10, $CHCl_3$)
11	 **4c**	SFC: 5% MeOH, 3.0 mL/min Chiralpak AD-H, λ = 235 nm t_R (min): major 6.88, minor 8.08	73	$[\alpha]_D^{25}$ –28.4 (c 1.14, $CHCl_3$)
12	 **4d**	SFC: 10% IPA, 3.0 mL/min Chiralcel OD-H, λ = 254 nm t_R (min): major 3.91, minor 3.03	88	$[\alpha]_D^{25}$ –25.8 (c 0.45, $CHCl_3$)
13	 **4e**	SFC: 5% IPA, 2.5 mL/min Chiralpak AS-H, λ = 210 nm t_R (min): major 7.10, minor 6.65	73	$[\alpha]_D^{25}$ –26.3 (c 0.50, $CHCl_3$)
14	 **4g**	SFC: 1% IPA, 3.0 mL/min Chiralcel OJ-H, λ = 210 nm t_R (min): major 3.82, minor 3.31	85	$[\alpha]_D^{25}$ –25.4 (c 0.54, $CHCl_3$)
15	 **4h**	SFC: 5% MeOH, 3.0 mL/min Chiralpak AD-H, λ = 210 nm t_R (min): major 8.31, minor 7.88	84	$[\alpha]_D^{25}$ –17.4 (c 1.15, $CHCl_3$)
16	 **4i**	SFC: 10% IPA, 2.5 mL/min Chiralcel OJ-H, λ = 254 nm t_R (min): major 9.61, minor 7.70	87	$[\alpha]_D^{25}$ –26.2 (c 0.90, $CHCl_3$)
17	 **4j**	SFC: 5% MeOH, 3.0 mL/min Chiralcel OJ-H, λ = 254 nm t_R (min): major 5.01, minor 4.30	93	$[\alpha]_D^{25}$ –20.6 (c 1.00, $CHCl_3$)
18	 **6**	SFC: 2% MeOH, 3.0 mL/min Chiralcel OJ-H, λ = 254 nm t_R (min): major 4.65, minor 3.14	94	$[\alpha]_D^{25}$ –50.9 (c 1.53, $CHCl_3$)
19	 **8**	GC: 85 °C isotherm G-TA column t_R (min): major 7.57, minor 7.20	96	$[\alpha]_D^{25}$ +24.2 (c 0.26, $CHCl_3$)

Determination of absolute stereochemistry by a combined Vibrational Circular Dichroism (VCD) spectroscopic and computational chemistry approach:

VCD spectroscopy: Enantiopure samples of compounds **2a** (5 mg/0.15 mL), **2d** (5.7 mg/0.15 mL), **2e** (25 mg/0.3 mL), **2f** (25 mg/0.6 mL) and **4a** (25 mg/0.6 mL) were dissolved in $CDCl_3$ (5 mg/0.15 mL) and placed in a 100 μm pathlength cell with BaF_2 windows. IR and VCD spectra were recorded on a ChiralIR™ VCD spectrometer (BioTools, Inc.), with 4 cm^{-1} resolution, 6 to 10 hours collection for sample and solvent, and instrument optimized at 1400 cm^{-1}. The solvent-subtracted IR and VCD spectra are shown in Figure S4.

Computational methods: All calculations were carried out with the Gaussian 09 package[1] using the B3LYP functional.[2,3] The 6-31G(d)[4] and def2-TZVPP[5] basis sets were used for geometry optimizations and the calculation of frequencies and IR and VCD properties,[6,7] respectively. According to previous results,[8-13] a triple-zeta basis set is required to accurately reproduce the experimental spectra. BSSE corrections were not considered in this work. All the stationary points located were characterized by the correct number and nature of their imaginary frequencies. Scaled frequencies were not considered. Thermal and entropic corrections to energy were calculated from vibrational frequencies. Bulk solvent effects were considered implicitly in the IR/VCD calculations through the SMD polarizable continuum model of Cramer and Truhlar[14] using the parameters for chloroform as implemented in Gaussian 09. A systematic conformational search around all rotatable bonds and ring isomers was performed at the B3LYP/6-31G(d) level. The lowest energy conformers (< 3 kcal mol^{-1}) were used in the calculation of the IR/VCD spectra at the higher theory level. The relative populations of each conformer derived from their relative enthalpies (ΔH) through a Boltzmann distribution at 25 ºC were used to scale their corresponding IR/VCD spectra. The energies and relative population of these conformers are shown in Table S1, and the lowest energy structures in Figure S1. The sum of all contributions was used to obtain the final theoretical spectra which were compared to those measured experimentally using a statistical implemented in

BioTools' CompareVOA software.[15] The optimized geometries and IR/VCD spectra for all calculated conformers can be obtained from the authors upon request.



(*S*)-**2a** (*S*)-**2d** (*S*)-**2e**

(*S*)-**2f** (*R*)-**4a**

Figure S1. Lowest energy structures calculated at the B3LYP/6-31G(d) level.

Discussion

The proper description of the dominant conformations in such flexible compounds is crucial to accurately reproduce the observed spectroscopic properties. This fact is clearly illustrated in Figure S2, which shows the radically different calculated spectra of all conformers of (*R*)-**4a**.

A detailed inspection of the individual spectra associated to each conformer reveals that the positive or negative values of the rotational strength (R_i) of each vibration depend not only on the absolute configuration of the stereogenic carbon, but also on the relative orientation of each functional group. Free rotations or conformational changes of some functional groups often have a more pronounced effect on the energy and intensity of their associated vibrations, than a change of configuration at remote stereogenic centers.

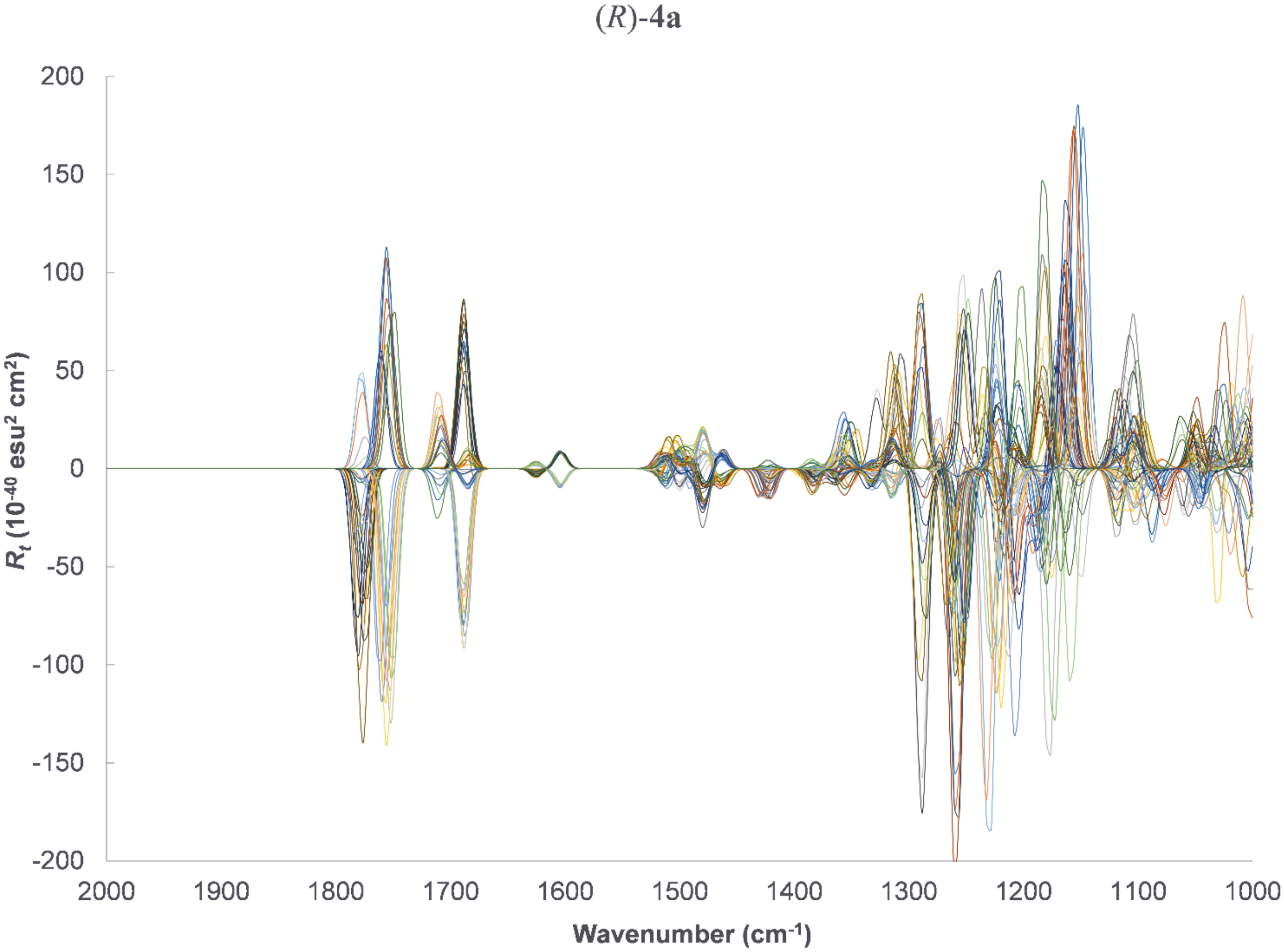
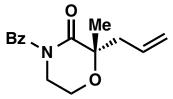
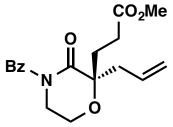


Figure S2. Overlay of the theoretical VCD spectra for each of the 48 conformers of compound (*R*)-**4a** calculated at the B3LYP/def2-TZVPP//B3LYP/6-31G(d) level.

In these systems, the influence of solvation effects (chloroform) on the relative population of each conformer, and thus on the global theoretical spectrum, is negligible (Figure S3); a slightly better agreement with experiments was obtained with the gas phase spectra.



(S)-2a



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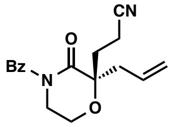
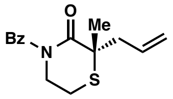


(S)-2e



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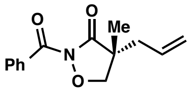


(R)-4a

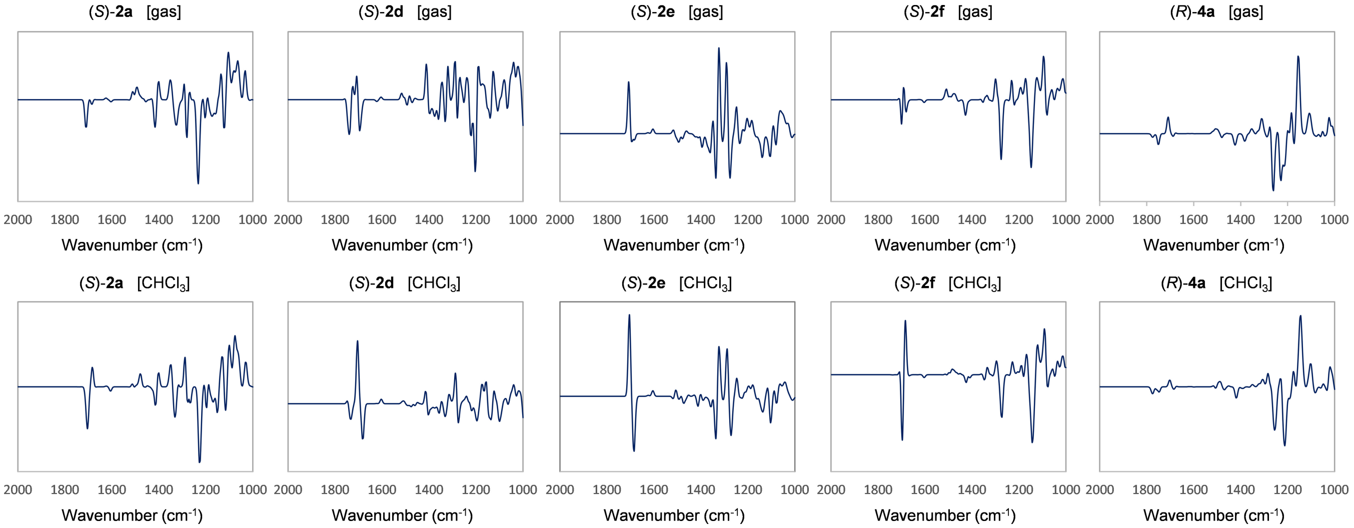
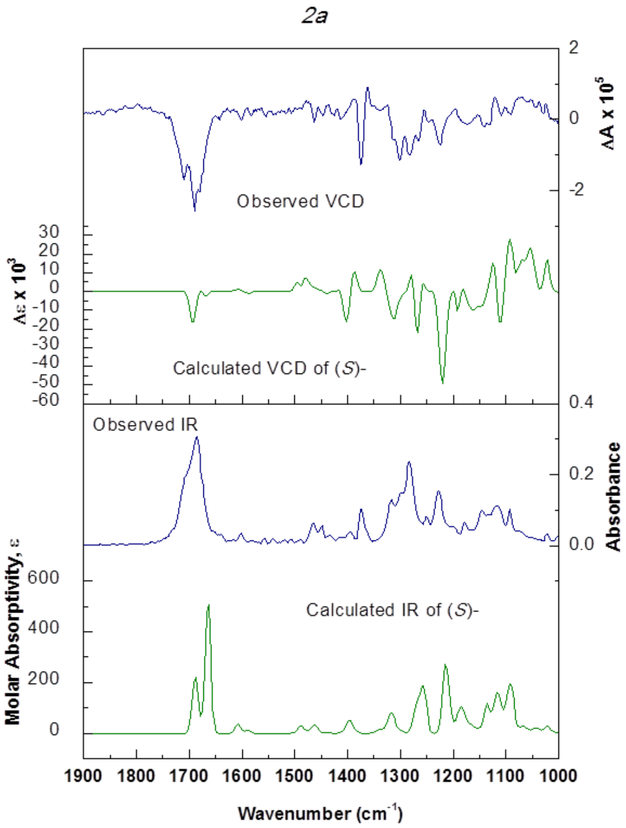
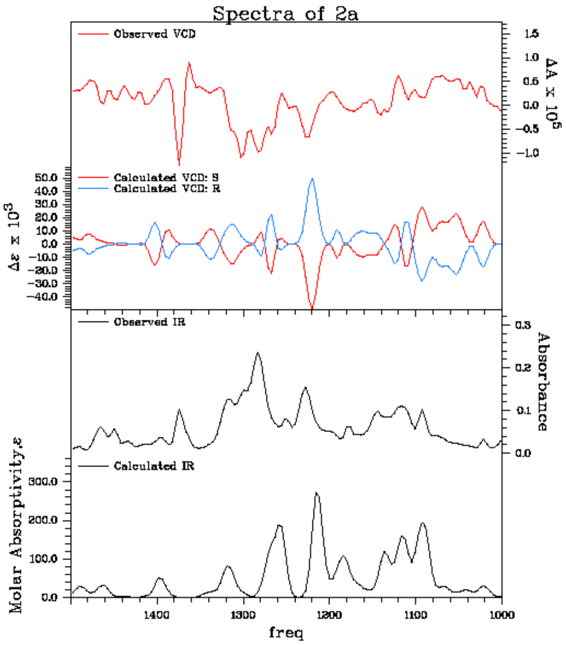


Figure S3. Conformationally weighted spectra in the gas phase and chloroform solution calculated at the B3LYP/def2-TZVPP//B3LYP/6-31G(d) level.

The comparison of the conformationally weighted theoretical and experimental VCD spectra reveals a remarkably good agreement between both sets of data (Figure S4), considering the high conformational flexibility of the analyzed substrates. The experiments and calculations performed throughout this study allowed the assignment of absolute configuration of the analyzed compounds to be (*S*)-**2a**, (*S*)-**2d**, (*S*)-**2e**, (*S*)-**2f** and (*R*)-**4a**.

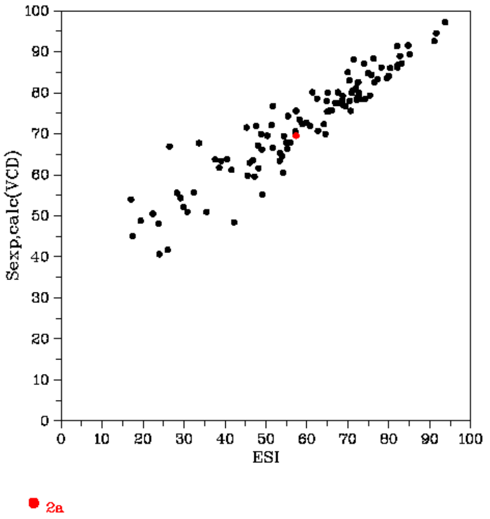




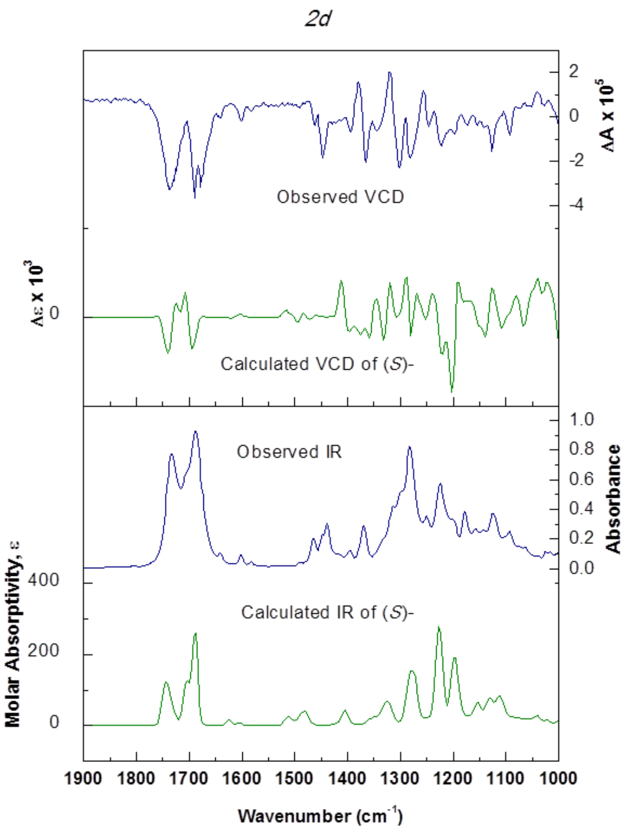
Scale= 0.990
TNS(IR)=75.6 TNS(VCD)= 57.7
SNS(S)= 69.5 SNS(R)= 12.1 ESI= 57.4

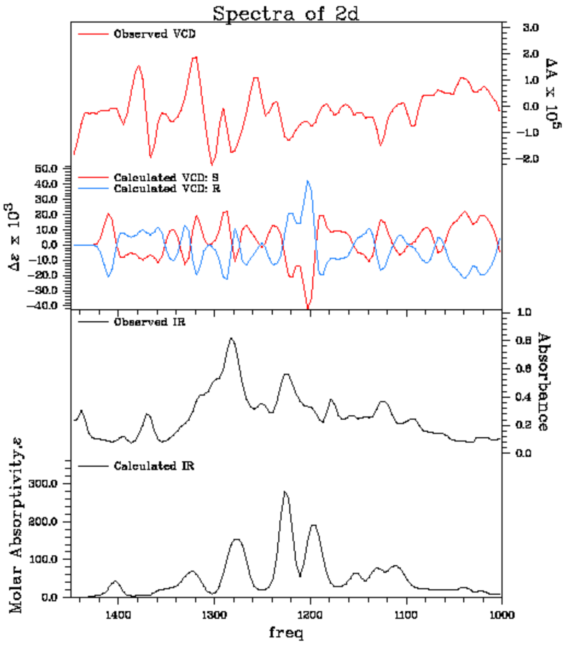
The absolute configuration of 2a
is S
The Confidence level is 94%

105 correct VCD assignments of Absolute Configuration



The new ESI-value lies in the 56th percentile
of the database for correct assignments

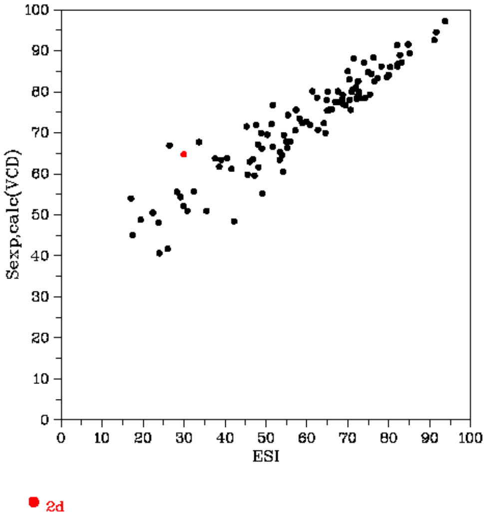




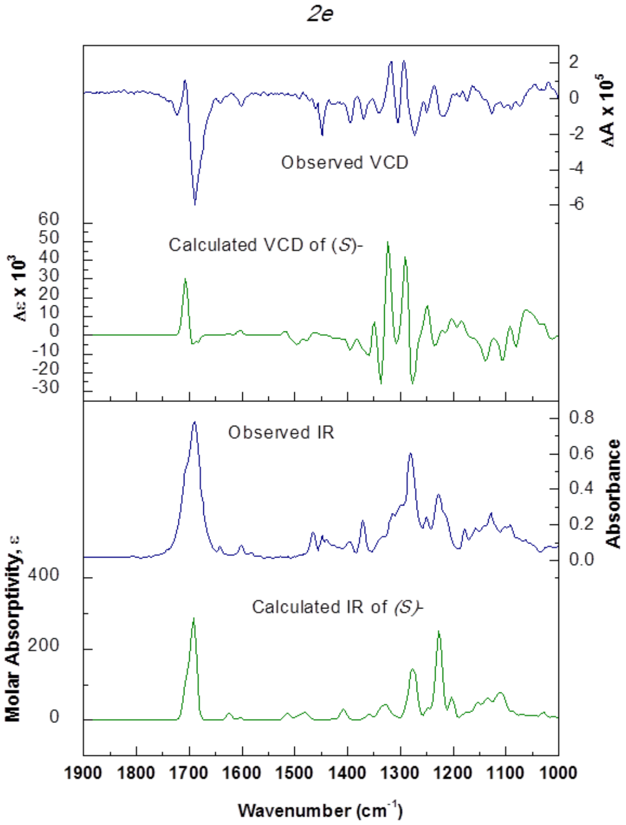
Scale= 0.999
TNS(IR)=88.3 TNS(VCD)= 29.8
SNS(S)= 64.7 SNS(R)= 34.7 ESI= 30.0

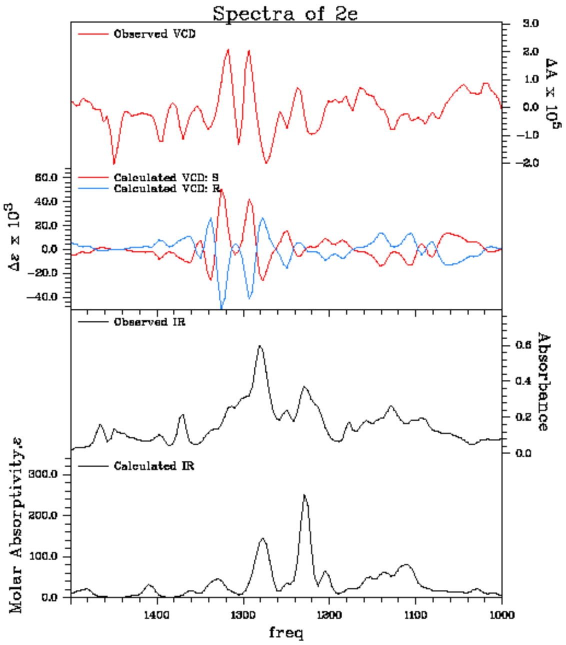
The absolute configuration of 2d
is S
The Confidence level is 61%

105 correct VCD assignments of Absolute Configuration



The new ESI-value lies in the 26th percentile
of the database for correct assignments

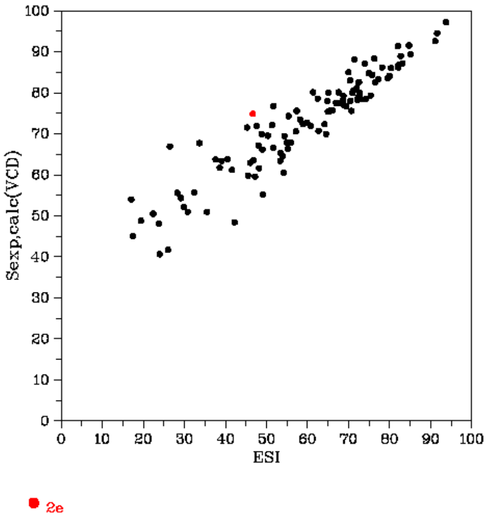




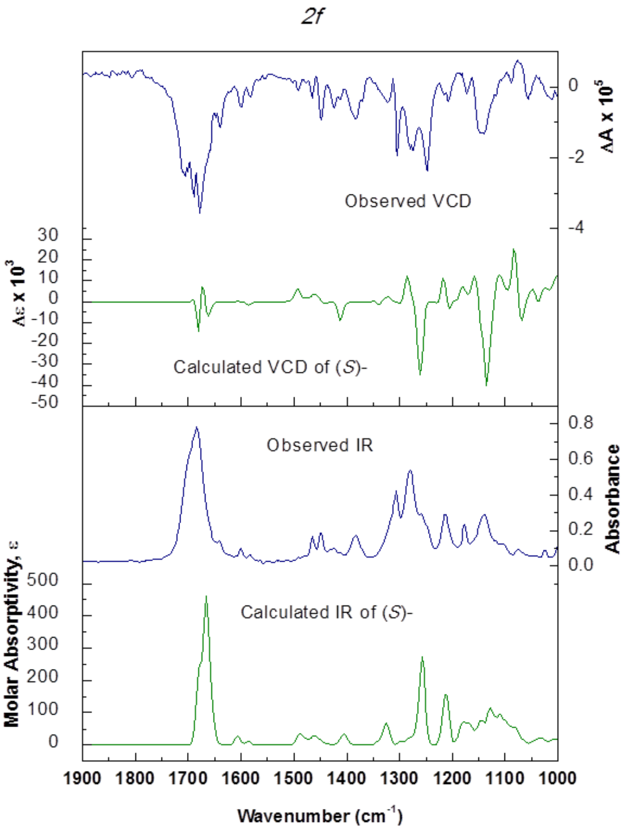
```
Scale= 1.001
TNS(IR)=87.5 TNS(VCD)=  53.6
SNS(S)= 74.8  SNS(R)= 28.2  ESI=  46.7
```

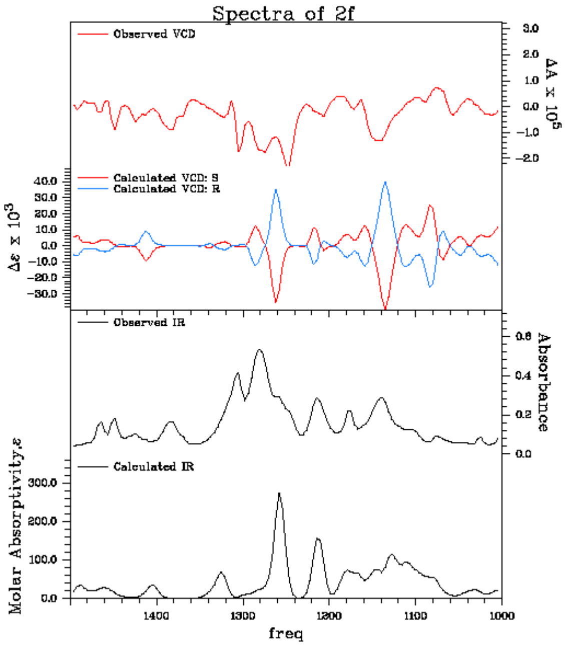
```
The absolute configuration of 2e
        is S
The Confidence level is  95%
```

105 correct VCD assignments of Absolute Configuration



The new ESI–value lies in the 36th percentile of the database for correct assignments

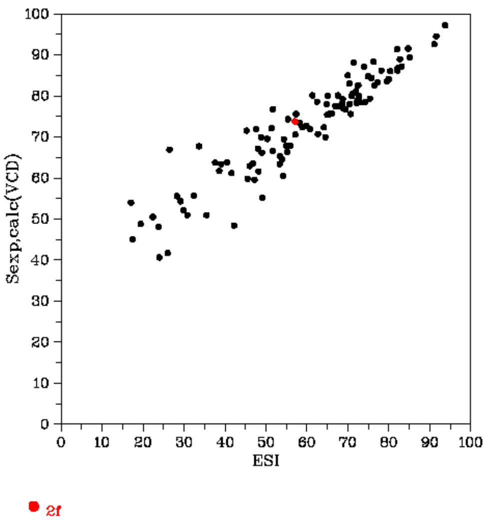




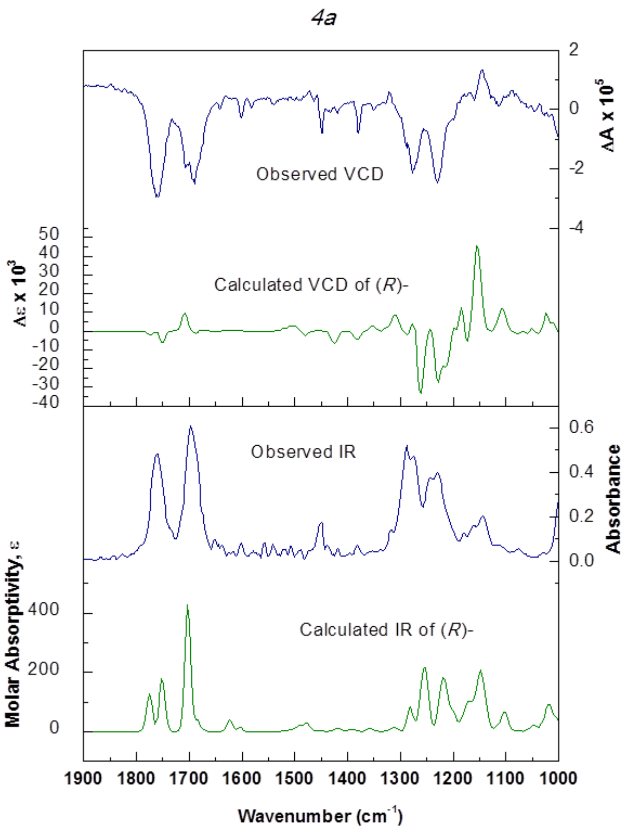
Scale= 0.989
TNS(IR)=76.8 TNS(VCD)= 51.4
SNS(S)= 73.8 SNS(R)= 16.7 ESI= 57.1

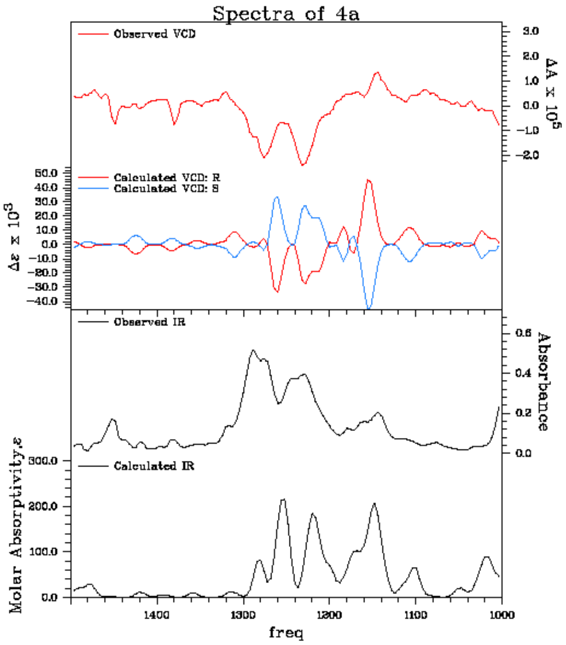
The absolute configuration of 2f
is S
The Confidence level is 100%

105 correct VCD assignments of Absolute Configuration



The new ESI-value lies in the 56th percentile
of the database for correct assignments

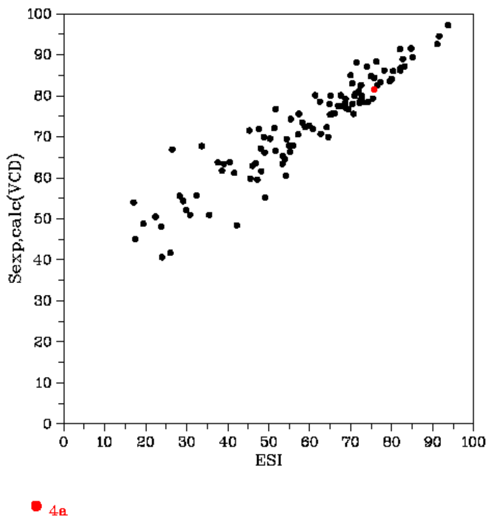




Scale= 1.000
TNS(IR)=78.7 TNS(VCD)= 73.1
SNS(R)= 81.5 SNS(S)= 5.7 ESI= 75.8

The absolute configuration of 4a
is R
The Confidence level is 100%

105 correct VCD assignments of Absolute Configuration



The new ESI–value lies in the 87th percentile
of the database for correct assignments

Figure S4. Experimental and calculated IR/VCD spectra of compounds **2a**, **2d**, **2e**, **2f** and **4a**. VCD calculations were performed at the B3LYP/TZVP level. In all cases the resolution (half-width at half height) of the experimental and calculated spectra is 4 and 6 cm^{-1}, respectively. The statistical correspondence (confidence level) between the experimental and calculated peaks is shown.

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Table S1. Energies, entropies, free energies, and lowest frequencies of the lowest energy conformers calculated at the B3LYP/def2-TZVPP//B3LYP/6-31G(d) level.

Structure	E_{elec} (Hartree)[a]	E_{elec} + ZPE (Hartree)[a]	H (Hartree)[a]	S (cal mol^{-1} K^{-1})[b]	G (Hartree)[a,b]	Lowest freq. (cm^{-1})	ΔH (kcal mol^{-1})[a]	Mol %
(*S*)-**2a**_c1	-862.580445	-862.286421	-862.268665	129.8	-862.330317	51.7	0.00	15.8
(*S*)-**2a**_c2	-862.580376	-862.286312	-862.268594	129.1	-862.329943	59.5	0.04	14.6
(*S*)-**2a**_c3	-862.579998	-862.285975	-862.268208	129.8	-862.329874	53.1	0.29	9.7
(*S*)-**2a**_c4	-862.579887	-862.285925	-862.268153	129.9	-862.329851	53.3	0.32	9.2
(*S*)-**2a**_c5	-862.579853	-862.285914	-862.268129	130.0	-862.329901	47.3	0.34	8.9
(*S*)-**2a**_c6	-862.579840	-862.285842	-862.268067	129.9	-862.329809	49.2	0.38	8.4
(*S*)-**2a**_c7	-862.579747	-862.285764	-862.267987	129.9	-862.329711	53.9	0.43	7.7
(*S*)-**2a**_c8	-862.578998	-862.284984	-862.267224	129.7	-862.328840	56.0	0.90	3.4
(*S*)-**2a**_c9	-862.578668	-862.284717	-862.266980	129.5	-862.328514	49.1	1.06	2.6
(*S*)-**2a**_c10	-862.578788	-862.284659	-862.266929	129.4	-862.328423	52.4	1.09	2.5
(*S*)-**2a**_c11	-862.578592	-862.284594	-862.266851	129.5	-862.328381	47.8	1.14	2.3
(*S*)-**2a**_c12	-862.578664	-862.284635	-862.266848	130.0	-862.328628	47.5	1.14	2.3
(*S*)-**2a**_c13	-862.578486	-862.284477	-862.266708	129.8	-862.328358	49.2	1.23	2.0
(*S*)-**2a**_c14	-862.578409	-862.284415	-862.266627	130.1	-862.328439	52.8	1.28	1.8
(*S*)-**2a**_c15	-862.578145	-862.284097	-862.266356	129.6	-862.327947	53.4	1.45	1.4
(*S*)-**2a**_c16	-862.578128	-862.284108	-862.266333	129.8	-862.327983	54.5	1.46	1.3
(*S*)-**2a**_c17	-862.578085	-862.284020	-862.266264	129.8	-862.327939	55.2	1.51	1.2
(*S*)-**2a**_c18	-862.578089	-862.284013	-862.266254	129.9	-862.327967	49.3	1.51	1.2
(*S*)-**2a**_c19	-862.578053	-862.284038	-862.266254	130.0	-862.328031	53.2	1.51	1.2
(*S*)-**2a**_c20	-862.577755	-862.283854	-862.266051	130.1	-862.327861	51.4	1.64	1.0
(*S*)-**2a**_c21	-862.577449	-862.283386	-862.265685	129.0	-862.326958	56.3	1.87	0.7
(*S*)-**2a**_c22	-862.576909	-862.283069	-862.265306	129.6	-862.326866	56.9	2.11	0.4

(*S*)-**2a**_c24	-862.575678	-862.281883	-862.264096	129.9	-862.325819	54.9	2.87	0.1
(*S*)-**2a**_c25	-862.570898	-862.277225	-862.259384	130.5	-862.321374	45.2	5.82	0.0
(*S*)-**2a**_c26	-862.570714	-862.276908	-862.259077	130.3	-862.320987	44.2	6.02	0.0
(*S*)-**2a**_c27	-862.570333	-862.276632	-862.258756	130.7	-862.320870	41.6	6.22	0.0
(*S*)-**2a**_c28	-862.570324	-862.276572	-862.258728	130.5	-862.320756	40.1	6.24	0.0
(*S*)-**2d**_c1	-1129.876623	-1129.511181	-1129.487925	157.2	-1129.562609	32.6	0.00	12.0
(*S*)-**2d**_c2	-1129.876418	-1129.510701	-1129.487503	156.8	-1129.562019	34.1	0.26	7.7
(*S*)-**2d**_c3	-1129.876311	-1129.510313	-1129.487289	155.6	-1129.561236	33.8	0.40	6.1
(*S*)-**2d**_c4	-1129.875885	-1129.510216	-1129.486976	157.3	-1129.561706	34.1	0.60	4.4
(*S*)-**2d**_c5	-1129.875707	-1129.510251	-1129.486963	157.5	-1129.561781	33.0	0.60	4.3
(*S*)-**2d**_c6	-1129.875723	-1129.509888	-1129.486816	155.7	-1129.560776	36.6	0.70	3.7
(*S*)-**2d**_c7	-1129.875721	-1129.509780	-1129.486766	155.2	-1129.560486	38.4	0.73	3.5
(*S*)-**2d**_c8	-1129.875664	-1129.509944	-1129.486757	156.5	-1129.561134	37.4	0.73	3.5
(*S*)-**2d**_c9	-1129.875490	-1129.509964	-1129.486739	156.8	-1129.561247	33.8	0.74	3.4
(*S*)-**2d**_c10	-1129.875554	-1129.509626	-1129.486569	155.8	-1129.560587	35.2	0.85	2.9
(*S*)-**2d**_c11	-1129.875337	-1129.509633	-1129.486439	156.4	-1129.560762	33.2	0.93	2.5
(*S*)-**2d**_c12	-1129.875089	-1129.509635	-1129.486367	157.1	-1129.560992	32.1	0.98	2.3
(*S*)-**2d**_c13	-1129.875252	-1129.509327	-1129.486273	155.3	-1129.560056	37.9	1.04	2.1
(*S*)-**2d**_c14	-1129.874888	-1129.509521	-1129.486232	157.3	-1129.560966	34.3	1.06	2.0
(*S*)-**2d**_c15	-1129.875051	-1129.509287	-1129.486208	155.9	-1129.560272	36.5	1.08	1.9
(*S*)-**2d**_c16	-1129.875199	-1129.509144	-1129.486076	155.4	-1129.559908	36.8	1.16	1.7
(*S*)-**2d**_c17	-1129.874879	-1129.509315	-1129.486066	156.9	-1129.560637	35.6	1.17	1.7
(*S*)-**2d**_c18	-1129.874718	-1129.509086	-1129.486001	156.0	-1129.560134	37.3	1.21	1.6
(*S*)-**2d**_c19	-1129.875006	-1129.508985	-1129.485911	155.5	-1129.559807	37.2	1.26	1.4
(*S*)-**2d**_c20	-1129.874791	-1129.509126	-1129.485887	157.2	-1129.560564	35.3	1.28	1.4
(*S*)-**2d**_c21	-1129.875031	-1129.508803	-1129.485870	154.3	-1129.559199	36.0	1.29	1.4

(*S*)-**2d**_c22	-1129.874484	-1129.508992	-1129.485763	157.1	-1129.560406	36.2	1.36	1.2
(*S*)-**2d**_c23	-1129.874655	-1129.508878	-1129.485718	156.5	-1129.560088	34.1	1.38	1.2
(*S*)-**2d**_c24	-1129.874441	-1129.508848	-1129.485673	156.3	-1129.559935	33.9	1.41	1.1
(*S*)-**2d**_c25	-1129.874400	-1129.508620	-1129.485549	155.5	-1129.559442	37.2	1.49	1.0
(*S*)-**2d**_c26	-1129.874505	-1129.508537	-1129.485525	155.4	-1129.559364	35.5	1.51	0.9
(*S*)-**2d**_c27	-1129.874544	-1129.508739	-1129.485516	157.1	-1129.560159	32.7	1.51	0.9
(*S*)-**2d**_c28	-1129.874384	-1129.508550	-1129.485474	155.7	-1129.559431	36.6	1.54	0.9
(*S*)-**2d**_c29	-1129.874497	-1129.508419	-1129.485469	154.0	-1129.558646	43.4	1.54	0.9
(*S*)-**2d**_c30	-1129.874430	-1129.508587	-1129.485462	155.8	-1129.559498	37.0	1.55	0.9
(*S*)-**2d**_c31	-1129.874257	-1129.508664	-1129.485446	156.6	-1129.559831	36.0	1.56	0.9
(*S*)-**2d**_c32	-1129.874445	-1129.508399	-1129.485390	154.9	-1129.558986	38.0	1.59	0.8
(*S*)-**2d**_c33	-1129.874139	-1129.508618	-1129.485389	156.7	-1129.559843	33.0	1.59	0.8
(*S*)-**2d**_c34	-1129.874331	-1129.508480	-1129.485387	155.9	-1129.559473	36.6	1.59	0.8
(*S*)-**2d**_c35	-1129.874303	-1129.508267	-1129.485315	154.0	-1129.558472	44.0	1.64	0.8
(*S*)-**2d**_c36	-1129.873988	-1129.508481	-1129.485259	156.5	-1129.559611	33.2	1.67	0.7
(*S*)-**2d**_c37	-1129.874271	-1129.508270	-1129.485241	155.0	-1129.558903	38.3	1.68	0.7
(*S*)-**2d**_c38	-1129.874283	-1129.508450	-1129.485237	156.8	-1129.559717	38.6	1.69	0.7
(*S*)-**2d**_c39	-1129.874216	-1129.508327	-1129.485233	155.5	-1129.559118	38.7	1.69	0.7
(*S*)-**2d**_c40	-1129.873890	-1129.508224	-1129.485091	156.4	-1129.559403	37.1	1.78	0.6
(*S*)-**2d**_c41	-1129.873896	-1129.508183	-1129.485043	156.6	-1129.559442	34.2	1.81	0.6
(*S*)-**2d**_c42	-1129.873879	-1129.508104	-1129.485021	156.0	-1129.559122	35.6	1.82	0.6
(*S*)-**2d**_c43	-1129.873691	-1129.508032	-1129.484934	156.0	-1129.559047	38.8	1.88	0.5
(*S*)-**2d**_c44	-1129.873670	-1129.507968	-1129.484890	155.8	-1129.558899	37.1	1.90	0.5
(*S*)-**2d**_c45	-1129.873872	-1129.507771	-1129.484824	154.4	-1129.558199	35.6	1.95	0.4
(*S*)-**2d**_c46	-1129.873625	-1129.507892	-1129.484771	156.1	-1129.558955	37.5	1.98	0.4
(*S*)-**2d**_c47	-1129.873665	-1129.507760	-1129.484767	154.3	-1129.558058	43.7	1.98	0.4
(*S*)-**2d**_c48	-1129.873681	-1129.507827	-1129.484764	155.5	-1129.558660	36.7	1.98	0.4

(*S*)-**2d**_c49	-1129.873661	-1129.507730	-1129.484727	154.8	-1129.558269	45.9	2.01	0.4
(*S*)-**2d**_c50	-1129.873622	-1129.507750	-1129.484695	155.4	-1129.558534	36.2	2.03	0.4
(*S*)-**2d**_c51	-1129.873528	-1129.507771	-1129.484667	155.7	-1129.558645	39.6	2.04	0.4
(*S*)-**2d**_c52	-1129.873614	-1129.507690	-1129.484617	155.8	-1129.558650	38.4	2.08	0.4
(*S*)-**2d**_c53	-1129.873711	-1129.507603	-1129.484604	155.1	-1129.558281	37.6	2.08	0.4
(*S*)-**2d**_c54	-1129.873526	-1129.507527	-1129.484599	154.4	-1129.557954	36.8	2.09	0.4
(*S*)-**2d**_c55	-1129.873366	-1129.507687	-1129.484561	156.3	-1129.558844	34.9	2.11	0.3
(*S*)-**2d**_c56	-1129.873603	-1129.507636	-1129.484477	156.1	-1129.558665	41.5	2.16	0.3
(*S*)-**2d**_c57	-1129.873394	-1129.507411	-1129.484473	154.0	-1129.557623	43.9	2.17	0.3
(*S*)-**2d**_c58	-1129.873380	-1129.507515	-1129.484447	155.7	-1129.558444	33.0	2.18	0.3
(*S*)-**2d**_c59	-1129.873481	-1129.507386	-1129.484422	154.2	-1129.557682	40.4	2.20	0.3
(*S*)-**2d**_c60	-1129.873557	-1129.507413	-1129.484380	155.2	-1129.558101	38.5	2.22	0.3
(*S*)-**2d**_c61	-1129.873388	-1129.507358	-1129.484350	155.0	-1129.557974	35.0	2.24	0.3
(*S*)-**2d**_c62	-1129.873198	-1129.507493	-1129.484322	156.0	-1129.558428	40.9	2.26	0.3
(*S*)-**2d**_c63	-1129.873363	-1129.507250	-1129.484187	155.1	-1129.557860	38.2	2.35	0.2
(*S*)-**2d**_c64	-1129.873302	-1129.507174	-1129.484179	155.2	-1129.557922	36.9	2.35	0.2
(*S*)-**2d**_c65	-1129.873397	-1129.507167	-1129.484163	154.4	-1129.557513	45.5	2.36	0.2
(*S*)-**2d**_c66	-1129.873039	-1129.507209	-1129.484129	155.7	-1129.558115	38.0	2.38	0.2
(*S*)-**2d**_c67	-1129.873033	-1129.507165	-1129.484124	155.4	-1129.557977	36.0	2.39	0.2
(*S*)-**2d**_c68	-1129.873064	-1129.507045	-1129.484073	155.0	-1129.557719	34.3	2.42	0.2
(*S*)-**2d**_c69	-1129.873145	-1129.507097	-1129.484067	155.0	-1129.557702	37.0	2.42	0.2
(*S*)-**2d**_c70	-1129.873046	-1129.507029	-1129.484060	154.6	-1129.557521	38.3	2.43	0.2
(*S*)-**2d**_c71	-1129.872917	-1129.507110	-1129.484042	156.0	-1129.558165	34.5	2.44	0.2
(*S*)-**2d**_c72	-1129.873031	-1129.506991	-1129.483987	154.9	-1129.557601	43.8	2.47	0.2
(*S*)-**2d**_c73	-1129.872681	-1129.506985	-1129.483874	155.9	-1129.557933	34.6	2.54	0.2
(*S*)-**2d**_c74	-1129.872723	-1129.506923	-1129.483811	155.9	-1129.557901	36.9	2.58	0.2
(*S*)-**2d**_c75	-1129.872838	-1129.506883	-1129.483793	155.8	-1129.557821	32.4	2.59	0.2

(*S*)-**2d**_c76	-1129.872708	-1129.506605	-1129.483603	155.1	-1129.557272	36.6	2.71	0.1
(*S*)-**2d**_c77	-1129.872510	-1129.506523	-1129.483530	154.5	-1129.556927	36.0	2.76	0.1
(*S*)-**2d**_c78	-1129.872628	-1129.506417	-1129.483475	154.0	-1129.556626	37.8	2.79	0.1
(*S*)-**2d**_c79	-1129.872453	-1129.506401	-1129.483383	154.5	-1129.556812	43.6	2.85	0.1
(*S*)-**2d**_c80	-1129.872158	-1129.506344	-1129.483362	154.8	-1129.556905	33.0	2.86	0.1
(*S*)-**2d**_c81	-1129.872467	-1129.506401	-1129.483346	154.8	-1129.556908	40.1	2.87	0.1
(*S*)-**2d**_c82	-1129.872640	-1129.506213	-1129.483333	153.6	-1129.556320	38.7	2.88	0.1
(*S*)-**2d**_c83	-1129.872520	-1129.506265	-1129.483291	154.0	-1129.556481	46.4	2.91	0.1
(*S*)-**2d**_c84	-1129.872276	-1129.506187	-1129.483249	154.0	-1129.556403	40.5	2.93	0.1
(*S*)-**2d**_c85	-1129.872186	-1129.506097	-1129.483118	154.6	-1129.556580	35.4	3.02	0.1
(*S*)-**2d**_c86	-1129.872162	-1129.505978	-1129.483077	153.9	-1129.556185	36.3	3.04	0.1
(*S*)-**2d**_c87	-1129.871868	-1129.505808	-1129.482854	154.3	-1129.556164	44.2	3.18	0.1
(*S*)-**2d**_c88	-1129.871568	-1129.505337	-1129.482389	153.9	-1129.555535	40.1	3.47	0.0
(*S*)-**2e**_c1	-994.180487	-993.858786	-993.838181	144.0	-993.906611	44.0	0.00	18.9
(*S*)-**2e**_c2	-994.179255	-993.857529	-993.836950	143.7	-993.905244	43.0	0.77	5.1
(*S*)-**2e**_c3	-994.179198	-993.857457	-993.836861	144.0	-993.905258	40.4	0.83	4.7
(*S*)-**2e**_c4	-994.179185	-993.857431	-993.836832	143.9	-993.905226	44.9	0.85	4.5
(*S*)-**2e**_c5	-994.178862	-993.857186	-993.836665	143.3	-993.904728	41.8	0.95	3.8
(*S*)-**2e**_c6	-994.178842	-993.856899	-993.836465	142.4	-993.904104	52.3	1.08	3.1
(*S*)-**2e**_c7	-994.178766	-993.857009	-993.836441	143.4	-993.904573	48.9	1.09	3.0
(*S*)-**2e**_c8	-994.178674	-993.856922	-993.836335	143.9	-993.904724	41.9	1.16	2.7
(*S*)-**2e**_c9	-994.178634	-993.856791	-993.836266	143.3	-993.904328	41.5	1.20	2.5
(*S*)-**2e**_c10	-994.178498	-993.856765	-993.836246	143.4	-993.904377	43.1	1.21	2.4
(*S*)-**2e**_c11	-994.178495	-993.856830	-993.836242	143.8	-993.904571	45.0	1.22	2.4
(*S*)-**2e**_c12	-994.178534	-993.856803	-993.836230	143.7	-993.904501	39.9	1.22	2.4
(*S*)-**2e**_c13	-994.178436	-993.856810	-993.836195	143.8	-993.904541	42.7	1.25	2.3

(*S*)-**2e**_c14	-994.178544	-993.856674	-993.836124	143.4	-993.904253	43.4	1.29	2.1
(*S*)-**2e**_c15	-994.178365	-993.856486	-993.836034	142.8	-993.903860	43.3	1.35	1.9
(*S*)-**2e**_c16	-994.178061	-993.856376	-993.835833	143.5	-993.904001	46.8	1.47	1.6
(*S*)-**2e**_c17	-994.177854	-993.856188	-993.835637	143.5	-993.903812	45.8	1.60	1.3
(*S*)-**2e**_c18	-994.177933	-993.856068	-993.835550	143.1	-993.903528	45.8	1.65	1.2
(*S*)-**2e**_c19	-994.177876	-993.856105	-993.835511	143.8	-993.903855	43.2	1.68	1.1
(*S*)-**2e**_c20	-994.177760	-993.856026	-993.835509	142.8	-993.903375	49.6	1.68	1.1
(*S*)-**2e**_c21	-994.177821	-993.856065	-993.835499	143.6	-993.903709	44.6	1.68	1.1
(*S*)-**2e**_c22	-994.177781	-993.855983	-993.835418	143.4	-993.903530	49.1	1.73	1.0
(*S*)-**2e**_c23	-994.177668	-993.856009	-993.835416	143.8	-993.903720	41.2	1.74	1.0
(*S*)-**2e**_c24	-994.177708	-993.855887	-993.835402	143.1	-993.903388	41.7	1.74	1.0
(*S*)-**2e**_c25	-994.177506	-993.856050	-993.835382	144.5	-993.904031	43.8	1.76	1.0
(*S*)-**2e**_c26	-994.177714	-993.855890	-993.835366	143.4	-993.903478	43.3	1.77	1.0
(*S*)-**2e**_c27	-994.177677	-993.855946	-993.835365	143.7	-993.903647	47.1	1.77	1.0
(*S*)-**2e**_c28	-994.177582	-993.855796	-993.835312	142.8	-993.903142	49.6	1.80	0.9
(*S*)-**2e**_c29	-994.177481	-993.855502	-993.835104	141.7	-993.902439	52.0	1.93	0.7
(*S*)-**2e**_c30	-994.177352	-993.855659	-993.835085	143.6	-993.903313	44.2	1.94	0.7
(*S*)-**2e**_c31	-994.177343	-993.855553	-993.835026	143.2	-993.903070	42.3	1.98	0.7
(*S*)-**2e**_c32	-994.177358	-993.855580	-993.835014	143.5	-993.903210	44.7	1.99	0.7
(*S*)-**2e**_c33	-994.177383	-993.855572	-993.834990	143.6	-993.903212	45.6	2.00	0.6
(*S*)-**2e**_c34	-994.177259	-993.855634	-993.834983	144.2	-993.903479	45.0	2.01	0.6
(*S*)-**2e**_c35	-994.177315	-993.855522	-993.834972	143.2	-993.902995	47.2	2.01	0.6
(*S*)-**2e**_c36	-994.177305	-993.855431	-993.834962	142.8	-993.902788	47.8	2.02	0.6
(*S*)-**2e**_c37	-994.177165	-993.855588	-993.834939	144.3	-993.903500	44.3	2.03	0.6
(*S*)-**2e**_c38	-994.177274	-993.855347	-993.834913	142.3	-993.902527	51.8	2.05	0.6
(*S*)-**2e**_c39	-994.177107	-993.855524	-993.834882	144.1	-993.903369	39.7	2.07	0.6
(*S*)-**2e**_c40	-994.177178	-993.855351	-993.834879	142.9	-993.902770	43.7	2.07	0.6

(*S*)-**2e**_c41	-994.177182	-993.855293	-993.834847	142.1	-993.902372	51.7	2.09	0.6
(*S*)-**2e**_c42	-994.176987	-993.855537	-993.834841	144.7	-993.903598	40.3	2.10	0.5
(*S*)-**2e**_c43	-994.177147	-993.855204	-993.834778	142.1	-993.902315	51.9	2.14	0.5
(*S*)-**2e**_c44	-994.177113	-993.855190	-993.834776	142.3	-993.902388	44.6	2.14	0.5
(*S*)-**2e**_c45	-994.177195	-993.855140	-993.834754	142.0	-993.902212	52.7	2.15	0.5
(*S*)-**2e**_c46	-994.176900	-993.855291	-993.834720	143.7	-993.903020	41.6	2.17	0.5
(*S*)-**2e**_c47	-994.176927	-993.855176	-993.834656	143.4	-993.902785	43.4	2.21	0.5
(*S*)-**2e**_c48	-994.176769	-993.855094	-993.834594	143.3	-993.902673	45.2	2.25	0.4
(*S*)-**2e**_c49	-994.176674	-993.855196	-993.834565	144.1	-993.903036	43.6	2.27	0.4
(*S*)-**2e**_c50	-994.176879	-993.855091	-993.834547	143.4	-993.902660	45.1	2.28	0.4
(*S*)-**2e**_c51	-994.176833	-993.855083	-993.834547	143.5	-993.902741	42.3	2.28	0.4
(*S*)-**2e**_c52	-994.176903	-993.855152	-993.834545	143.9	-993.902924	47.4	2.28	0.4
(*S*)-**2e**_c53	-994.176736	-993.855138	-993.834507	144.0	-993.902942	42.9	2.31	0.4
(*S*)-**2e**_c54	-994.176878	-993.855053	-993.834488	143.5	-993.902678	43.6	2.32	0.4
(*S*)-**2e**_c55	-994.176775	-993.855043	-993.834479	143.6	-993.902693	45.4	2.32	0.4
(*S*)-**2e**_c56	-994.176896	-993.855033	-993.834471	143.6	-993.902717	42.8	2.33	0.4
(*S*)-**2e**_c57	-994.176810	-993.854960	-993.834459	143.3	-993.902545	43.7	2.34	0.4
(*S*)-**2e**_c58	-994.176896	-993.854920	-993.834457	142.6	-993.902234	45.4	2.34	0.4
(*S*)-**2e**_c59	-994.176765	-993.854979	-993.834454	143.3	-993.902536	40.8	2.34	0.4
(*S*)-**2e**_c60	-994.176765	-993.854877	-993.834430	142.7	-993.902215	44.8	2.35	0.4
(*S*)-**2e**_c61	-994.176660	-993.854878	-993.834408	142.4	-993.902085	51.4	2.37	0.3
(*S*)-**2e**_c62	-994.176714	-993.854981	-993.834394	143.7	-993.902656	41.2	2.38	0.3
(*S*)-**2e**_c63	-994.176757	-993.854832	-993.834332	143.1	-993.902340	42.5	2.42	0.3
(*S*)-**2e**_c64	-994.176563	-993.854925	-993.834298	143.9	-993.902693	44.2	2.44	0.3
(*S*)-**2e**_c65	-994.176463	-993.854768	-993.834201	143.5	-993.902391	44.1	2.50	0.3
(*S*)-**2e**_c66	-994.176434	-993.854818	-993.834186	144.0	-993.902627	46.5	2.51	0.3
(*S*)-**2e**_c67	-994.176366	-993.854716	-993.834170	143.5	-993.902341	45.5	2.52	0.3

(*S*)-**2e**_c68	-994.176446	-993.854643	-993.834154	142.9	-993.902040	44.4	2.53	0.3
(*S*)-**2e**_c69	-994.176448	-993.854621	-993.834091	143.5	-993.902254	47.4	2.57	0.2
(*S*)-**2e**_c70	-994.176294	-993.854624	-993.834071	143.7	-993.902324	44.2	2.58	0.2
(*S*)-**2e**_c71	-994.176420	-993.854560	-993.834027	143.4	-993.902181	42.1	2.61	0.2
(*S*)-**2e**_c72	-994.176068	-993.854648	-993.833983	144.4	-993.902605	40.7	2.63	0.2
(*S*)-**2e**_c73	-994.176303	-993.854454	-993.833913	143.4	-993.902044	43.6	2.68	0.2
(*S*)-**2e**_c74	-994.176161	-993.854365	-993.833893	142.7	-993.901683	49.2	2.69	0.2
(*S*)-**2e**_c75	-994.176132	-993.854349	-993.833849	143.3	-993.901945	42.3	2.72	0.2
(*S*)-**2e**_c76	-994.176185	-993.854373	-993.833826	143.3	-993.901906	39.3	2.73	0.2
(*S*)-**2e**_c77	-994.176044	-993.854240	-993.833782	142.5	-993.901506	43.1	2.76	0.2
(*S*)-**2e**_c78	-994.176196	-993.854127	-993.833721	142.2	-993.901295	48.5	2.80	0.2
(*S*)-**2e**_c79	-994.175925	-993.854178	-993.833678	143.2	-993.901735	41.6	2.83	0.2
(*S*)-**2e**_c80	-994.175993	-993.854158	-993.833668	143.0	-993.901594	47.1	2.83	0.2
(*S*)-**2e**_c81	-994.175941	-993.854160	-993.833664	142.8	-993.901513	46.5	2.83	0.2
(*S*)-**2e**_c82	-994.175735	-993.854206	-993.833614	143.6	-993.901840	46.3	2.87	0.1
(*S*)-**2e**_c83	-994.175912	-993.854159	-993.833600	143.5	-993.901786	45.9	2.87	0.1
(*S*)-**2e**_c84	-994.175912	-993.854112	-993.833559	143.4	-993.901676	50.0	2.90	0.1
(*S*)-**2e**_c85	-994.175948	-993.854074	-993.833555	143.2	-993.901602	46.1	2.90	0.1
(*S*)-**2e**_c86	-994.175681	-993.854111	-993.833546	143.6	-993.901756	48.9	2.91	0.1
(*S*)-**2e**_c87	-994.175895	-993.853975	-993.833512	142.7	-993.901336	43.5	2.93	0.1
(*S*)-**2e**_c88	-994.175737	-993.854025	-993.833437	143.6	-993.901664	46.8	2.98	0.1
(*S*)-**2e**_c89	-994.175715	-993.853994	-993.833434	143.6	-993.901684	45.7	2.98	0.1
(*S*)-**2e**_c90	-994.175891	-993.853785	-993.833400	141.9	-993.900814	51.8	3.00	0.1
(*S*)-**2e**_c91	-994.175802	-993.853794	-993.833393	142.0	-993.900882	49.8	3.00	0.1
(*S*)-**2e**_c92	-994.175722	-993.853820	-993.833386	142.3	-993.900985	44.7	3.01	0.1
(*S*)-**2e**_c93	-994.175706	-993.853902	-993.833364	143.4	-993.901481	38.1	3.02	0.1
(*S*)-**2e**_c94	-994.175729	-993.853716	-993.833324	141.9	-993.900760	50.1	3.05	0.1

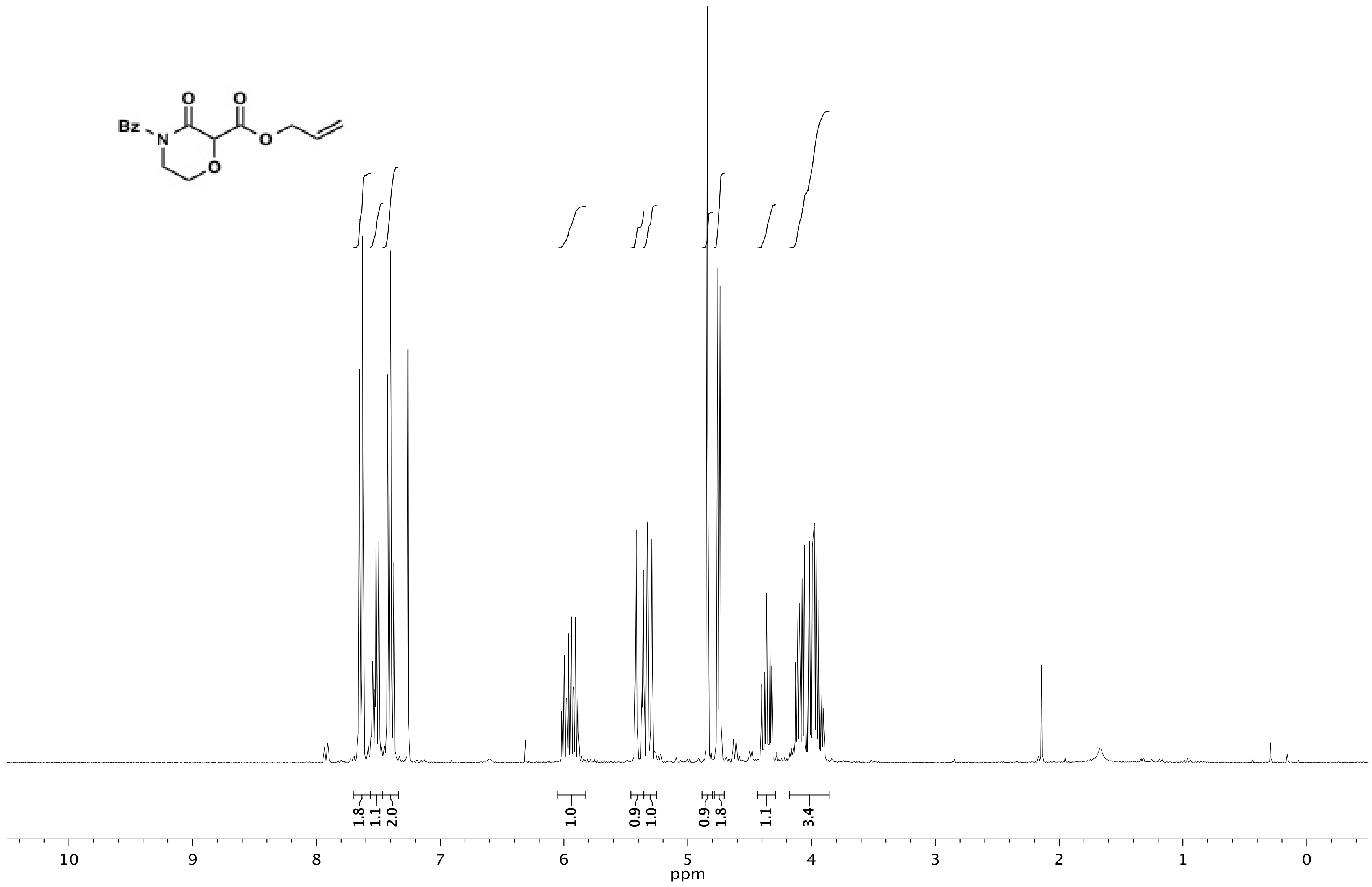
(*S*)-**2e**_c95	-994.175447	-993.853816	-993.833308	143.0	-993.901253	45.3	3.06	0.1
(*S*)-**2e**_c96	-994.175575	-993.853598	-993.833206	142.1	-993.900717	46.6	3.12	0.1
(*S*)-**2e**_c97	-994.175408	-993.853641	-993.833099	143.4	-993.901248	48.8	3.19	0.1
(*S*)-**2e**_c98	-994.175342	-993.853558	-993.833039	142.8	-993.900898	50.3	3.23	0.1
(*S*)-**2e**_c99	-994.175303	-993.853552	-993.832991	143.7	-993.901270	44.9	3.26	0.1
(*S*)-**2e**_c100	-994.175256	-993.853504	-993.832967	143.2	-993.900988	39.0	3.27	0.1
(*S*)-**2e**_c101	-994.175104	-993.853417	-993.832925	143.0	-993.900868	46.9	3.30	0.1
(*S*)-**2e**_c102	-994.175314	-993.853330	-993.832901	142.7	-993.900687	45.5	3.31	0.1
(*S*)-**2e**_c103	-994.175146	-993.853345	-993.832848	143.2	-993.900890	44.6	3.35	0.1
(*S*)-**2e**_c104	-994.175129	-993.853178	-993.832788	142.0	-993.900253	46.9	3.38	0.1
(*S*)-**2e**_c105	-994.175038	-993.853310	-993.832783	143.3	-993.900883	44.7	3.39	0.1
(*S*)-**2e**_c106	-994.174958	-993.853278	-993.832780	142.7	-993.900567	48.3	3.39	0.1
(*S*)-**2e**_c107	-994.175118	-993.853167	-993.832759	142.0	-993.900247	50.5	3.40	0.1
(*S*)-**2e**_c108	-994.175073	-993.853078	-993.832694	142.3	-993.900304	46.1	3.44	0.1
(*S*)-**2e**_c109	-994.175013	-993.853118	-993.832640	142.8	-993.900478	42.6	3.48	0.1
(*S*)-**2e**_c110	-994.174972	-993.853020	-993.832633	142.3	-993.900241	49.3	3.48	0.1
(*S*)-**2e**_c111	-994.174740	-993.852971	-993.832528	142.6	-993.900294	43.0	3.55	0.0
(*S*)-**2e**_c112	-994.174792	-993.852964	-993.832524	142.3	-993.900140	50.0	3.55	0.0
(*S*)-**2e**_c113	-994.174547	-993.852782	-993.832330	142.3	-993.899963	46.8	3.67	0.0
(*S*)-**2e**_c114	-994.174579	-993.852621	-993.832227	142.3	-993.899823	42.9	3.74	0.0
(*S*)-**2e**_c115	-994.171893	-993.850227	-993.829653	143.5	-993.897855	45.3	5.35	0.0
(*S*)-**2f**_c1	-1185.548805	-1185.258203	-1185.239805	132.8	-1185.302906	52.3	0.00	20.5
(*S*)-**2f**_c2	-1185.548375	-1185.257790	-1185.239418	132.5	-1185.302379	52.6	0.24	13.6
(*S*)-**2f**_c3	-1185.548185	-1185.257529	-1185.239145	132.6	-1185.302163	50.3	0.41	10.2
(*S*)-**2f**_c4	-1185.547951	-1185.257264	-1185.238922	132.1	-1185.301699	49.2	0.55	8.0
(*S*)-**2f**_c5	-1185.547943	-1185.257171	-1185.238837	132.0	-1185.301566	54.8	0.61	7.3

(*S*)-**2f**_c6	-1185.547718	-1185.257089	-1185.238705	132.6	-1185.301715	50.7	0.69	6.4
(*S*)-**2f**_c7	-1185.547580	-1185.256784	-1185.238471	132.3	-1185.301315	52.6	0.84	5.0
(*S*)-**2f**_c8	-1185.547356	-1185.256678	-1185.238314	132.7	-1185.301359	49.2	0.94	4.2
(*S*)-**2f**_c9	-1185.547462	-1185.256652	-1185.238303	132.5	-1185.301277	53.1	0.94	4.2
(*S*)-**2f**_c10	-1185.547202	-1185.256447	-1185.238118	132.4	-1185.301029	51.7	1.06	3.4
(*S*)-**2f**_c11	-1185.547188	-1185.256258	-1185.237997	131.7	-1185.300569	56.1	1.13	3.0
(*S*)-**2f**_c12	-1185.546860	-1185.256180	-1185.237793	132.9	-1185.300961	48.7	1.26	2.4
(*S*)-**2f**_c13	-1185.546765	-1185.255999	-1185.237671	132.4	-1185.300593	50.1	1.34	2.1
(*S*)-**2f**_c14	-1185.546660	-1185.255888	-1185.237543	132.6	-1185.300528	49.9	1.42	1.9
(*S*)-**2f**_c15	-1185.546575	-1185.255765	-1185.237462	131.9	-1185.300127	55.0	1.47	1.7
(*S*)-**2f**_c16	-1185.546368	-1185.255648	-1185.237319	131.9	-1185.299991	52.7	1.56	1.5
(*S*)-**2f**_c17	-1185.546200	-1185.255433	-1185.237115	132.2	-1185.299915	55.0	1.69	1.2
(*S*)-**2f**_c18	-1185.545812	-1185.255228	-1185.236852	132.8	-1185.299943	45.6	1.85	0.9
(*S*)-**2f**_c19	-1185.545922	-1185.255186	-1185.236840	132.6	-1185.299856	50.2	1.86	0.9
(*S*)-**2f**_c20	-1185.545718	-1185.254966	-1185.236587	132.7	-1185.299617	53.3	2.02	0.7
(*S*)-**2f**_c21	-1185.545335	-1185.254743	-1185.236321	133.1	-1185.299565	48.4	2.19	0.5
(*S*)-**2f**_c22	-1185.544678	-1185.253803	-1185.235515	131.8	-1185.298131	51.1	2.69	0.2
(*S*)-**2f**_c23	-1185.543975	-1185.253438	-1185.235020	133.0	-1185.298220	50.5	3.00	0.1
(*S*)-**2f**_c24	-1185.543408	-1185.252883	-1185.234524	132.4	-1185.297411	53.1	3.31	0.1
(*S*)-**2f**_c25	-1185.540998	-1185.250434	-1185.232022	132.6	-1185.295036	48.7	4.88	0.0
(*S*)-**2f**_c26	-1185.540183	-1185.249525	-1185.231115	132.9	-1185.294258	49.2	5.45	0.0
(*S*)-**2f**_c27	-1185.539168	-1185.248629	-1185.230161	133.5	-1185.293591	43.6	6.05	0.0
(*R*)-**4a**_c1	-823.200871	-822.936613	-822.919763	125.7	-822.979504	53.5	0.00	9.7
(*R*)-**4a**_c2	-823.201047	-822.936580	-822.919755	125.8	-822.979503	52.1	0.01	9.6
(*R*)-**4a**_c3	-823.200706	-822.936311	-822.919467	125.8	-822.979261	54.7	0.19	7.1
(*R*)-**4a**_c4	-823.200513	-822.936296	-822.919417	126.0	-822.979288	55.2	0.22	6.7

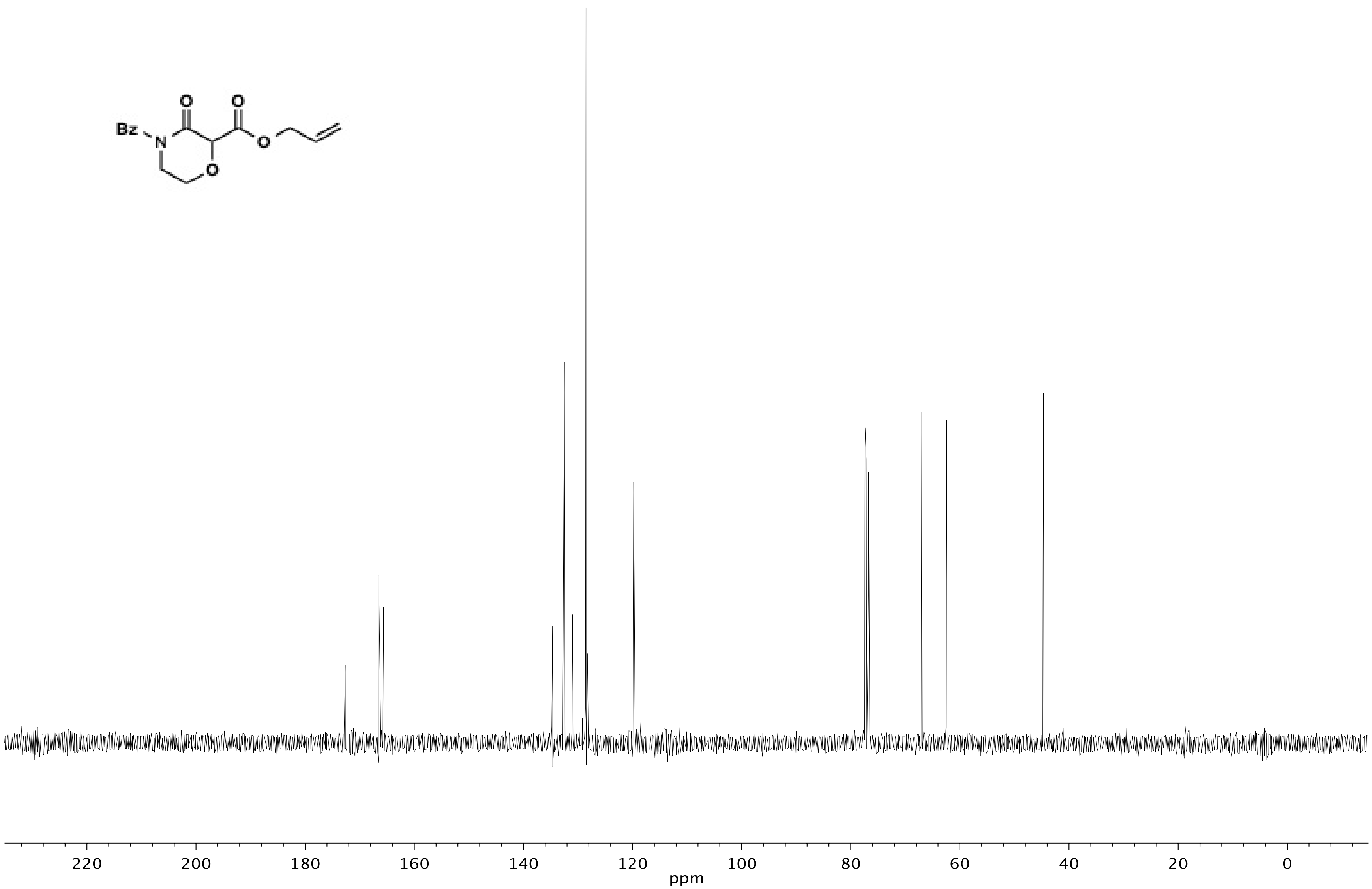
(*R*)-**4a**_c5	-823.200425	-822.936254	-822.919387	126.1	-822.979280	50.3	0.24	6.5
(*R*)-**4a**_c6	-823.200527	-822.936230	-822.919376	126.1	-822.979285	49.6	0.24	6.4
(*R*)-**4a**_c7	-823.200327	-822.936153	-822.919246	126.2	-822.979199	52.1	0.32	5.6
(*R*)-**4a**_c8	-823.200194	-822.936011	-822.919154	125.8	-822.978926	52.9	0.38	5.1
(*R*)-**4a**_c9	-823.200203	-822.935979	-822.919103	126.3	-822.979096	51.8	0.41	4.8
(*R*)-**4a**_c10	-823.200085	-822.935927	-822.919044	126.3	-822.979052	52.6	0.45	4.5
(*R*)-**4a**_c11	-823.199895	-822.935720	-822.918836	126.2	-822.978783	51.0	0.58	3.6
(*R*)-**4a**_c12	-823.199814	-822.935708	-822.918832	126.1	-822.978734	52.6	0.58	3.6
(*R*)-**4a**_c13	-823.199512	-822.935438	-822.918545	126.1	-822.978437	51.8	0.76	2.7
(*R*)-**4a**_c14	-823.199559	-822.935387	-822.918522	125.8	-822.978311	57.4	0.78	2.6
(*R*)-**4a**_c15	-823.199394	-822.935157	-822.918306	125.6	-822.978005	48.9	0.91	2.1
(*R*)-**4a**_c16	-823.199466	-822.935119	-822.918286	125.7	-822.977988	51.3	0.93	2.0
(*R*)-**4a**_c17	-823.199173	-822.935050	-822.918186	126.0	-822.978050	58.6	0.99	1.8
(*R*)-**4a**_c18	-823.199176	-822.935025	-822.918141	126.1	-822.978046	47.2	1.02	1.7
(*R*)-**4a**_c19	-823.199080	-822.934925	-822.918066	126.0	-822.977937	50.4	1.06	1.6
(*R*)-**4a**_c20	-823.198824	-822.934688	-822.917837	125.9	-822.977645	49.6	1.21	1.3
(*R*)-**4a**_c21	-823.198728	-822.934624	-822.917754	125.9	-822.977589	49.7	1.26	1.2
(*R*)-**4a**_c22	-823.198755	-822.934672	-822.917695	126.8	-822.977938	43.6	1.30	1.1
(*R*)-**4a**_c23	-823.198701	-822.934336	-822.917534	125.6	-822.977210	51.9	1.40	0.9
(*R*)-**4a**_c24	-823.198467	-822.934405	-822.917433	126.7	-822.977630	45.0	1.46	0.8
(*R*)-**4a**_c25	-823.198575	-822.934324	-822.917384	126.6	-822.977531	48.8	1.49	0.8
(*R*)-**4a**_c26	-823.198363	-822.934155	-822.917208	126.7	-822.977389	46.6	1.60	0.6
(*R*)-**4a**_c27	-823.198354	-822.934163	-822.917185	126.9	-822.977465	48.3	1.62	0.6
(*R*)-**4a**_c28	-823.198025	-822.934081	-822.917059	127.1	-822.977428	47.3	1.70	0.6
(*R*)-**4a**_c29	-823.198055	-822.933893	-822.916920	126.8	-822.977181	48.6	1.78	0.5
(*R*)-**4a**_c30	-823.197821	-822.933793	-822.916822	126.6	-822.976971	46.0	1.85	0.4
(*R*)-**4a**_c31	-823.197635	-822.933779	-822.916762	127.0	-822.977085	43.2	1.88	0.4

(*R*)-**4a**_c32	-823.197816	-822.933738	-822.916753	126.8	-822.977000	47.7	1.89	0.4
(*R*)-**4a**_c33	-823.197784	-822.933712	-822.916724	126.8	-822.976976	49.0	1.91	0.4
(*R*)-**4a**_c34	-823.197599	-822.933579	-822.916592	126.8	-822.976845	43.4	1.99	0.3
(*R*)-**4a**_c35	-823.197546	-822.933545	-822.916531	127.0	-822.976889	44.3	2.03	0.3
(*R*)-**4a**_c36	-823.197214	-822.933183	-822.916198	126.7	-822.976398	44.6	2.24	0.2
(*R*)-**4a**_c37	-823.197130	-822.933116	-822.916142	126.6	-822.976316	46.8	2.27	0.2
(*R*)-**4a**_c38	-823.196953	-822.932984	-822.915983	126.7	-822.976187	45.7	2.37	0.2
(*R*)-**4a**_c39	-823.196890	-822.932933	-822.915939	126.8	-822.976176	43.3	2.40	0.2
(*R*)-**4a**_c40	-823.196792	-822.932781	-822.915882	126.1	-822.975810	53.6	2.44	0.2
(*R*)-**4a**_c41	-823.196452	-822.932532	-822.915531	126.9	-822.975826	39.7	2.66	0.1
(*R*)-**4a**_c42	-823.196664	-822.932405	-822.915462	126.6	-822.975599	43.5	2.70	0.1
(*R*)-**4a**_c43	-823.196546	-822.932380	-822.915442	126.5	-822.975525	45.4	2.71	0.1
(*R*)-**4a**_c44	-823.196222	-822.932151	-822.915284	126.2	-822.975228	55.3	2.81	0.1
(*R*)-**4a**_c45	-823.196178	-822.932146	-822.915194	126.6	-822.975343	46.0	2.87	0.1
(*R*)-**4a**_c46	-823.195834	-822.931941	-822.914926	127.0	-822.975284	43.7	3.04	0.1
(*R*)-**4a**_c47	-823.194178	-822.930268	-822.913248	127.0	-822.973613	44.8	4.09	0.0
(*R*)-**4a**_c48	-823.193766	-822.929863	-822.912863	126.9	-822.973181	45.0	4.33	0.0

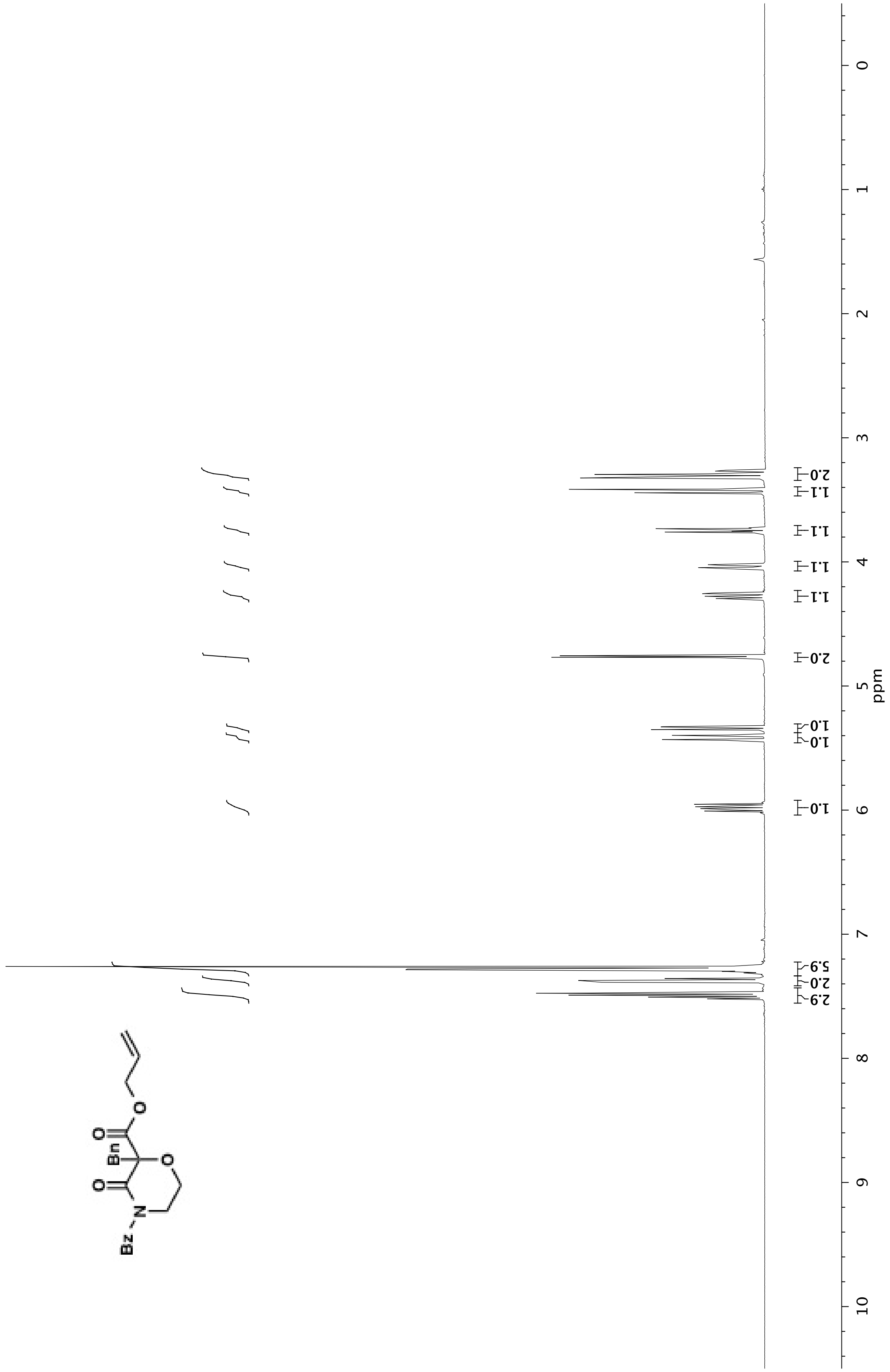
[a] 1 Hartree = 627.51 kcal mol^{-1}. [b] Thermal corrections at 298.15 K.



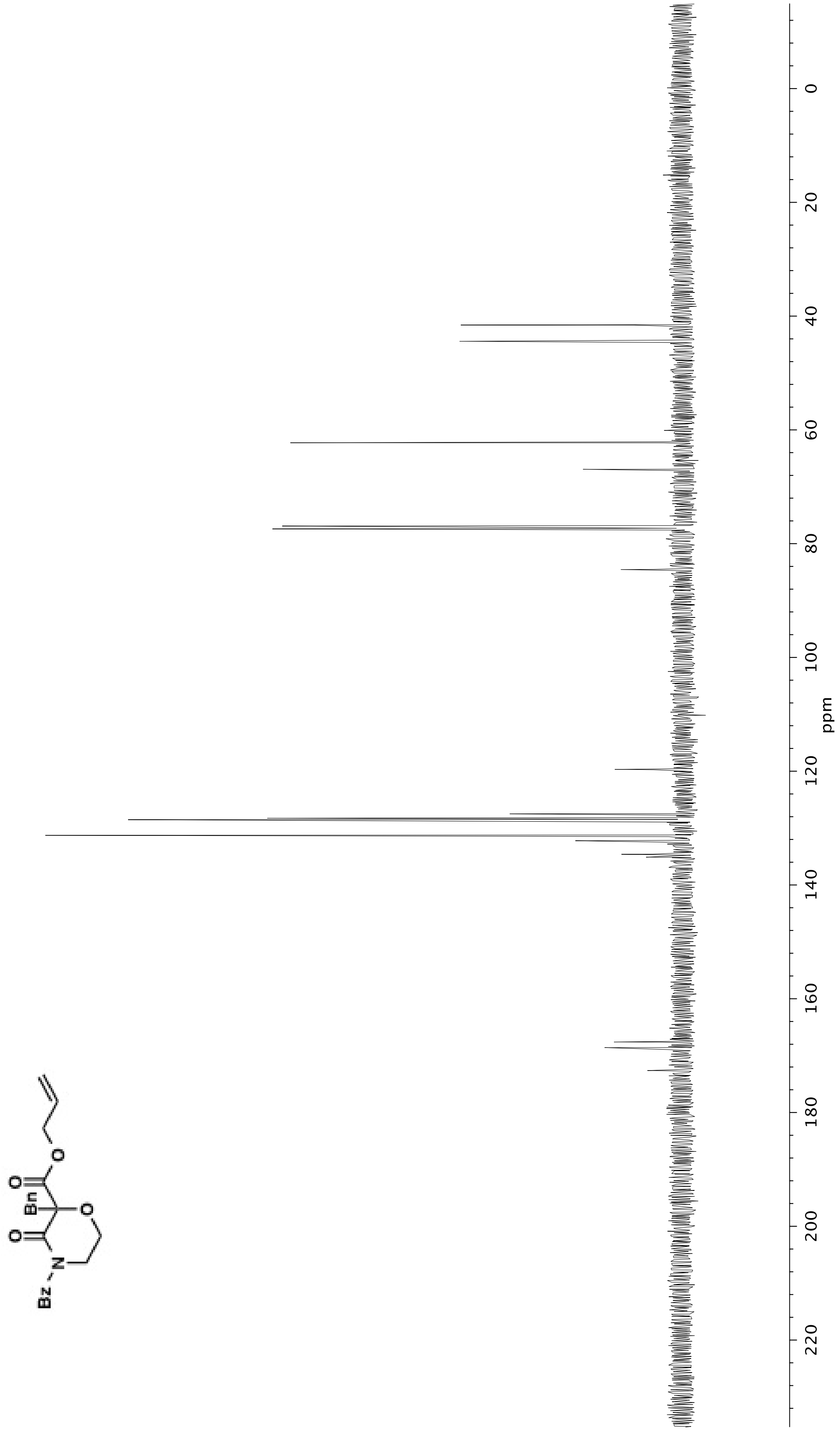
^{1}H NMR (300 MHz, CDCl$_3$) of compound **SI-2**.



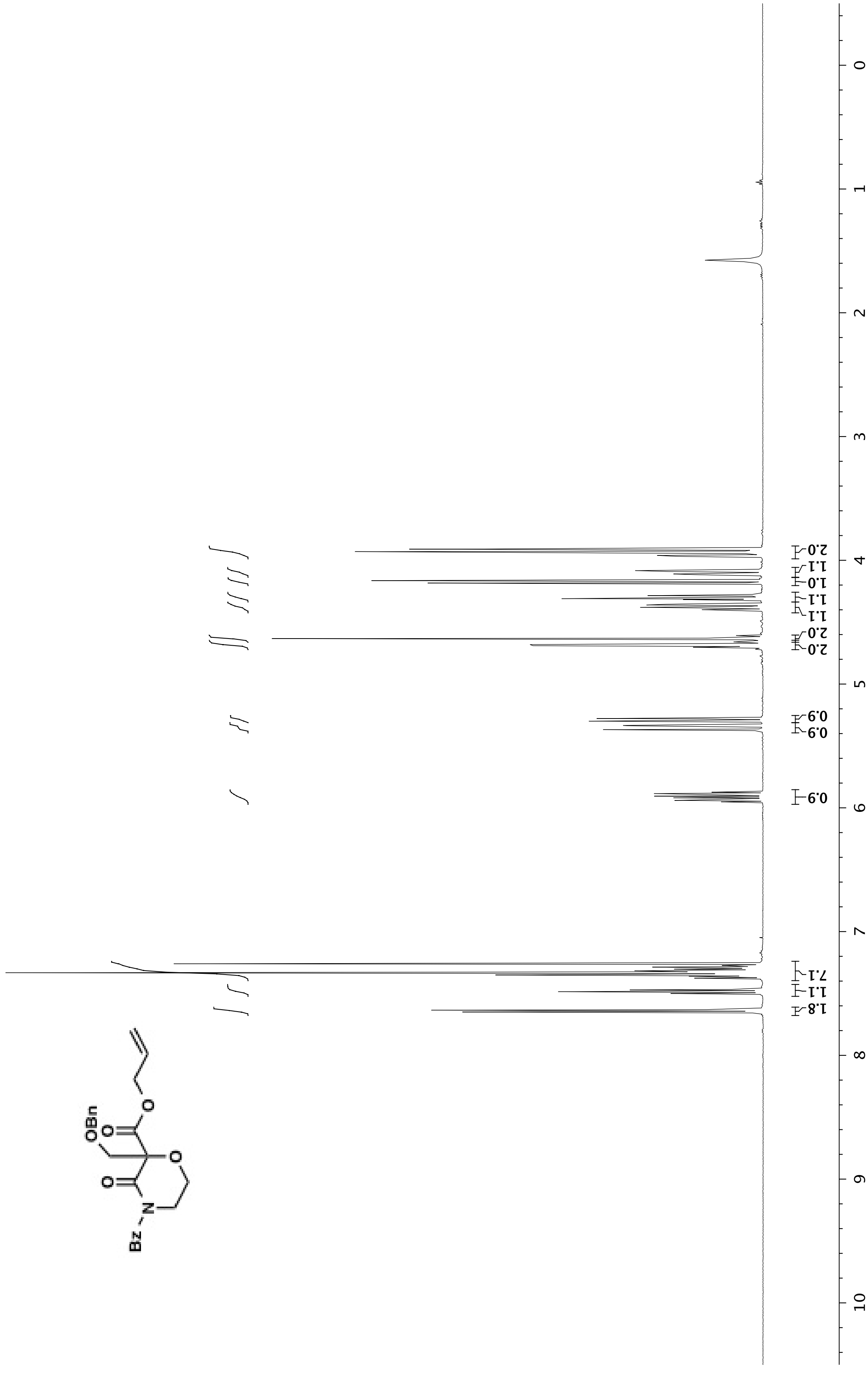
^{13}C NMR (76 MHz, CDCl$_3$) of compound **SI-2**.



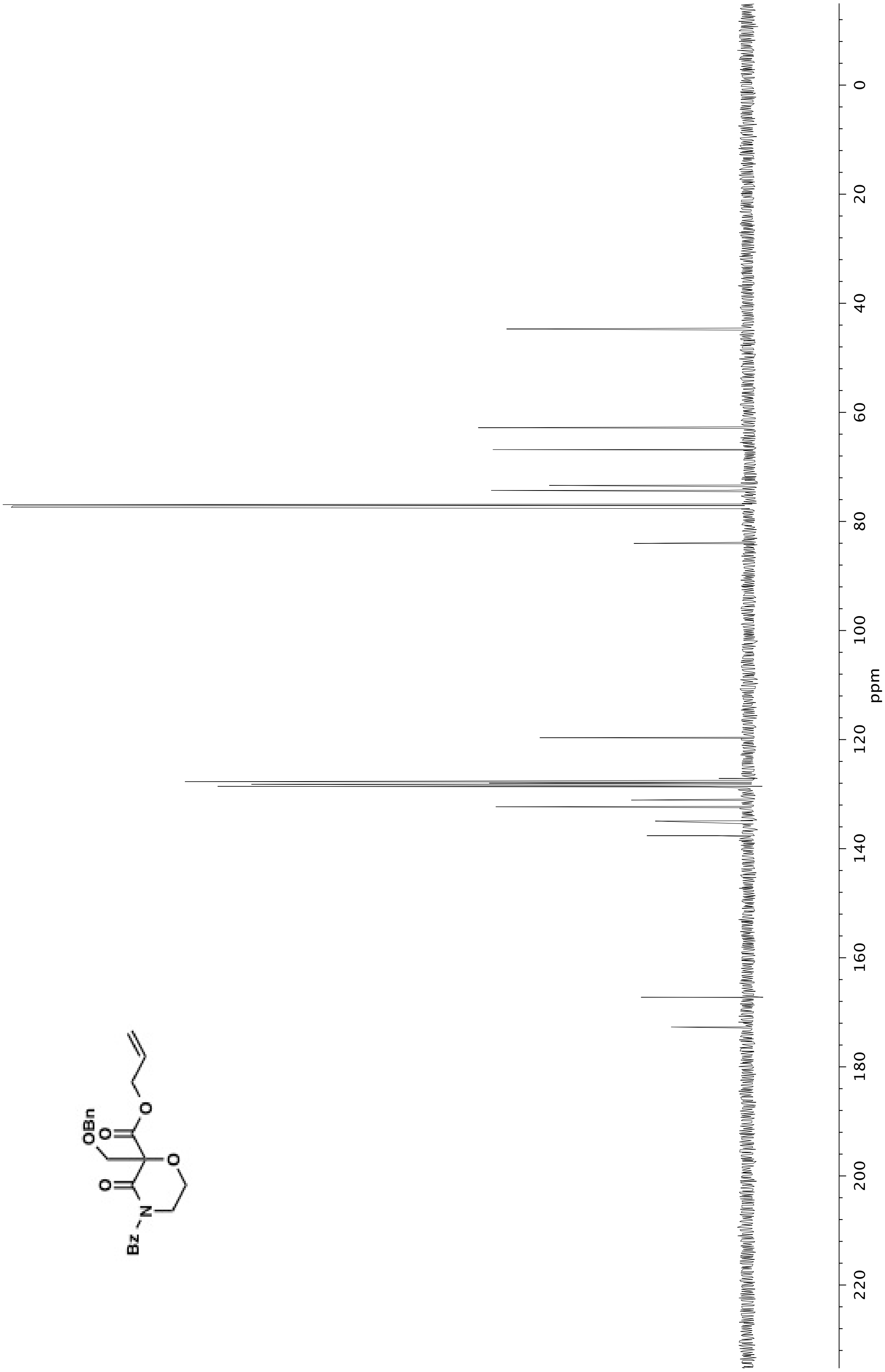
^{1}H NMR (500 MHz, CDCl$_3$) of compound **1b**.



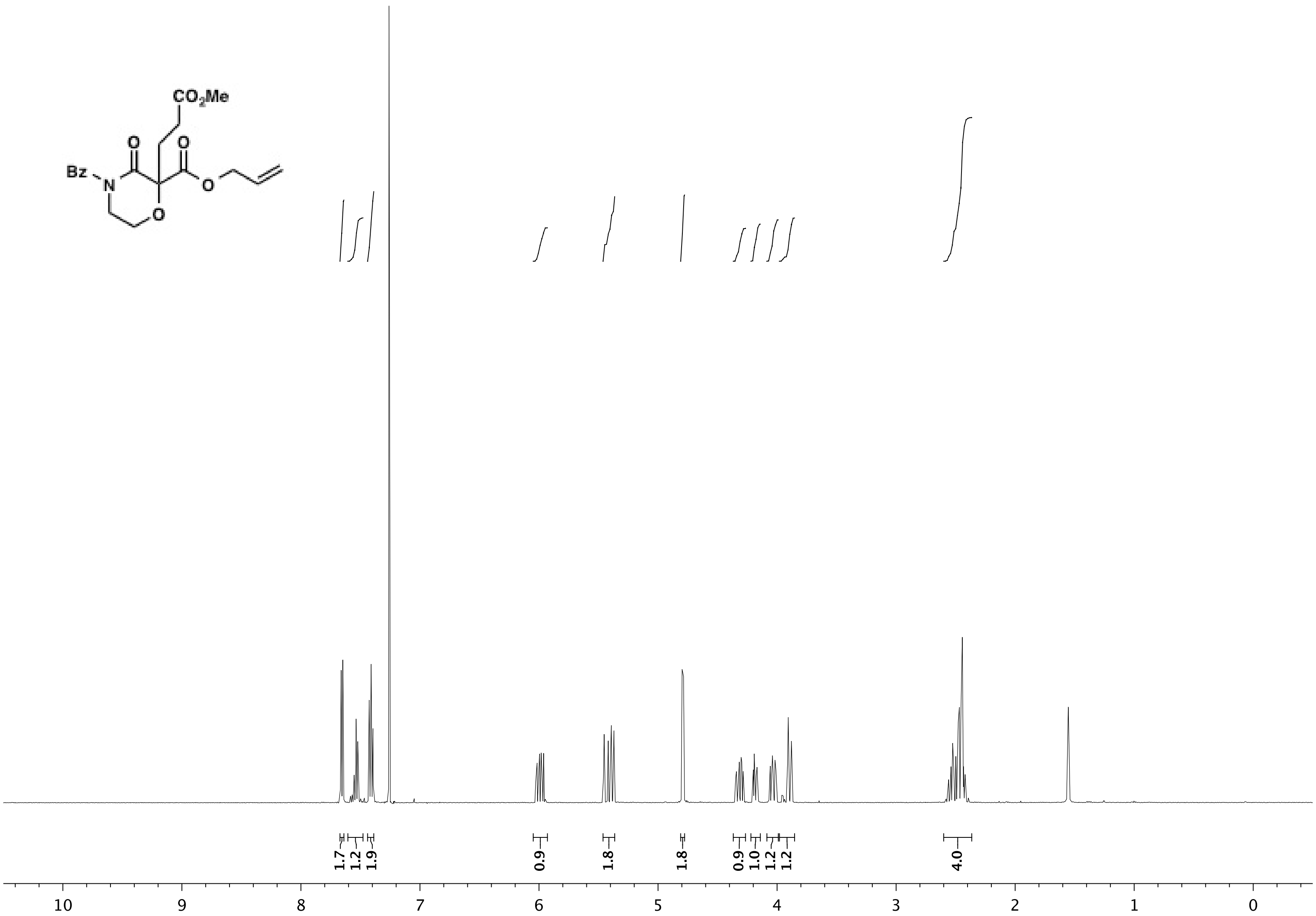
^{13}C NMR (126 MHz, $CDCl_3$) of compound **1b**.



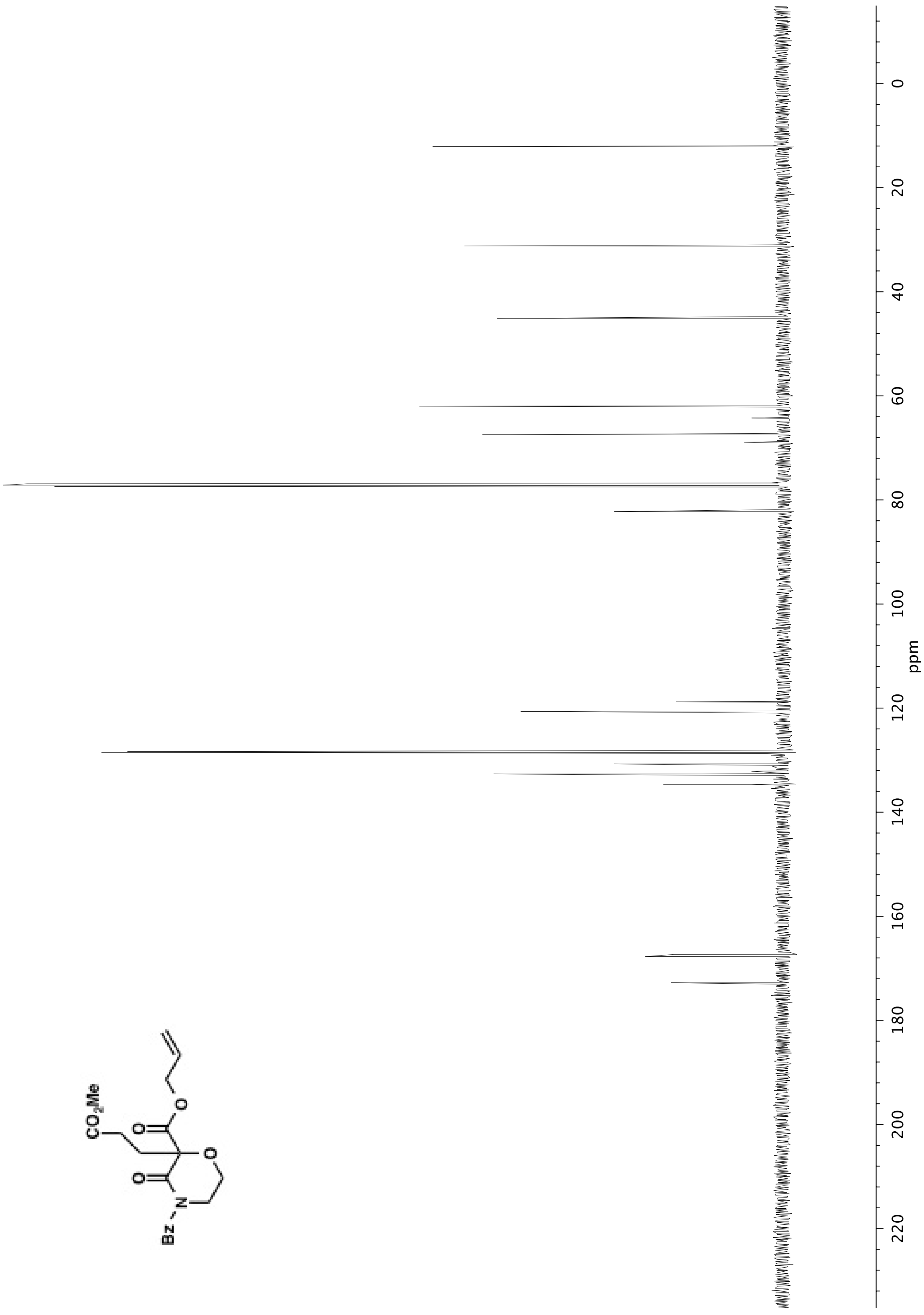
^{1}H NMR (500 MHz, $CDCl_3$) of compound **1c**.



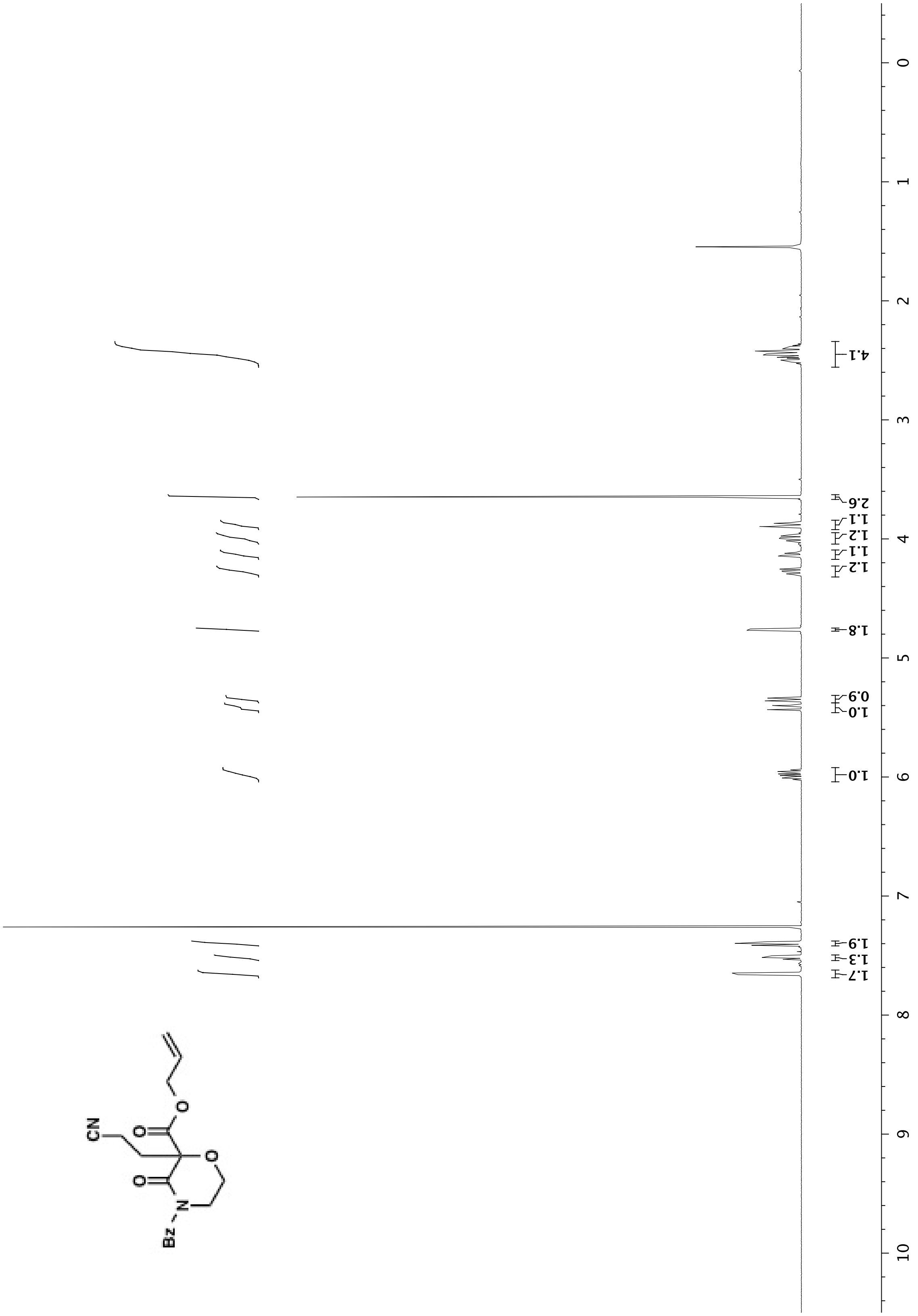
^{13}C NMR (126 MHz, CDCl$_3$) of compound **1c**.



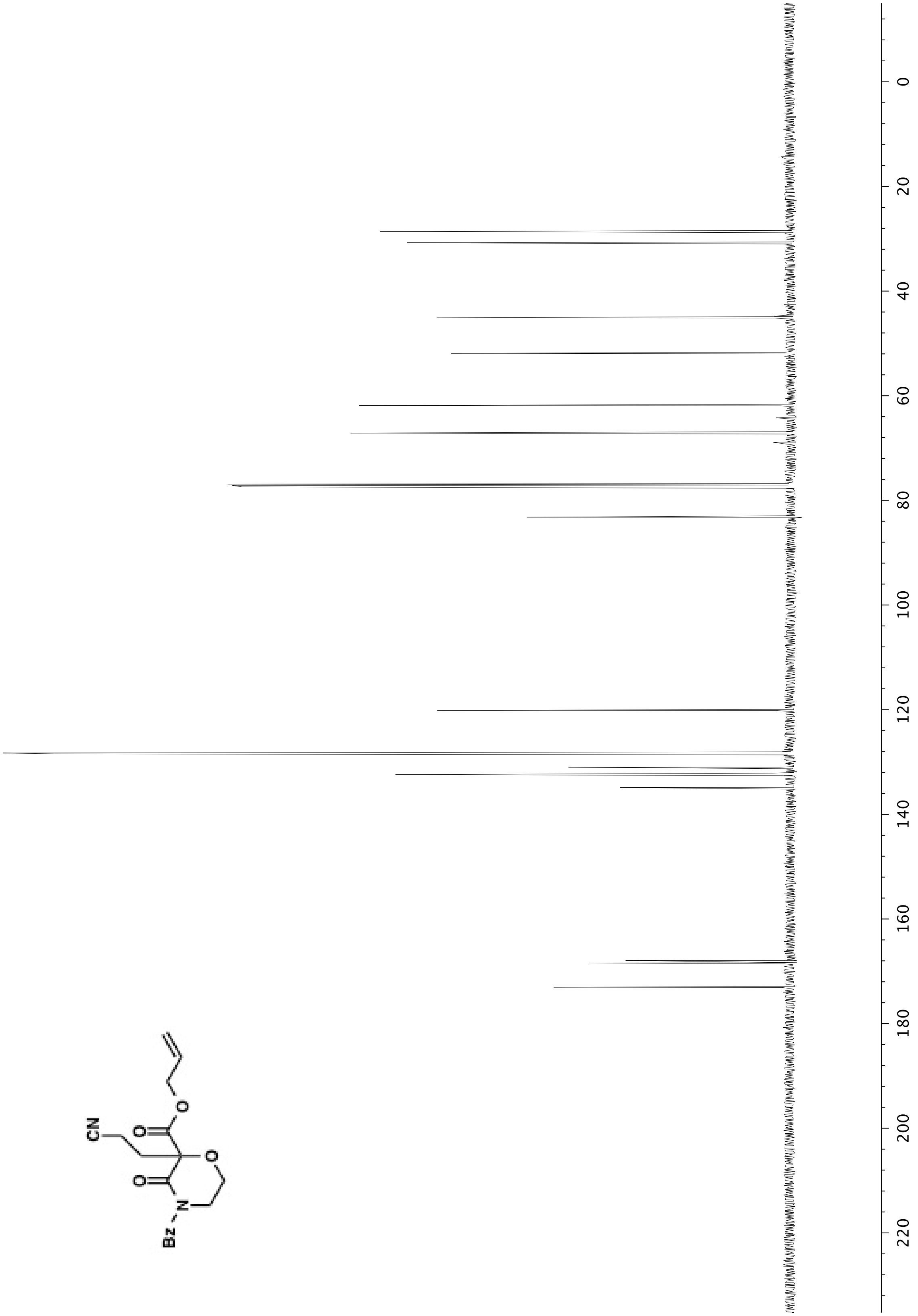
^{1}H NMR (500 MHz, $CDCl_3$) of compound **1e**.



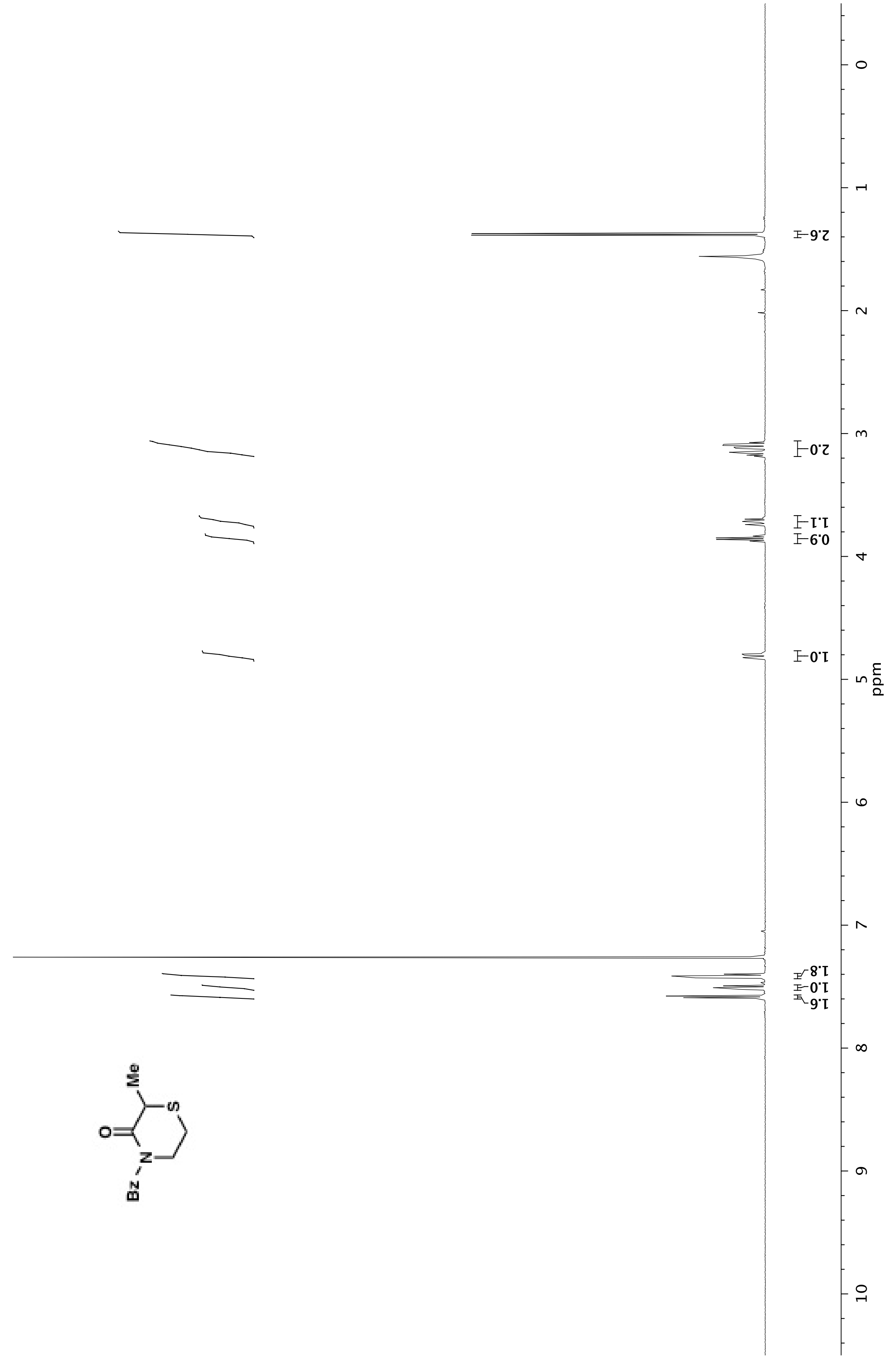
^{13}C NMR (126 MHz, CDCl$_3$) of compound **1e**.



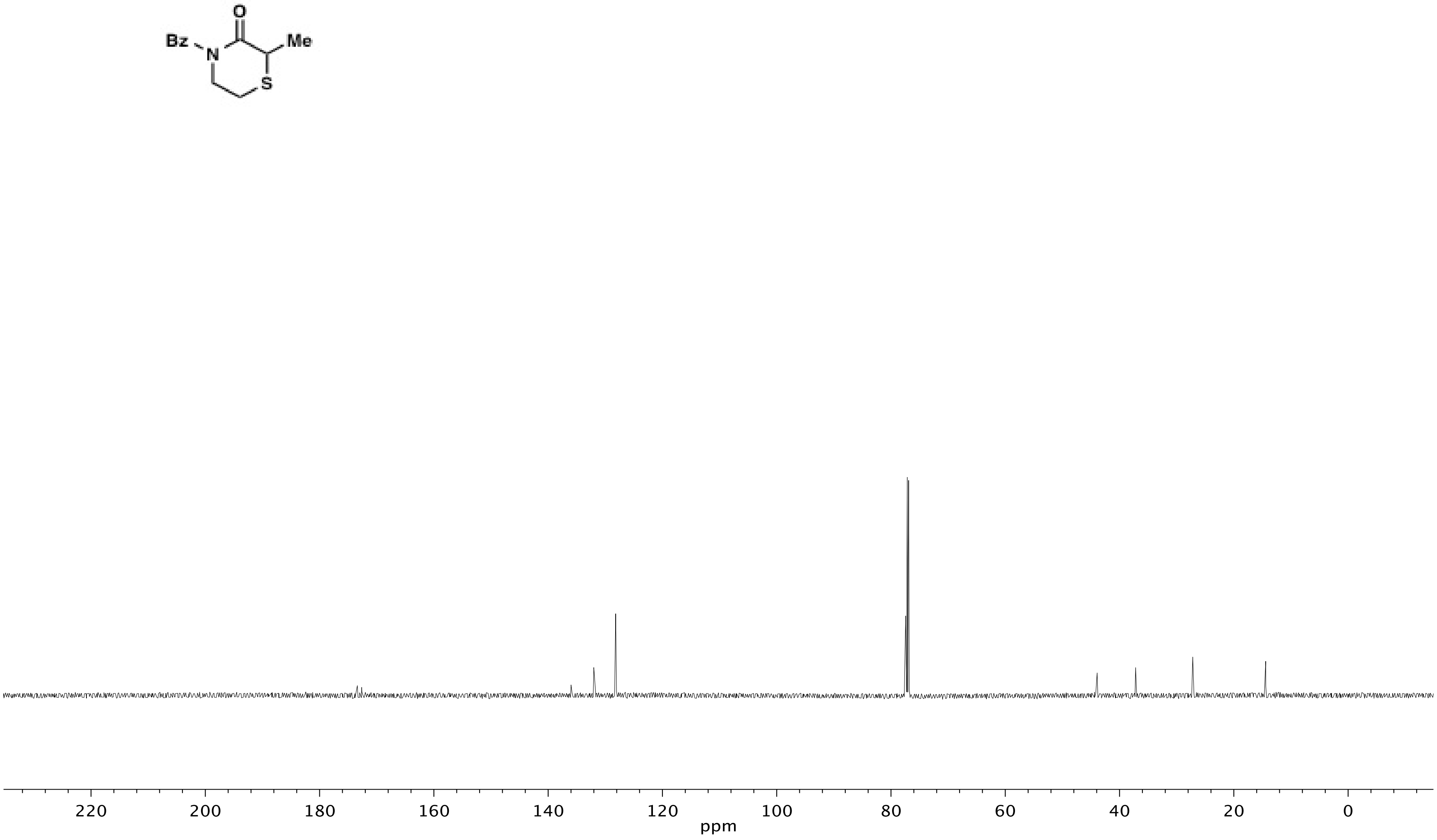
^{1}H NMR (500 MHz, $CDCl_3$) of compound **1d**.



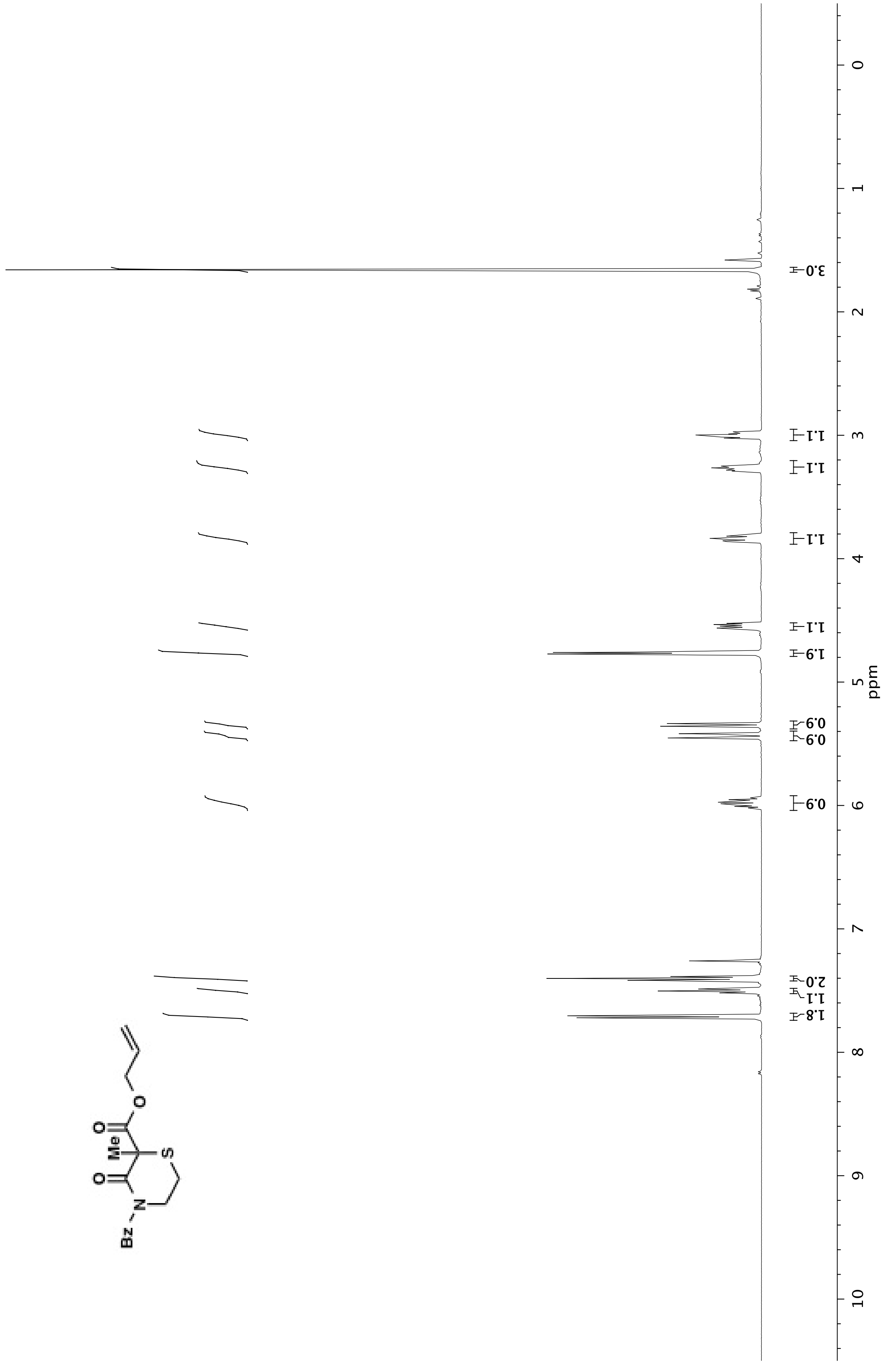
^{13}C NMR (126 MHz, CDCl$_3$) of compound **1d**.



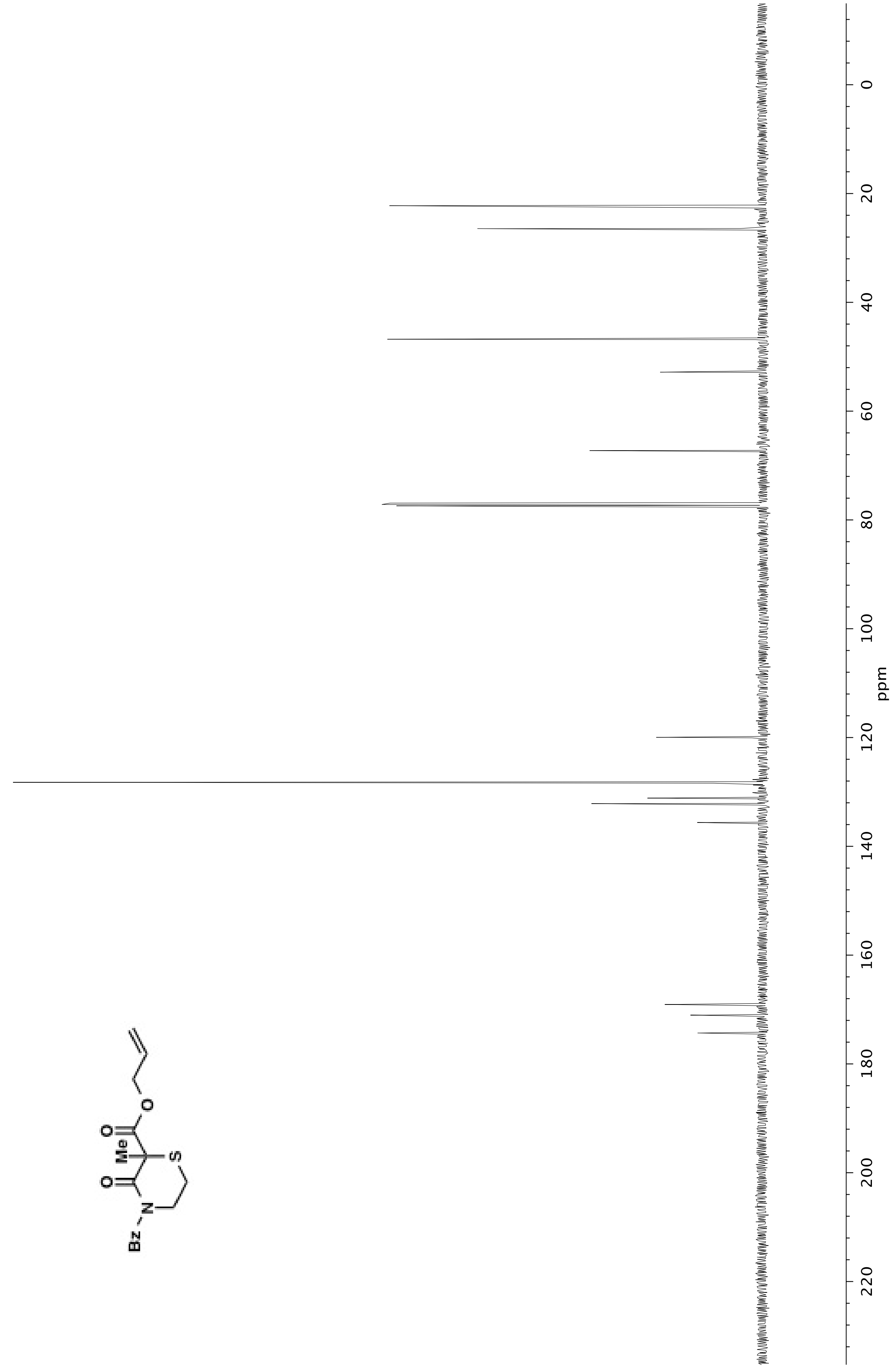
^{1}H NMR (500 MHz, CDCl$_3$) of compound **SI-4**.



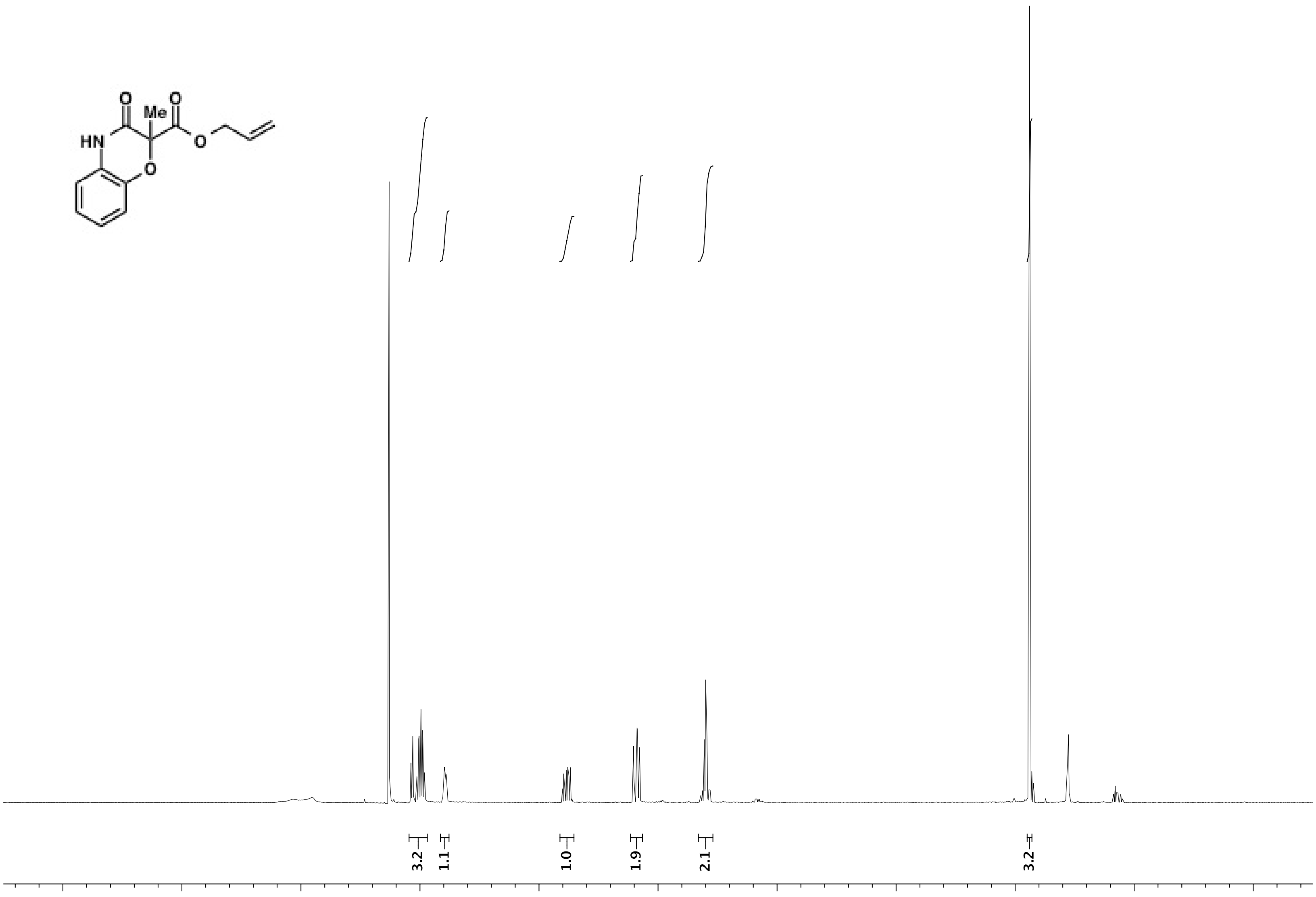
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-4**.



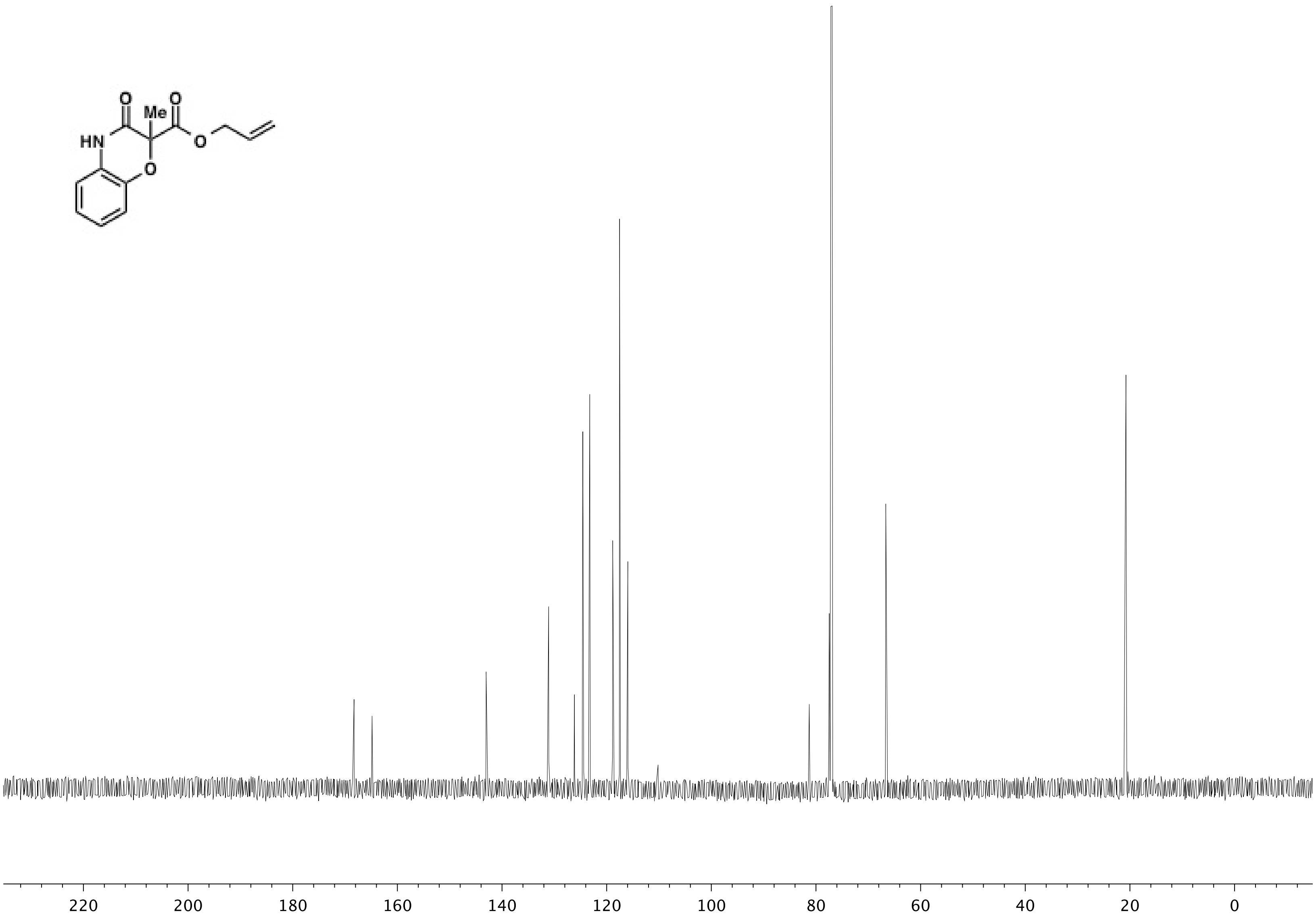
^{1}H NMR (500 MHz, CDCl$_3$) of compound **1f**.



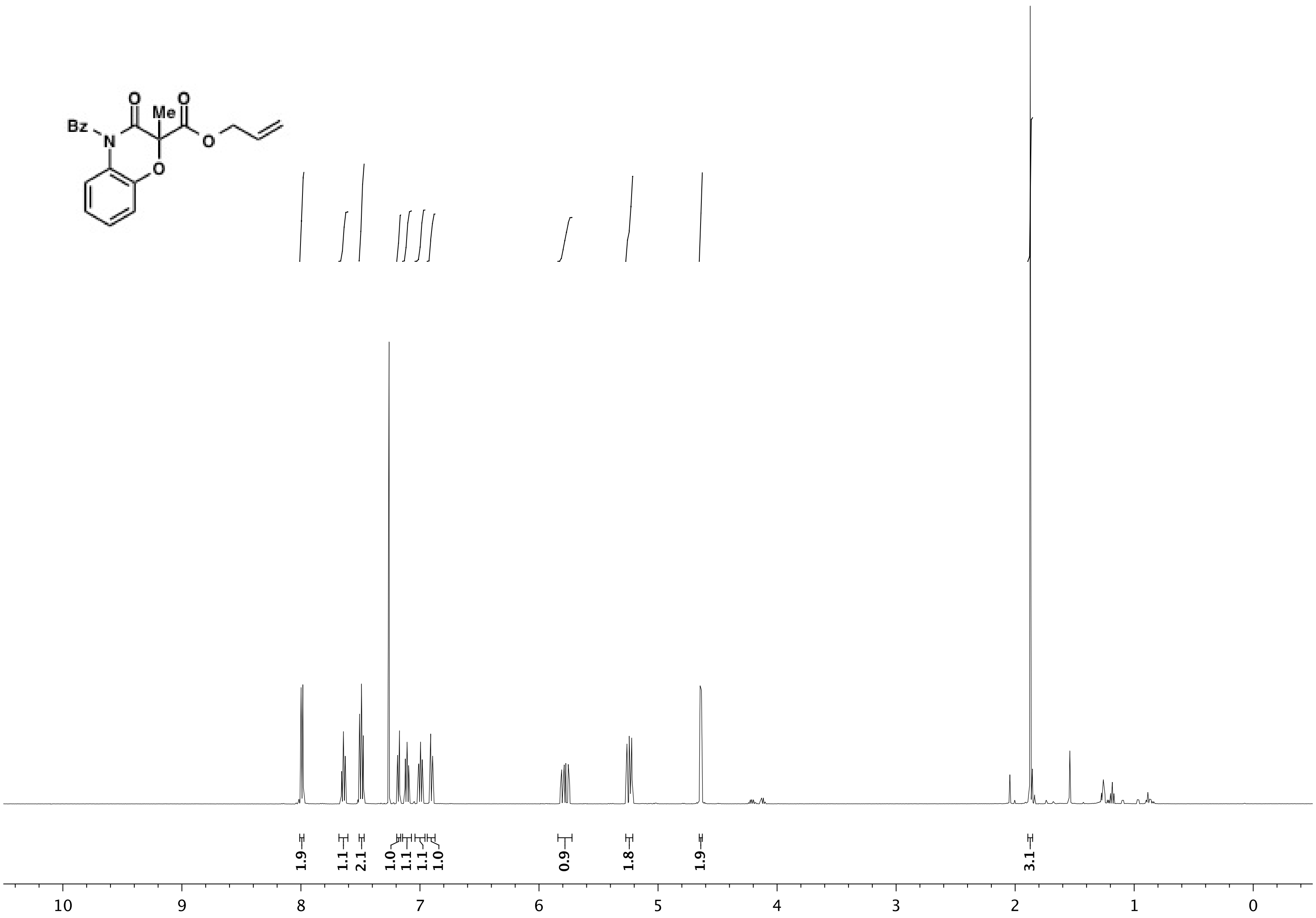
^{13}C NMR (126 MHz, CDCl$_3$) of compound **1f**.



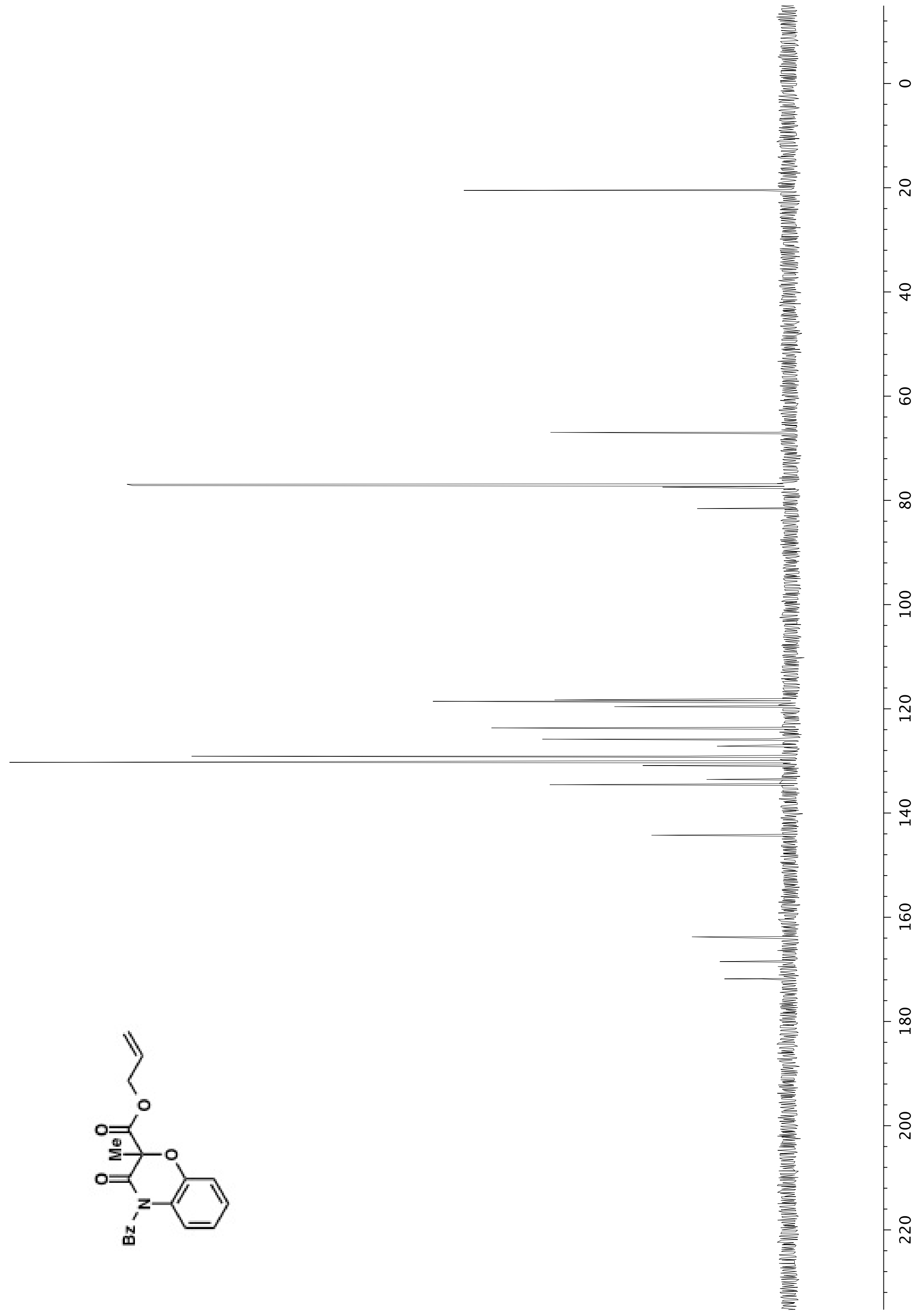
^{1}H NMR (500 MHz, CDCl$_3$) of compound **SI-6**.



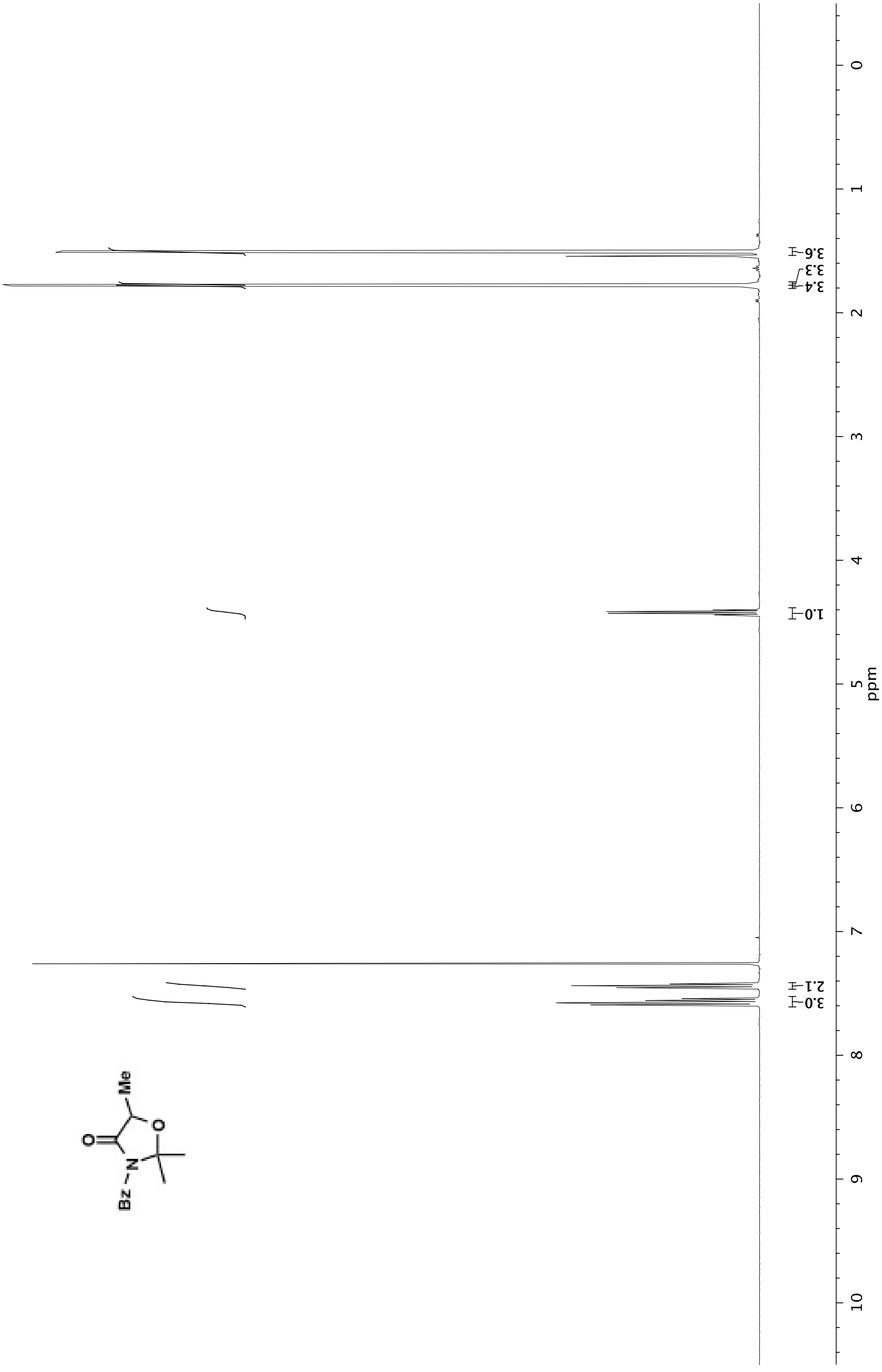
^{13}C NMR (126 MHz, $CDCl_3$) of compound **SI-6**.



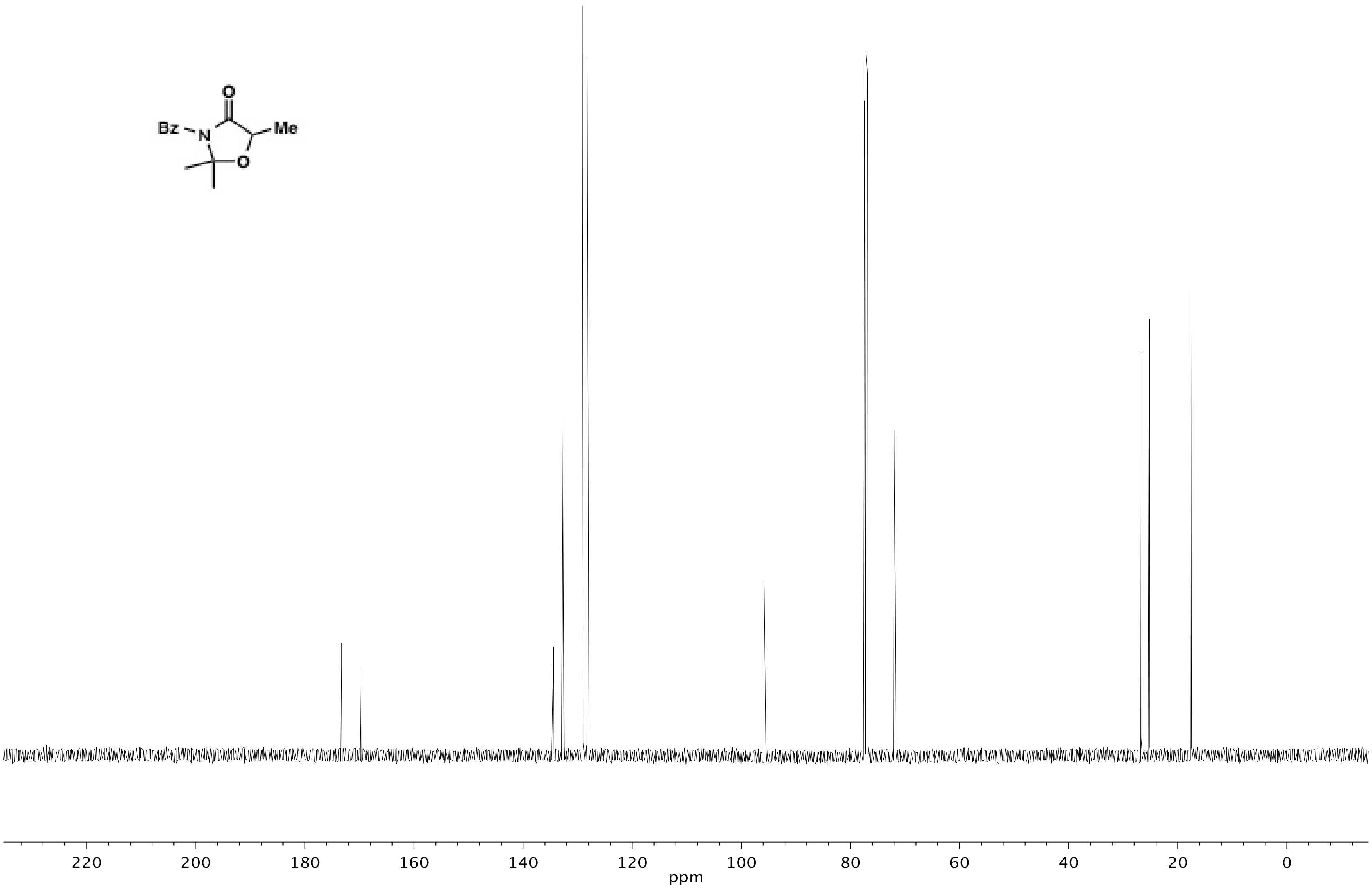
^{1}H NMR (500 MHz, CDCl$_3$) of compound **1g**.



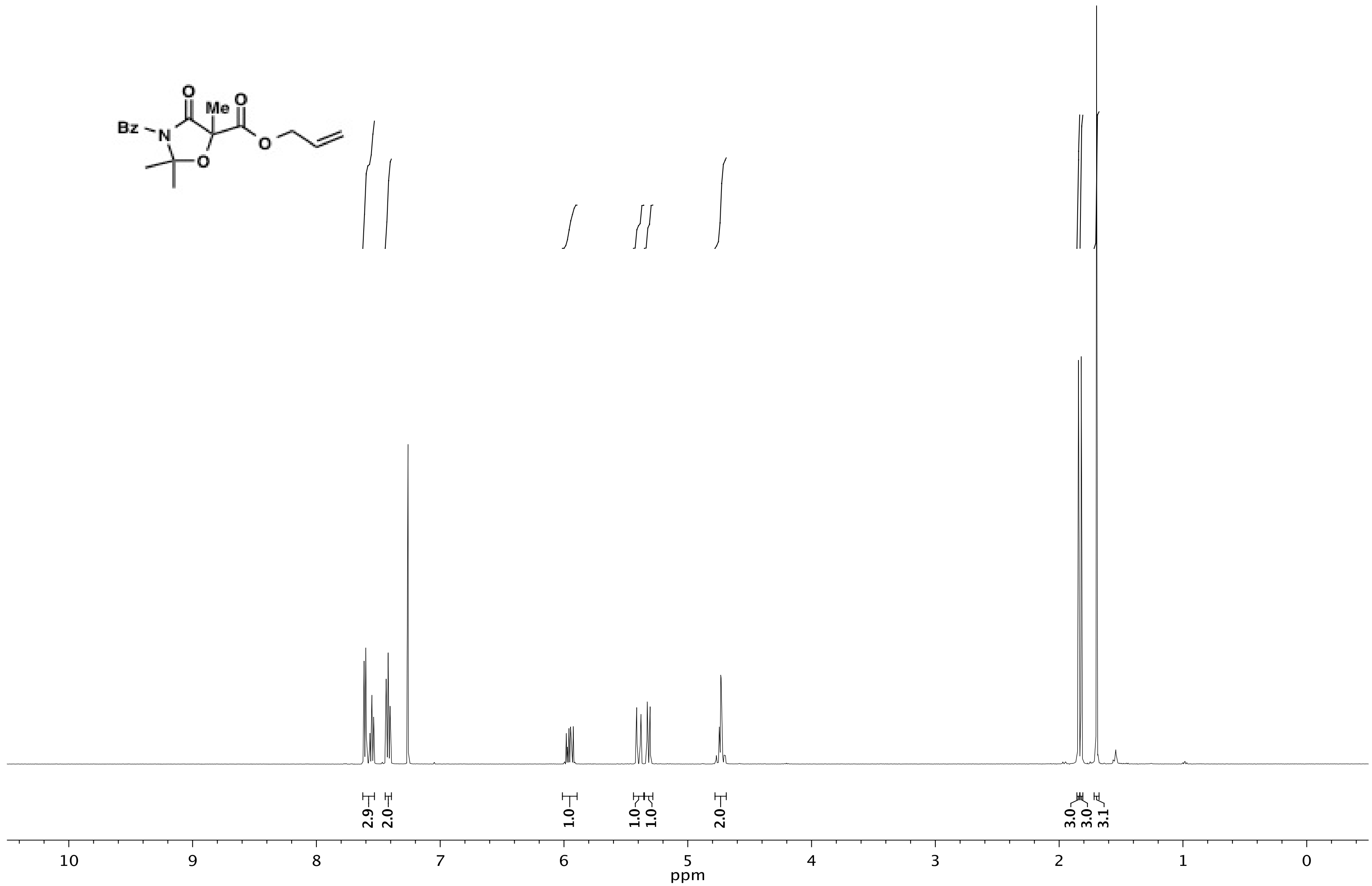
^{13}C NMR (126 MHz, CDCl$_3$) of compound **1g**.



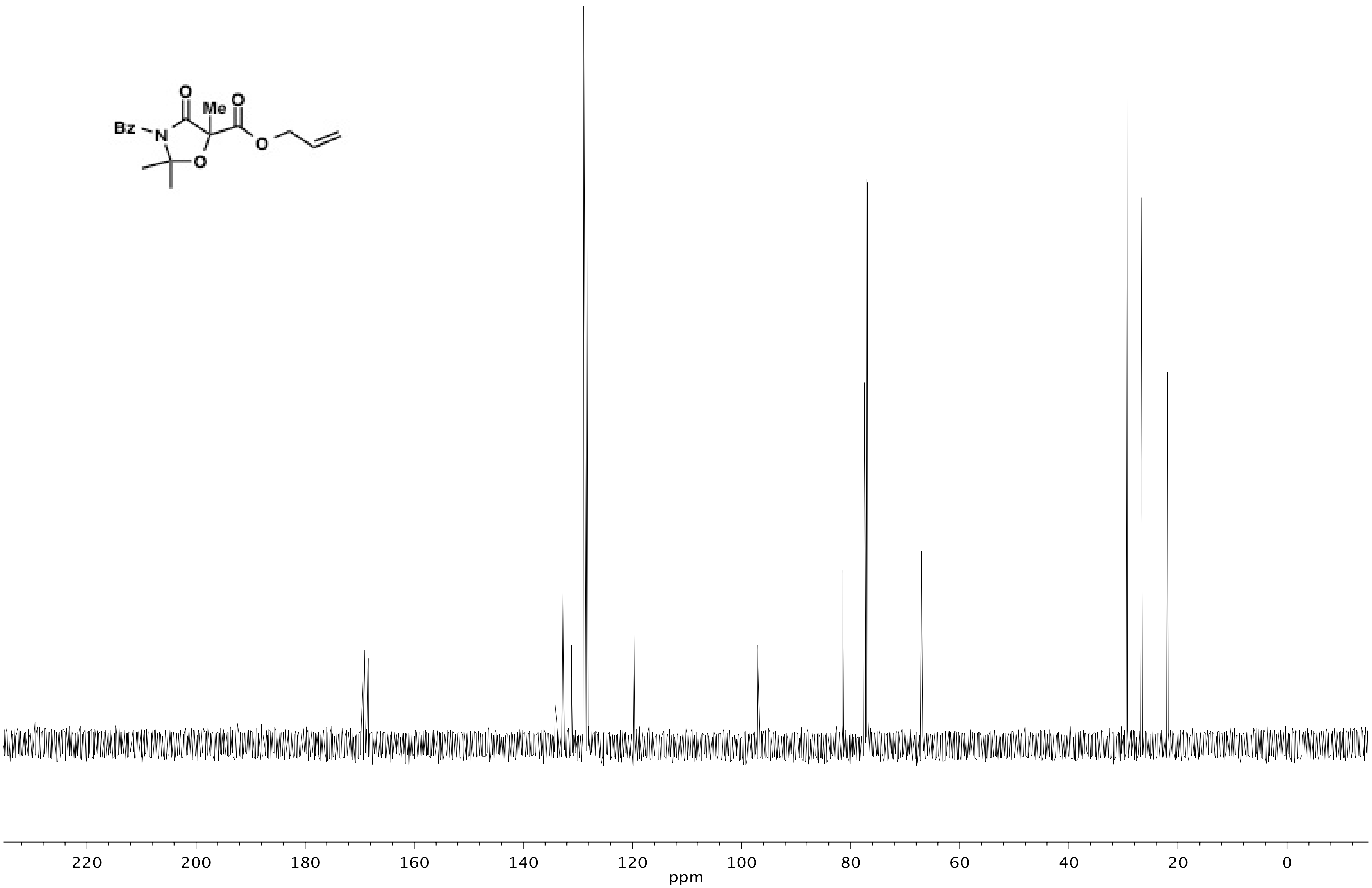
^{1}H NMR (500 MHz, CDCl$_3$) of compound **SI-7**.



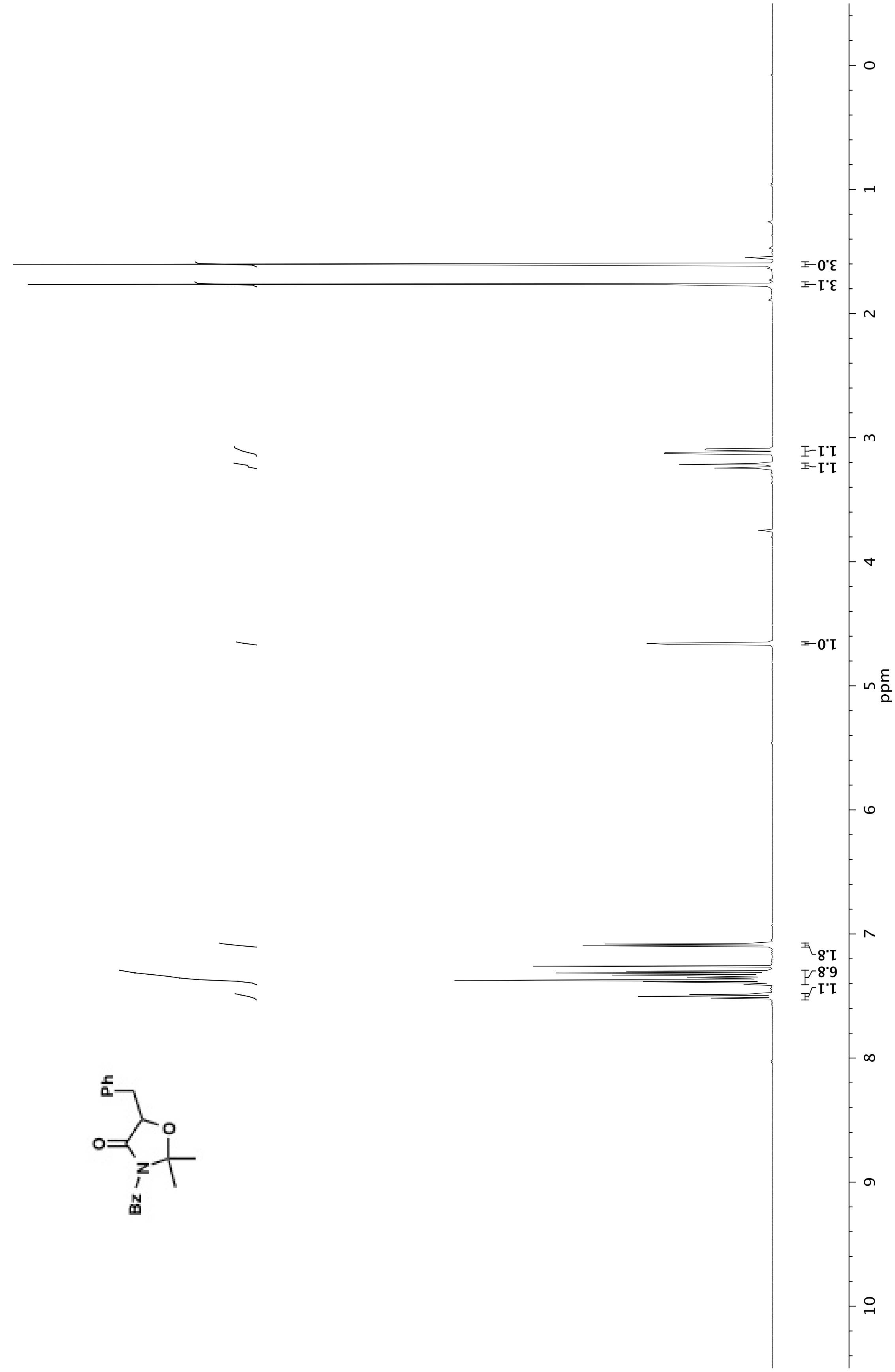
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-7**.



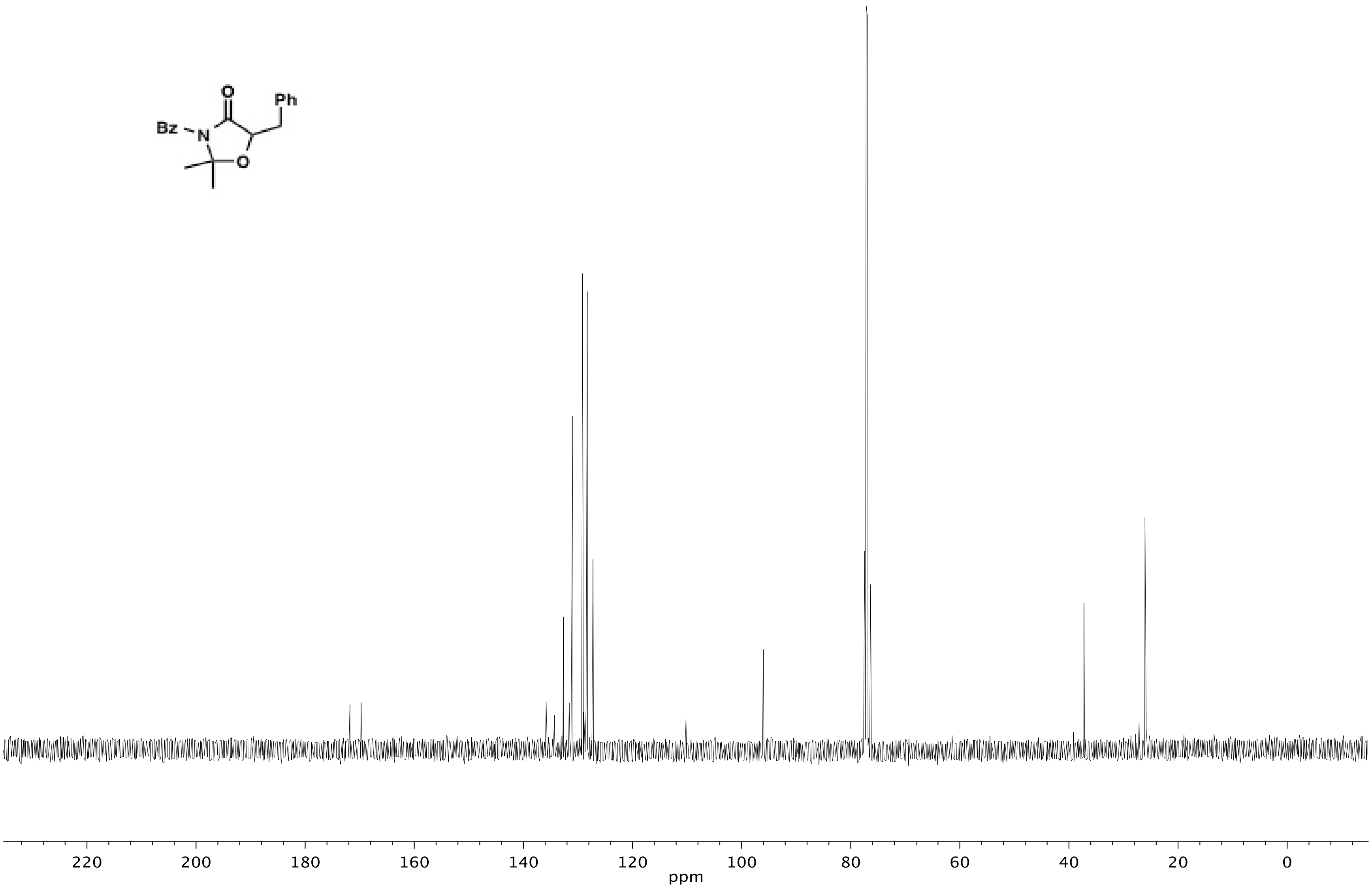
^{1}H NMR (500 MHz, CDCl$_3$) of compound **1h**.



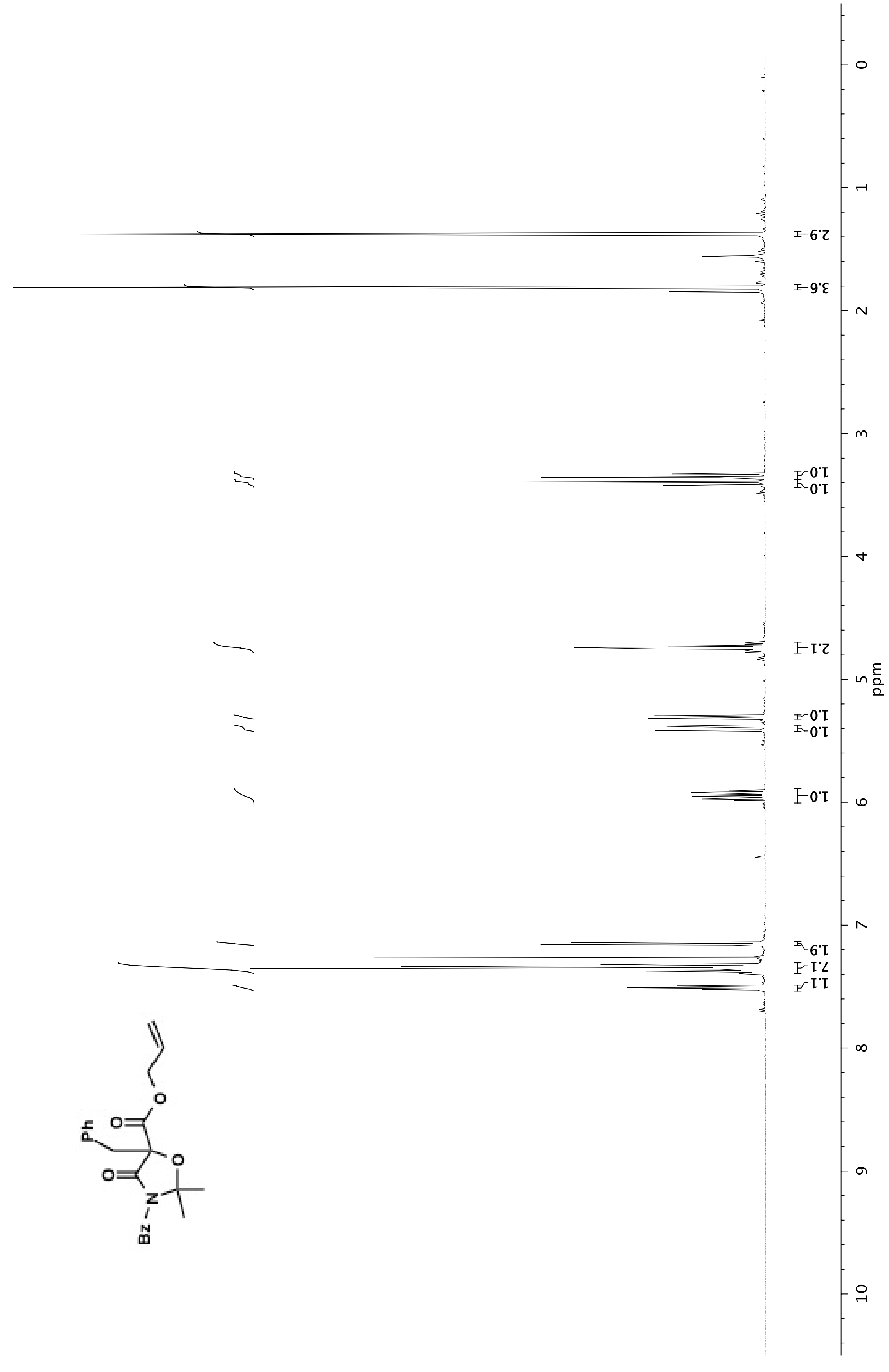
^{13}C NMR (126 MHz, CDCl$_3$) of compound **1h**.



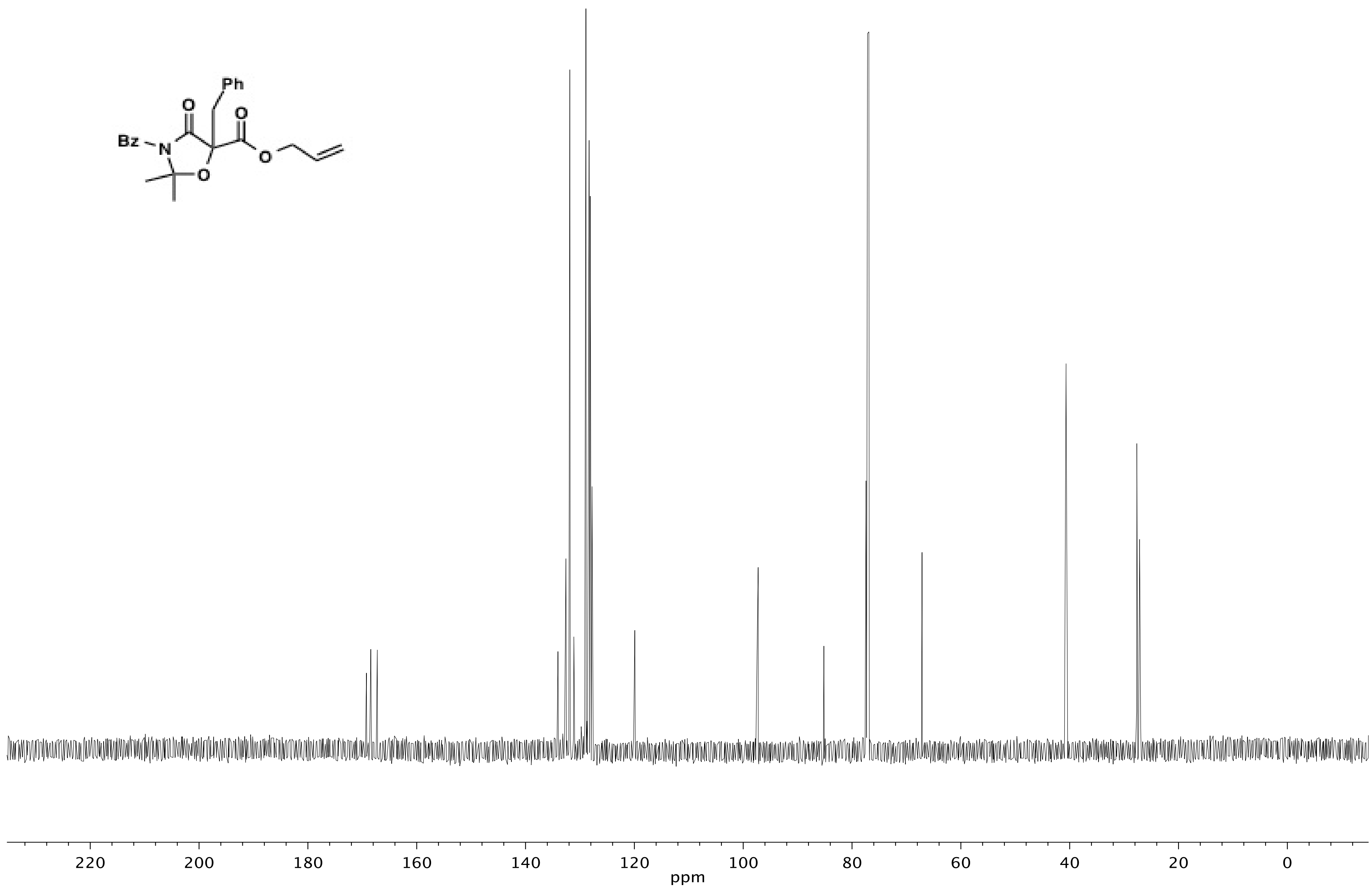
^{1}H NMR (500 MHz, $CDCl_3$) of compound **SI-9**.



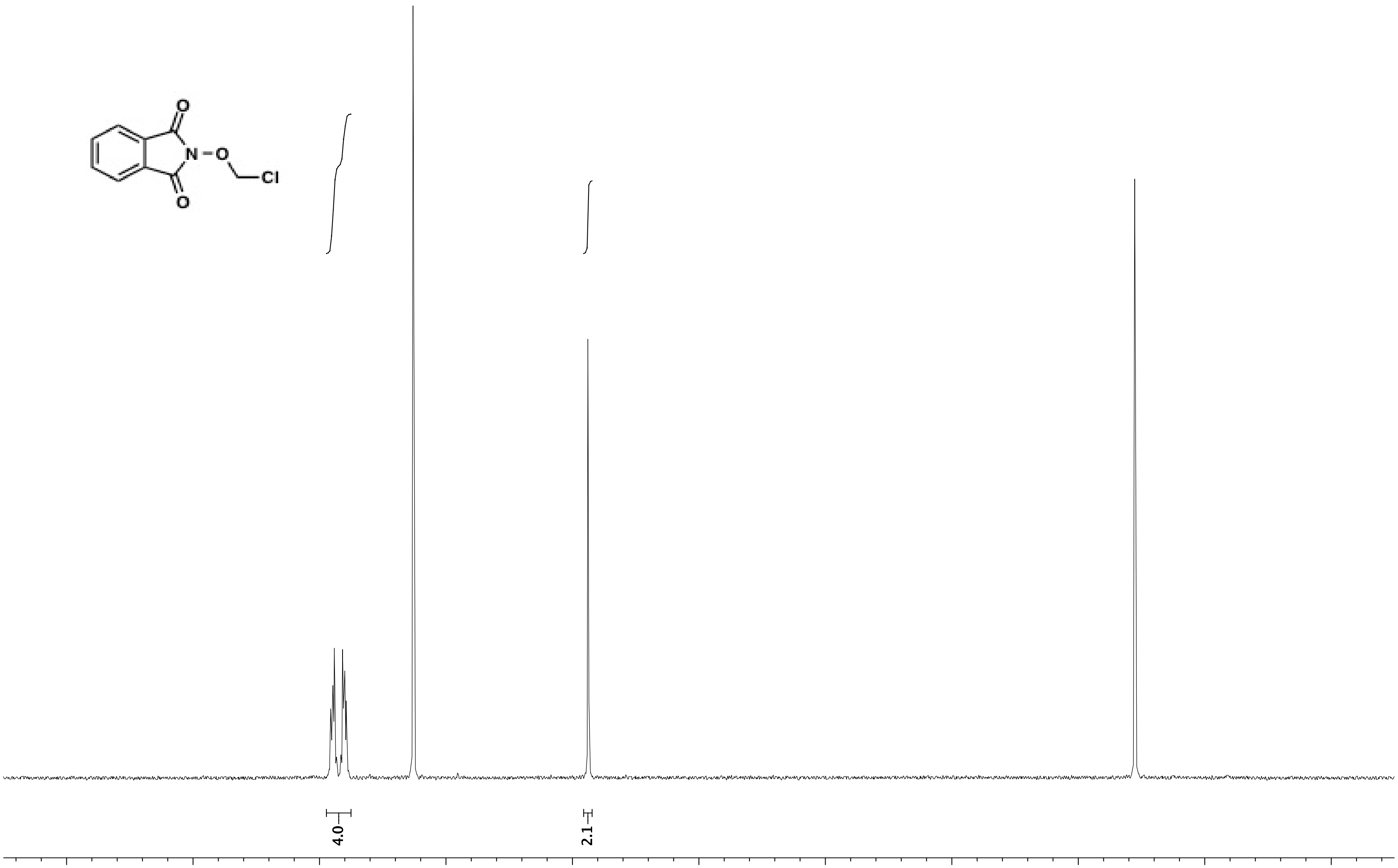
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-9**.



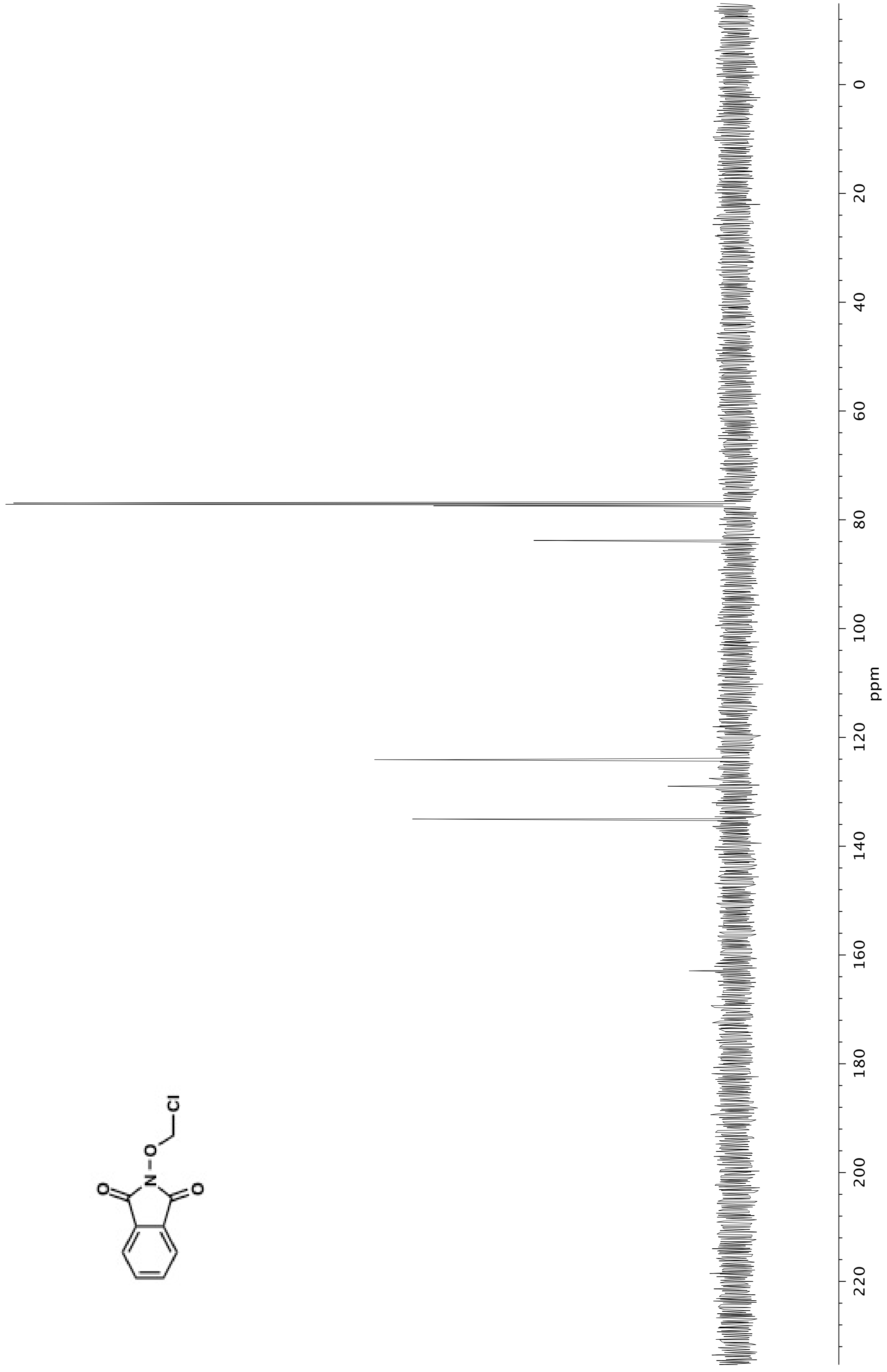
^{1}H NMR (500 MHz, CDCl$_3$) of compound **1i**.



^{13}C NMR (126 MHz, CDCl$_3$) of compound **1i**.



^{1}H NMR (300 MHz, CDCl$_3$) of compound **SI-10**.



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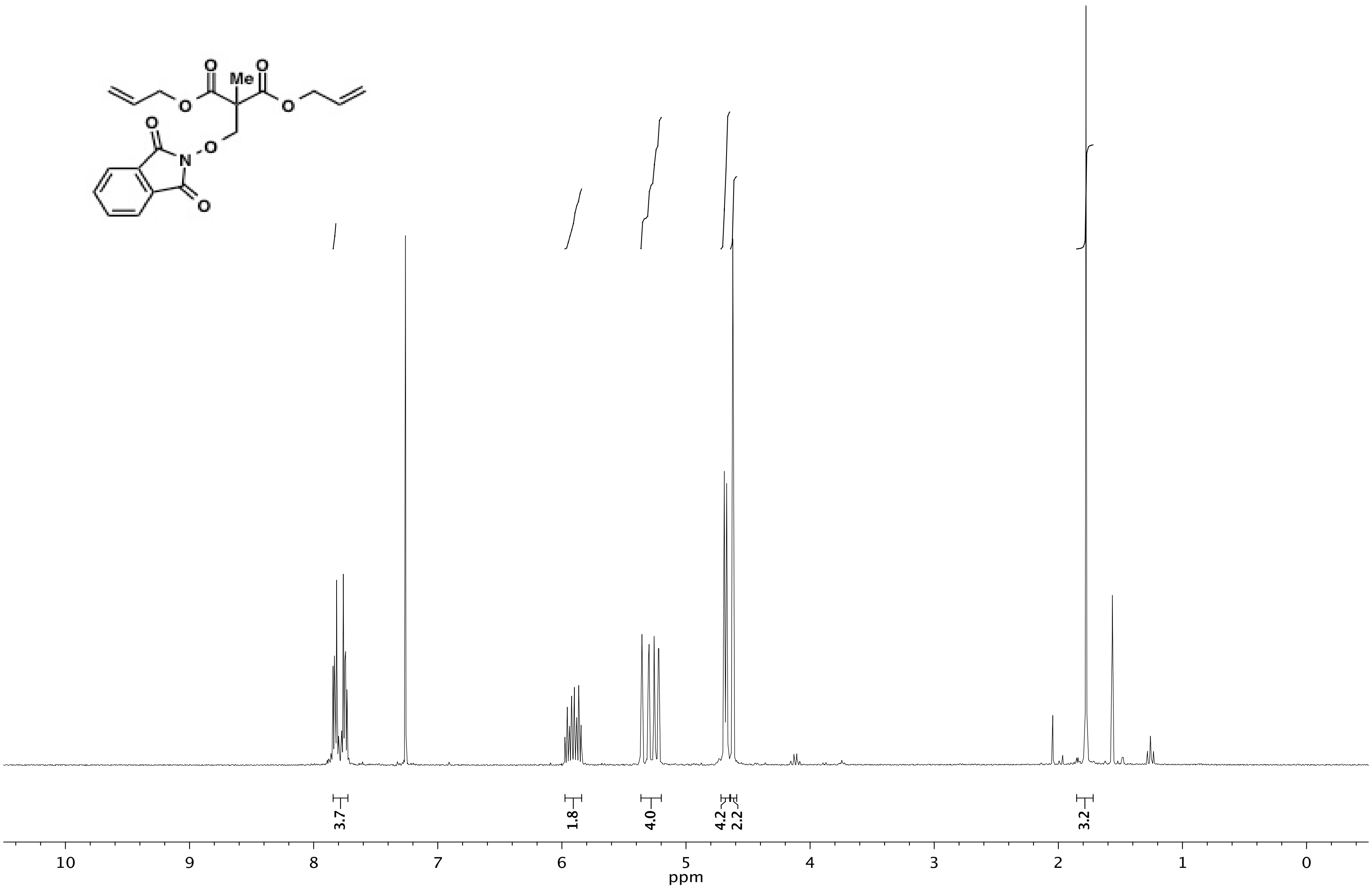
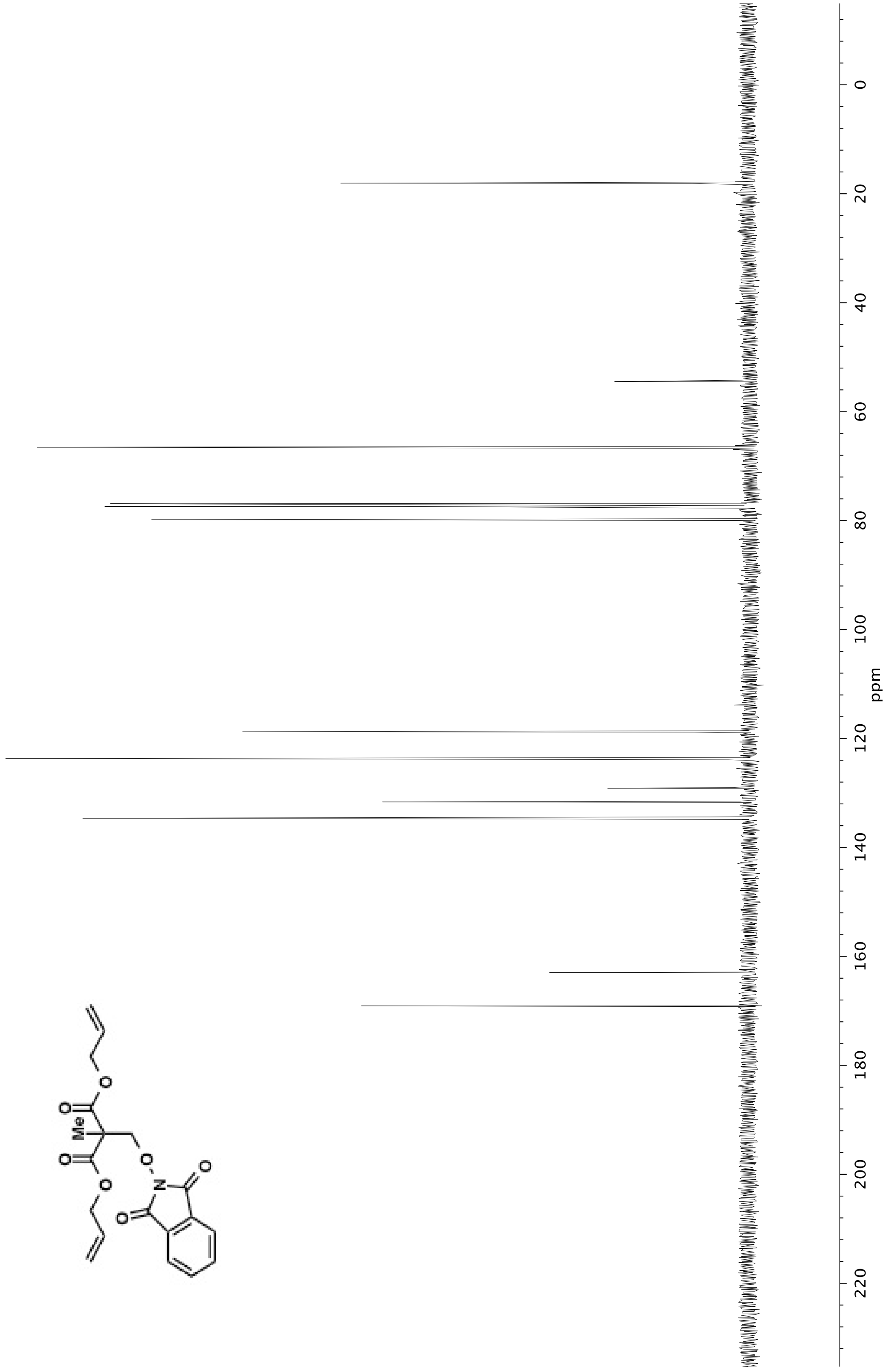
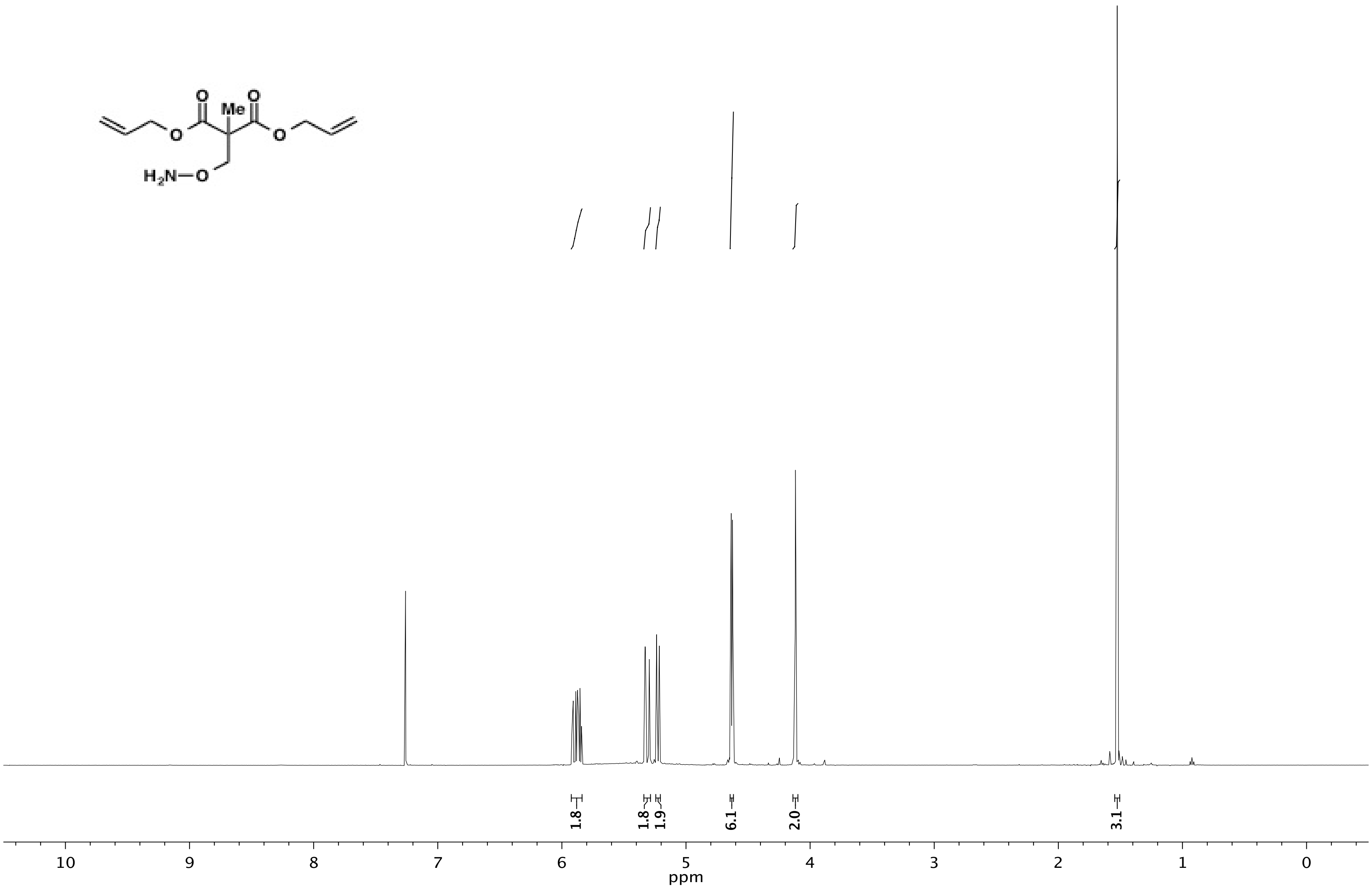


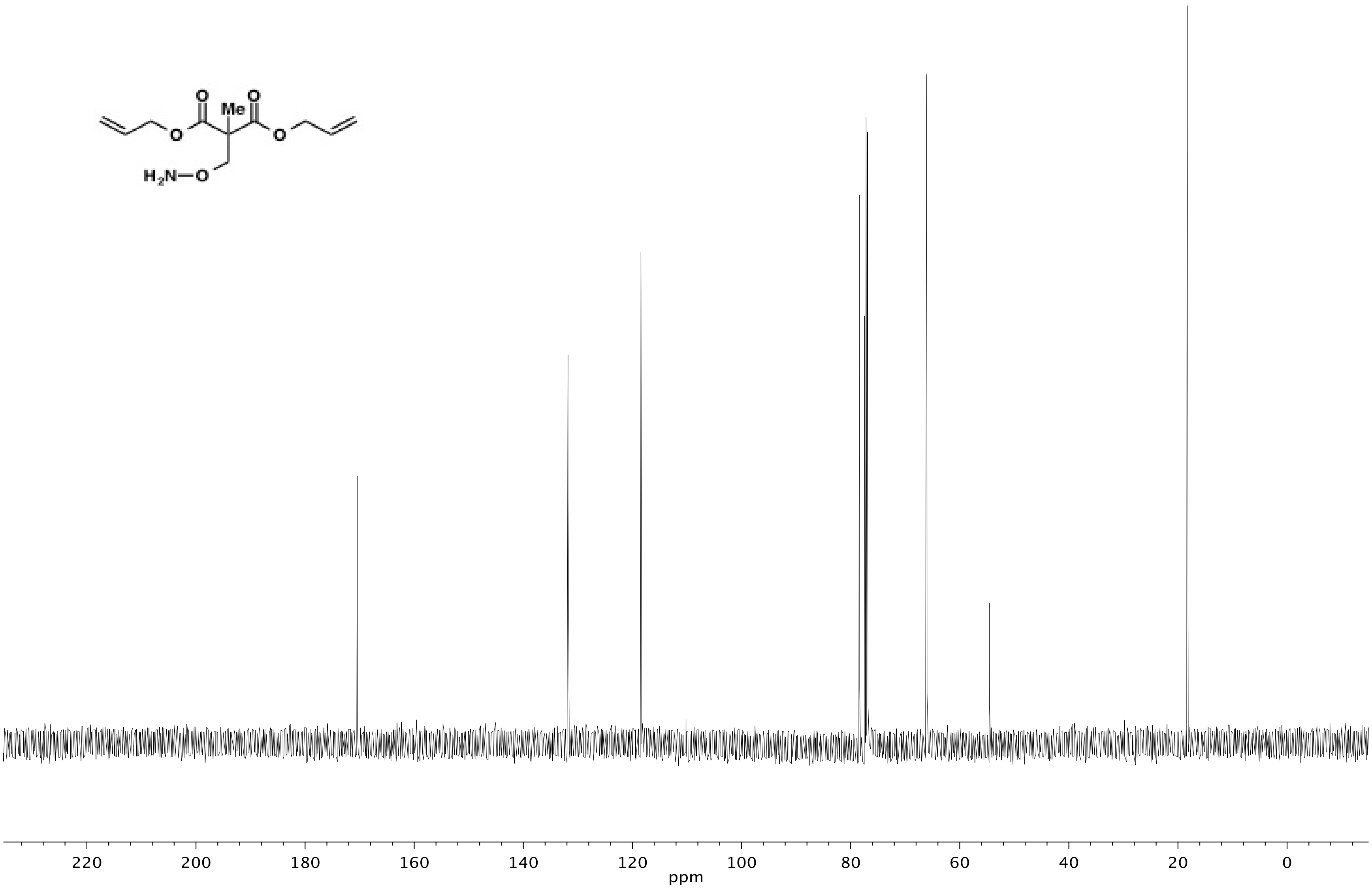
^{1}H NMR (300 MHz, CDCl$_3$) of compound **SI-11**.



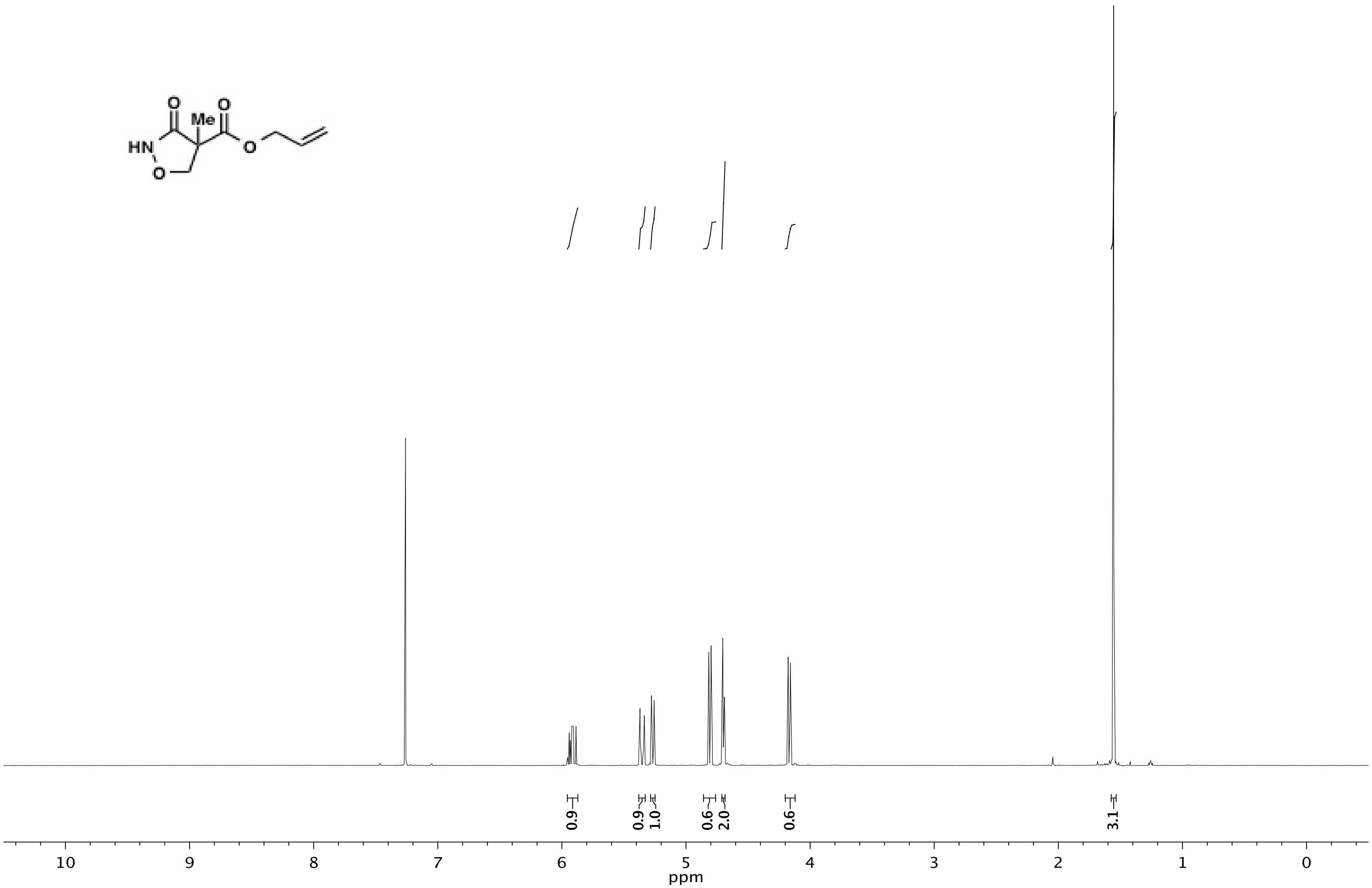
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-11**.



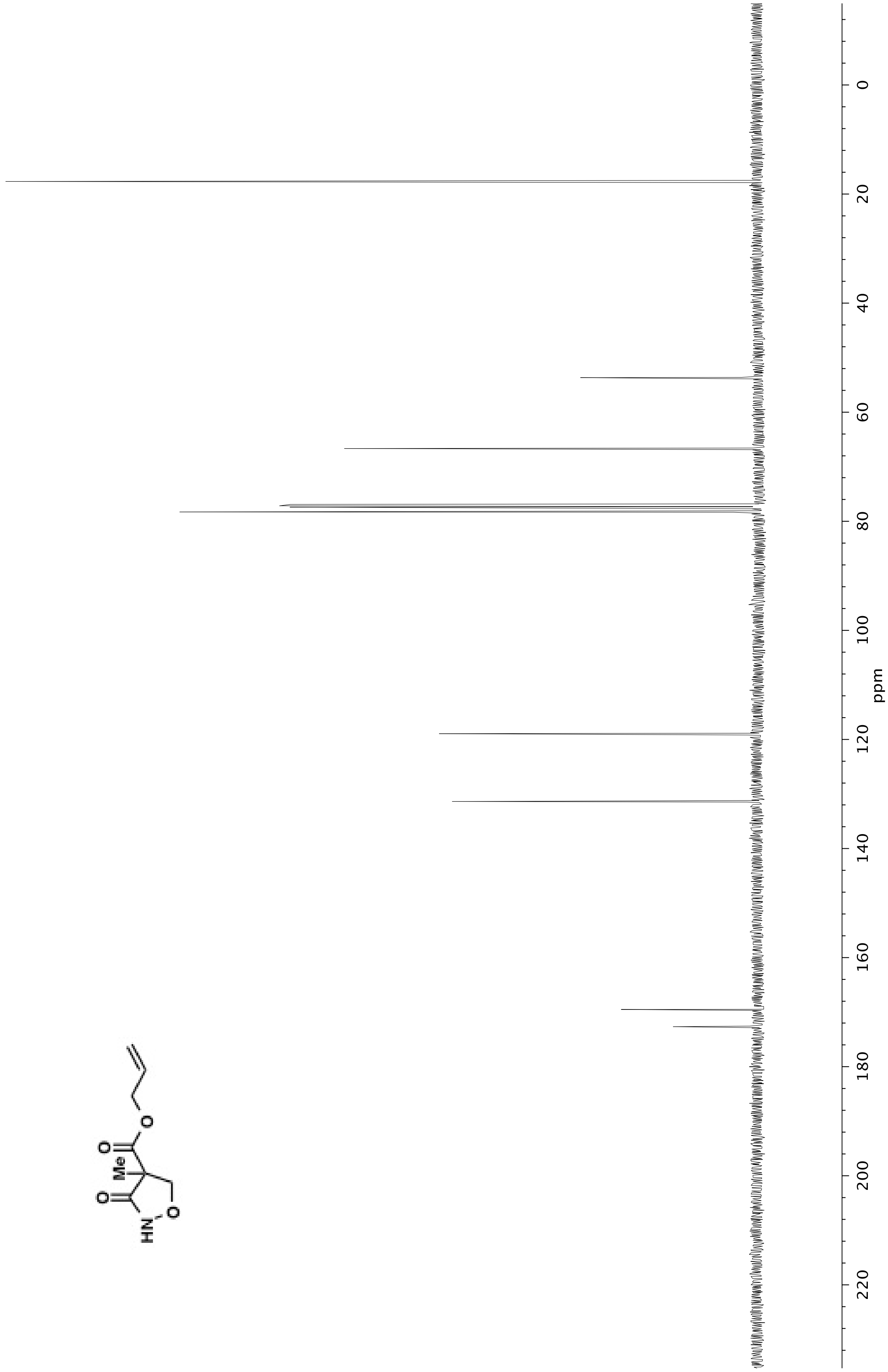
^{1}H NMR (500 MHz, CDCl$_3$) of compound **SI-12**.



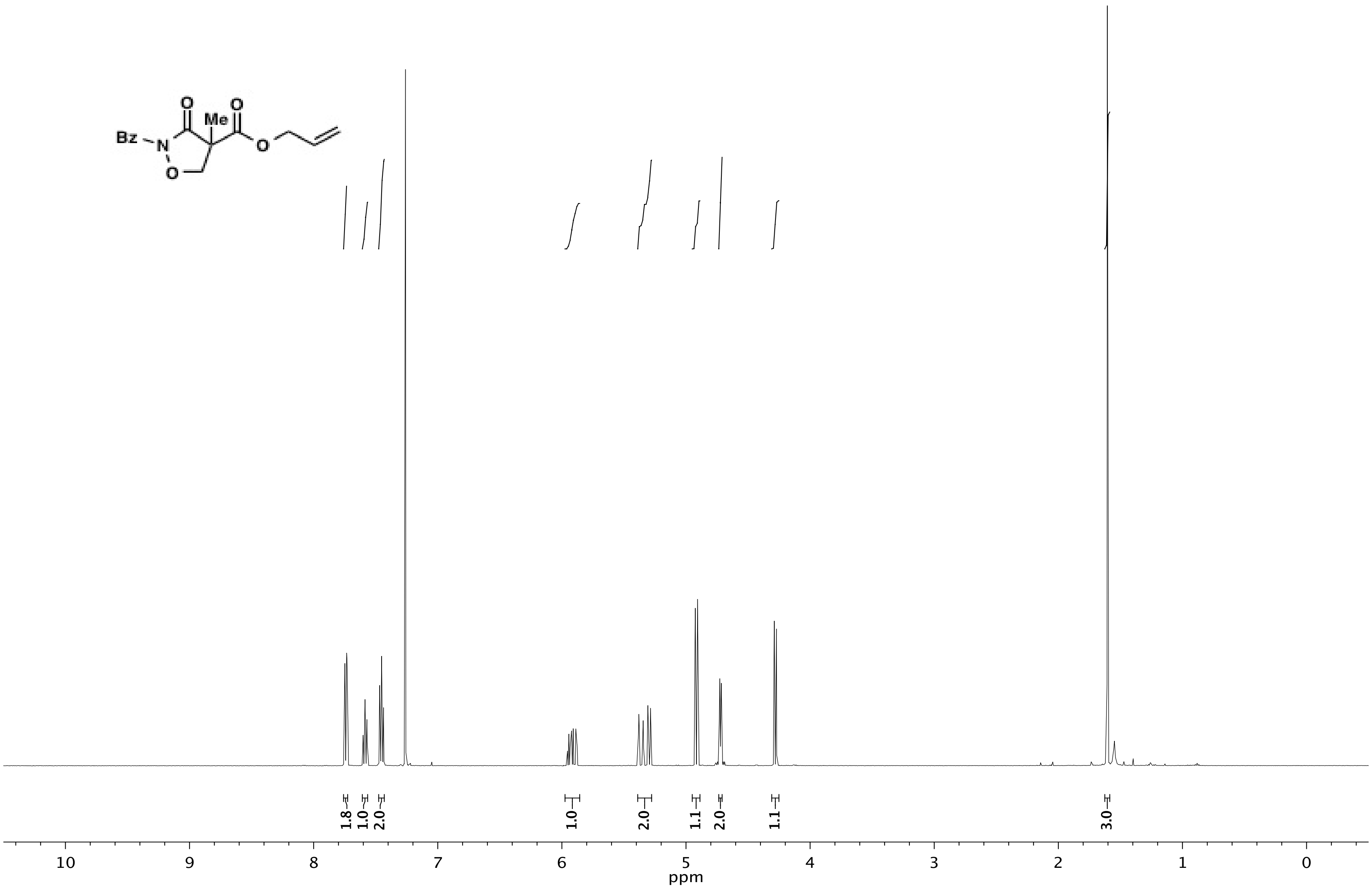
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-12**.



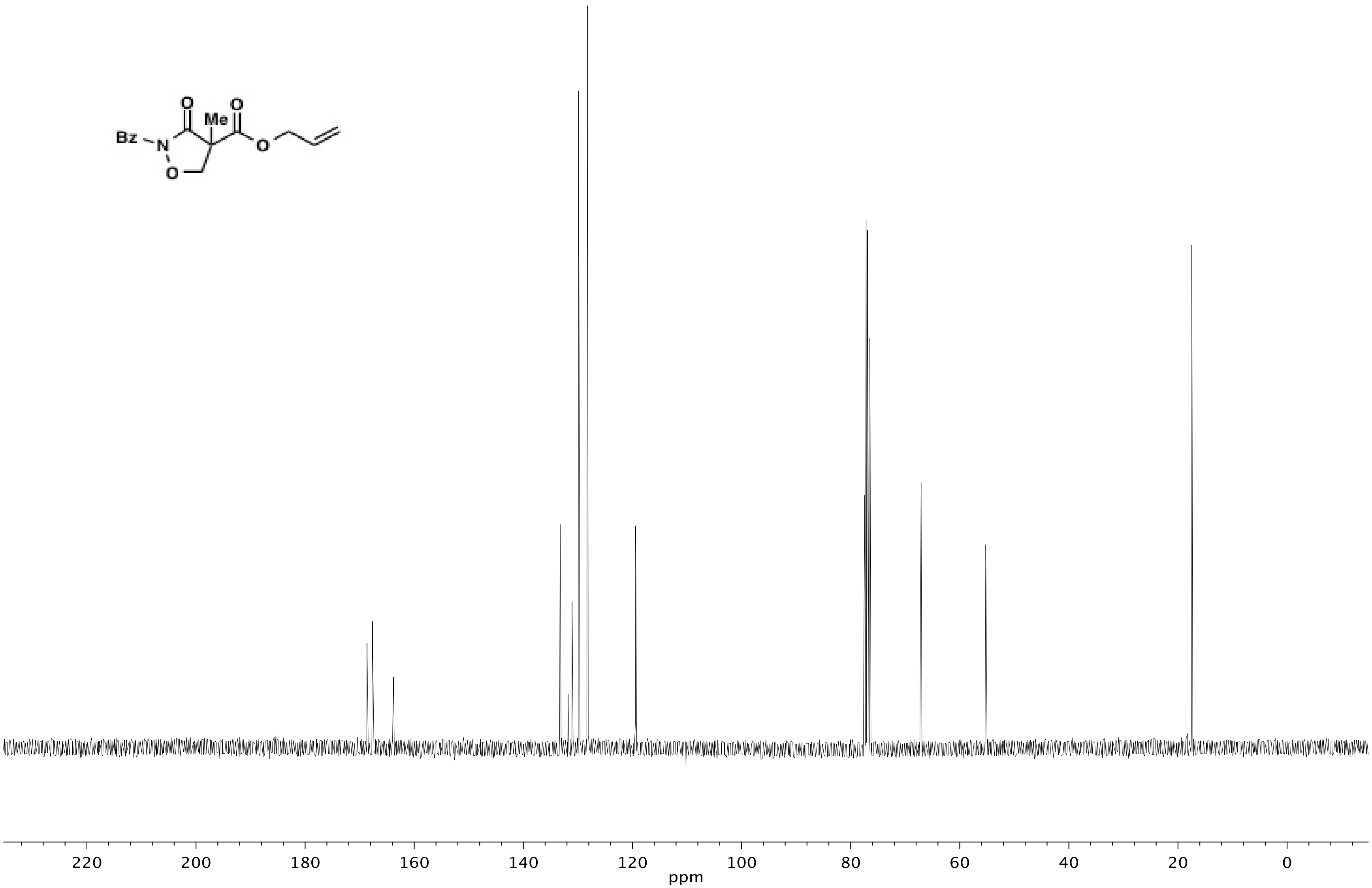
^{1}H NMR (500 MHz, CDCl$_3$) of compound **SI-13**.



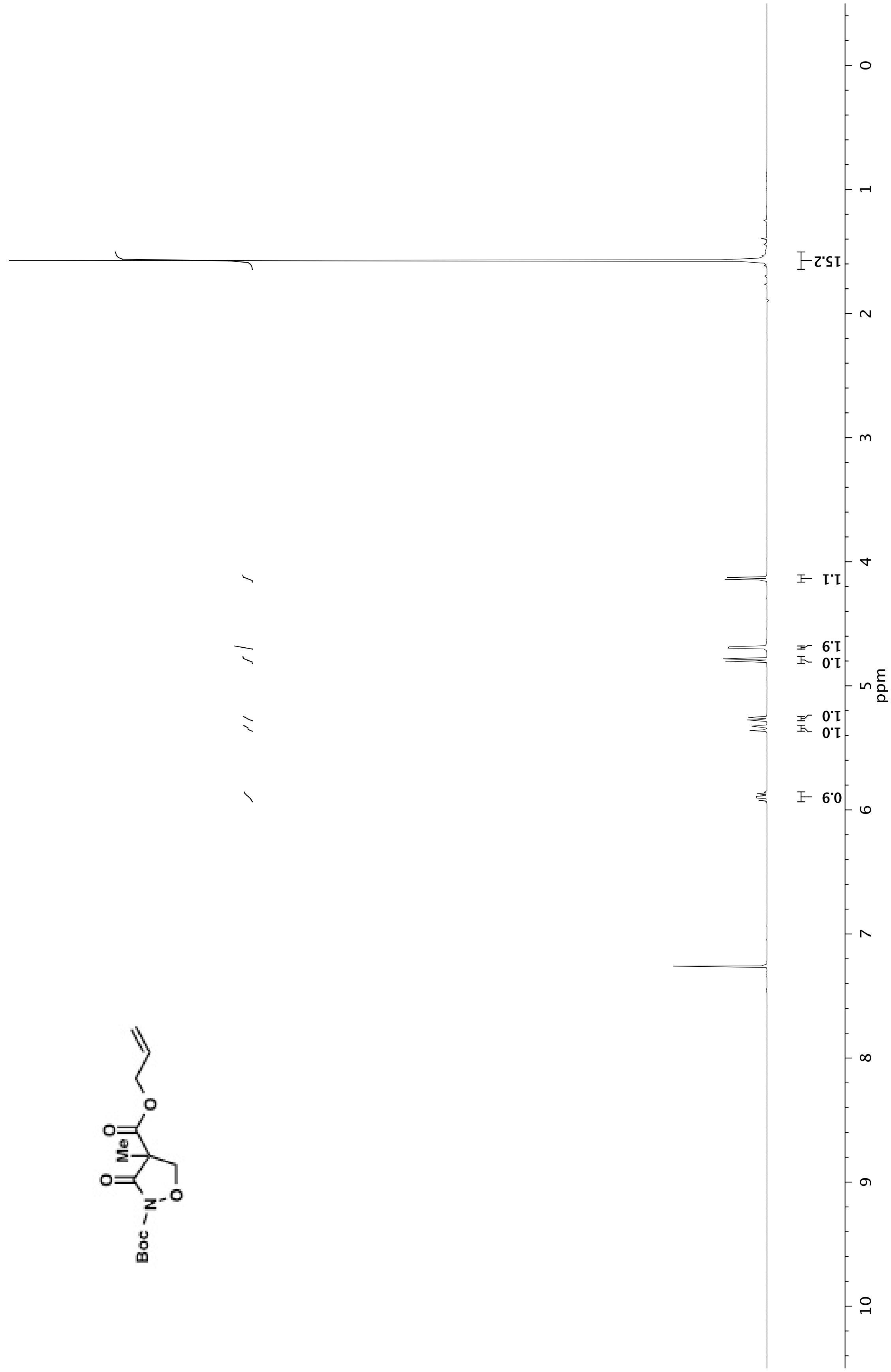
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-13**.



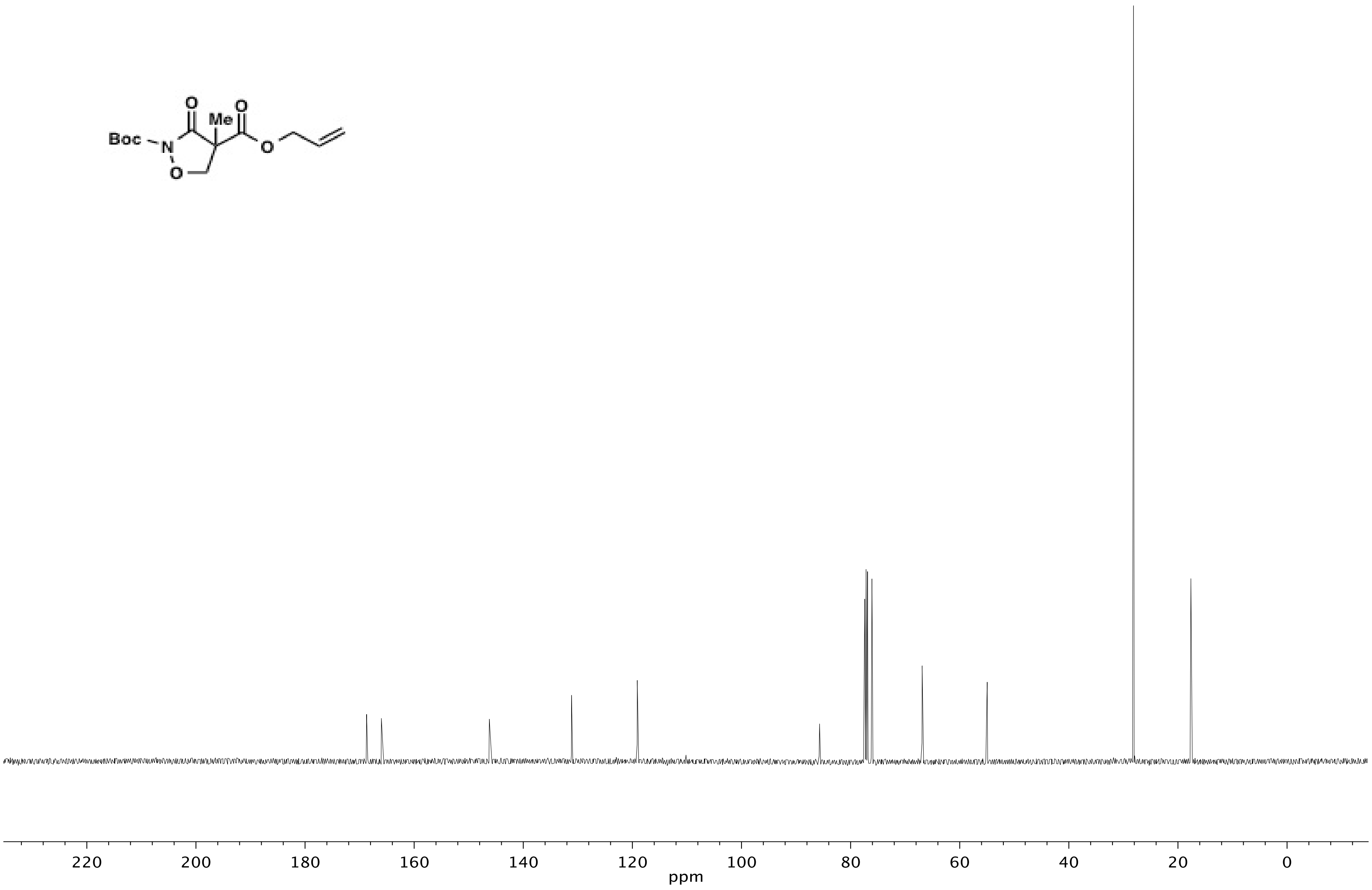
^{1}H NMR (500 MHz, $CDCl_3$) of compound **3a**.



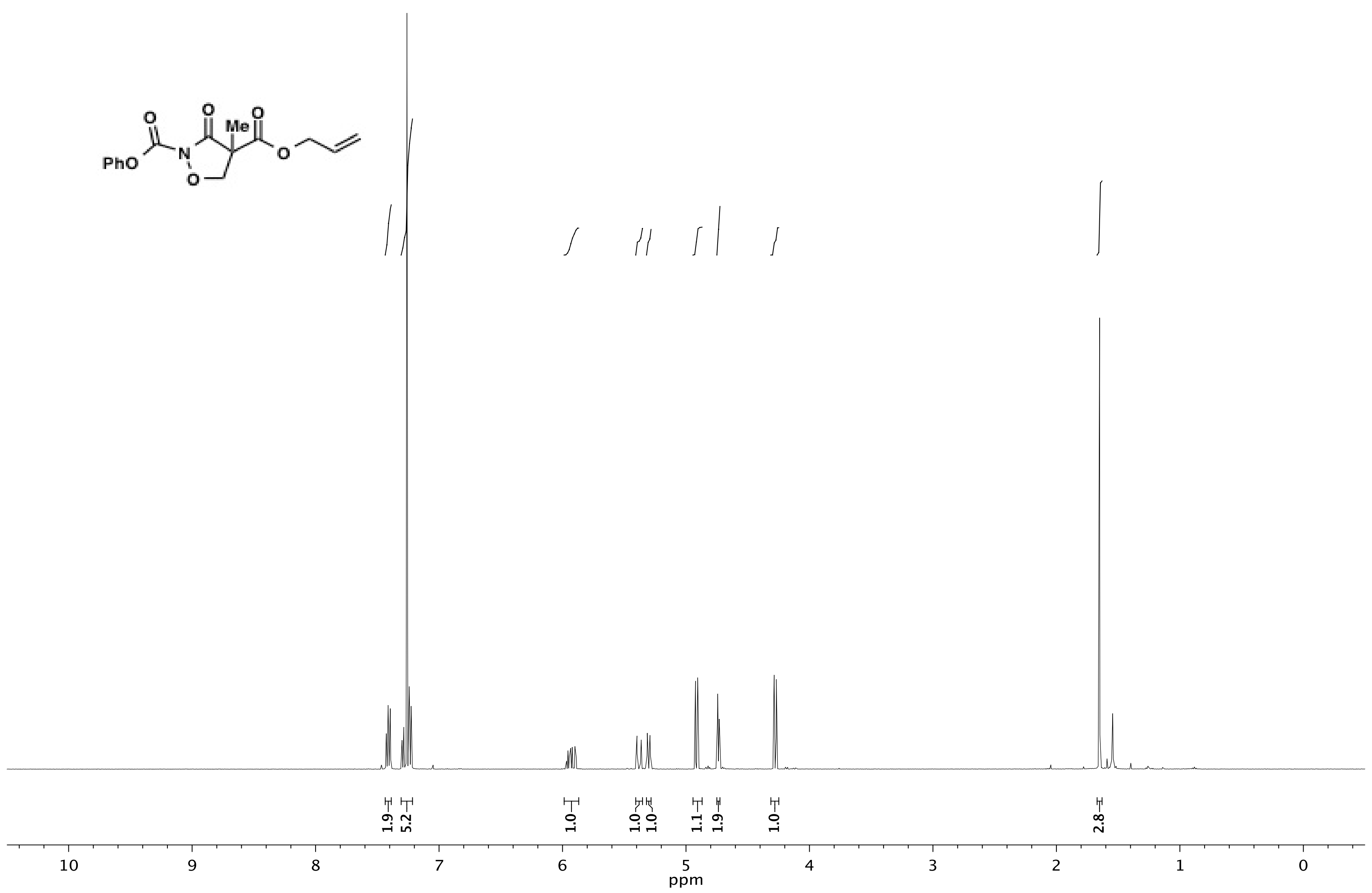
^{13}C NMR (126 MHz, CDCl$_3$) of compound **3a**.



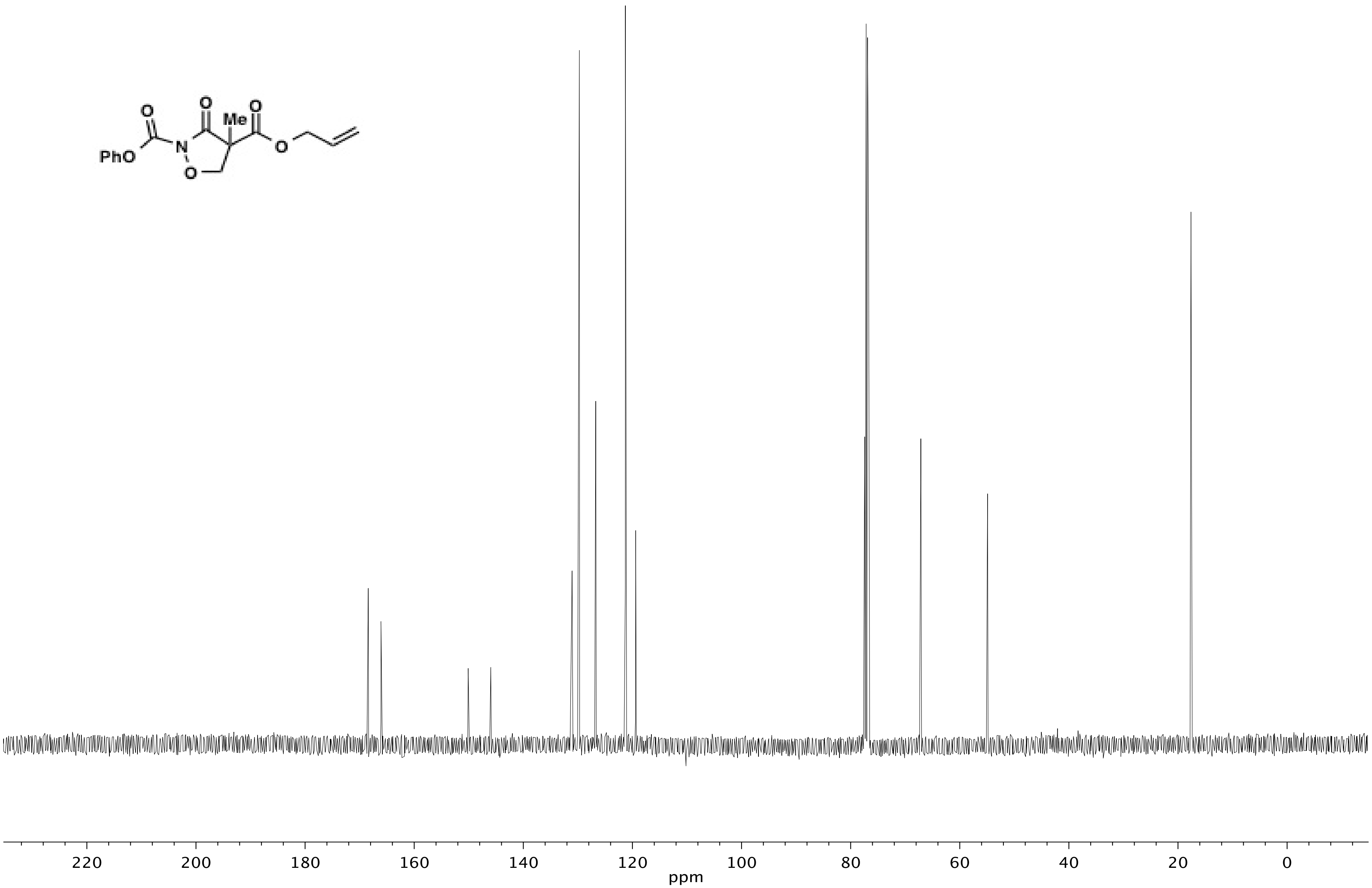
^{1}H NMR (500 MHz, CDCl$_3$) of compound **3b**.



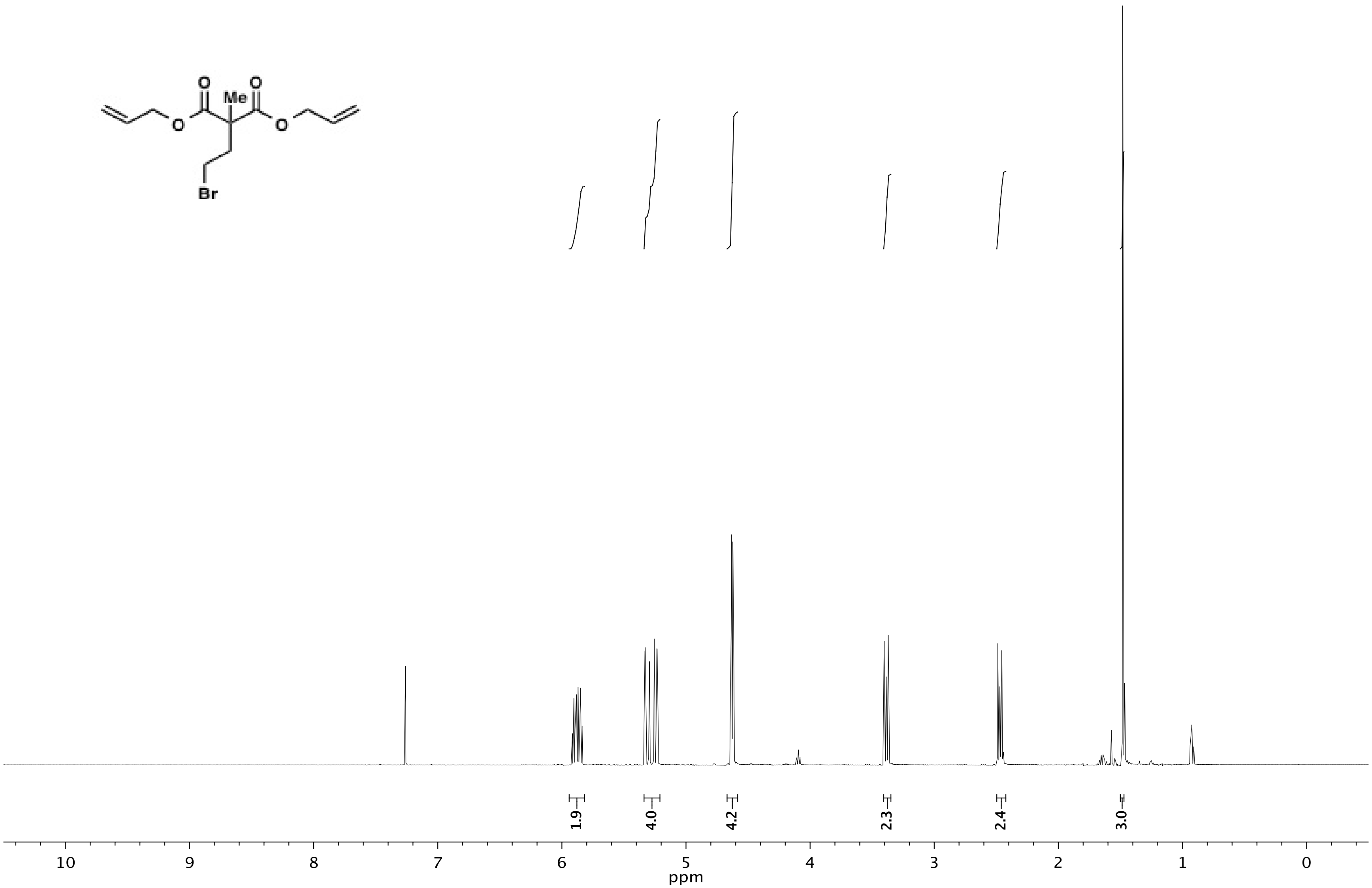
^{13}C NMR (126 MHz, CDCl$_3$) of compound **3b**.



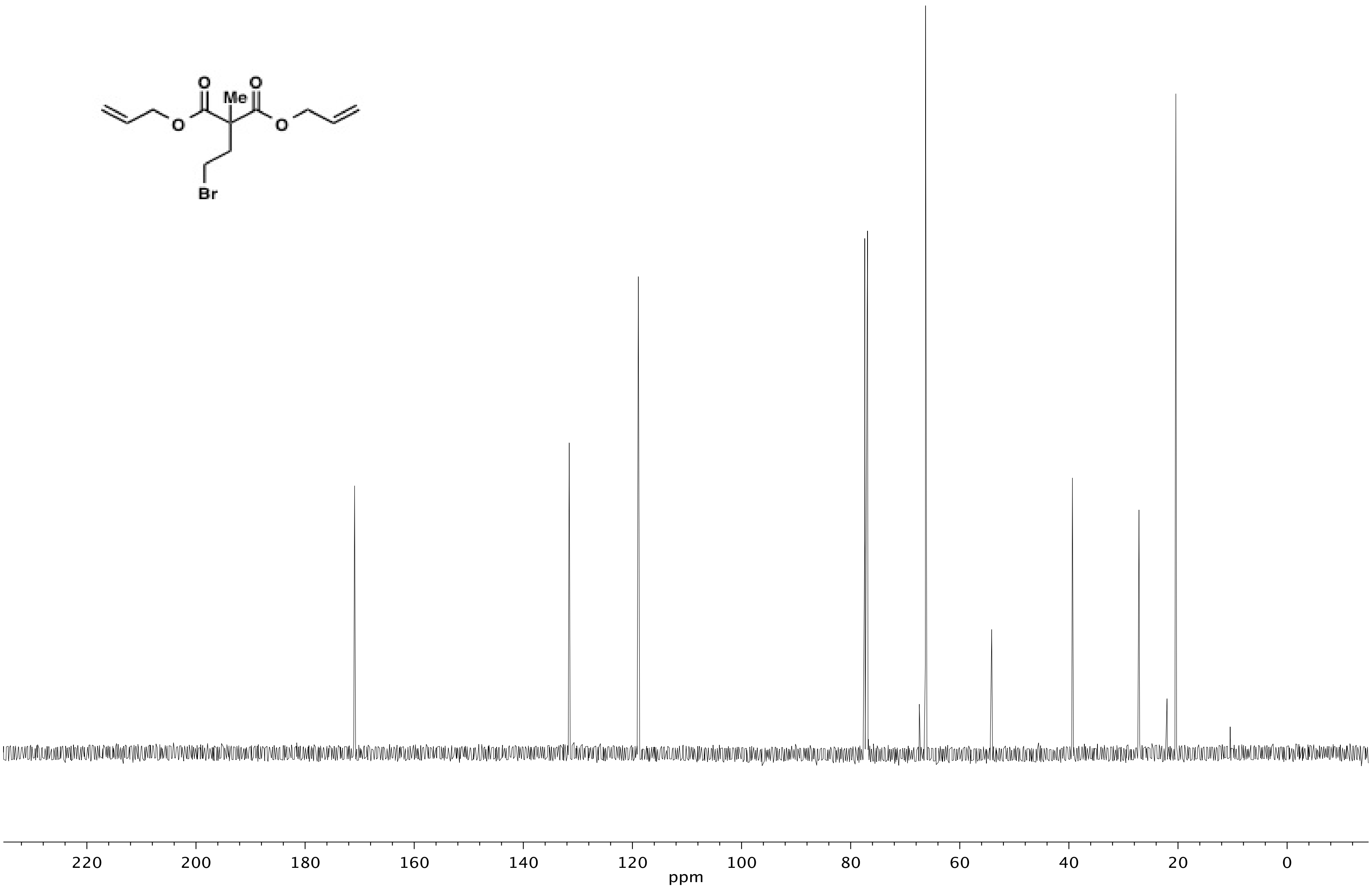
^{1}H NMR (500 MHz, CDCl$_3$) of compound **3c**.



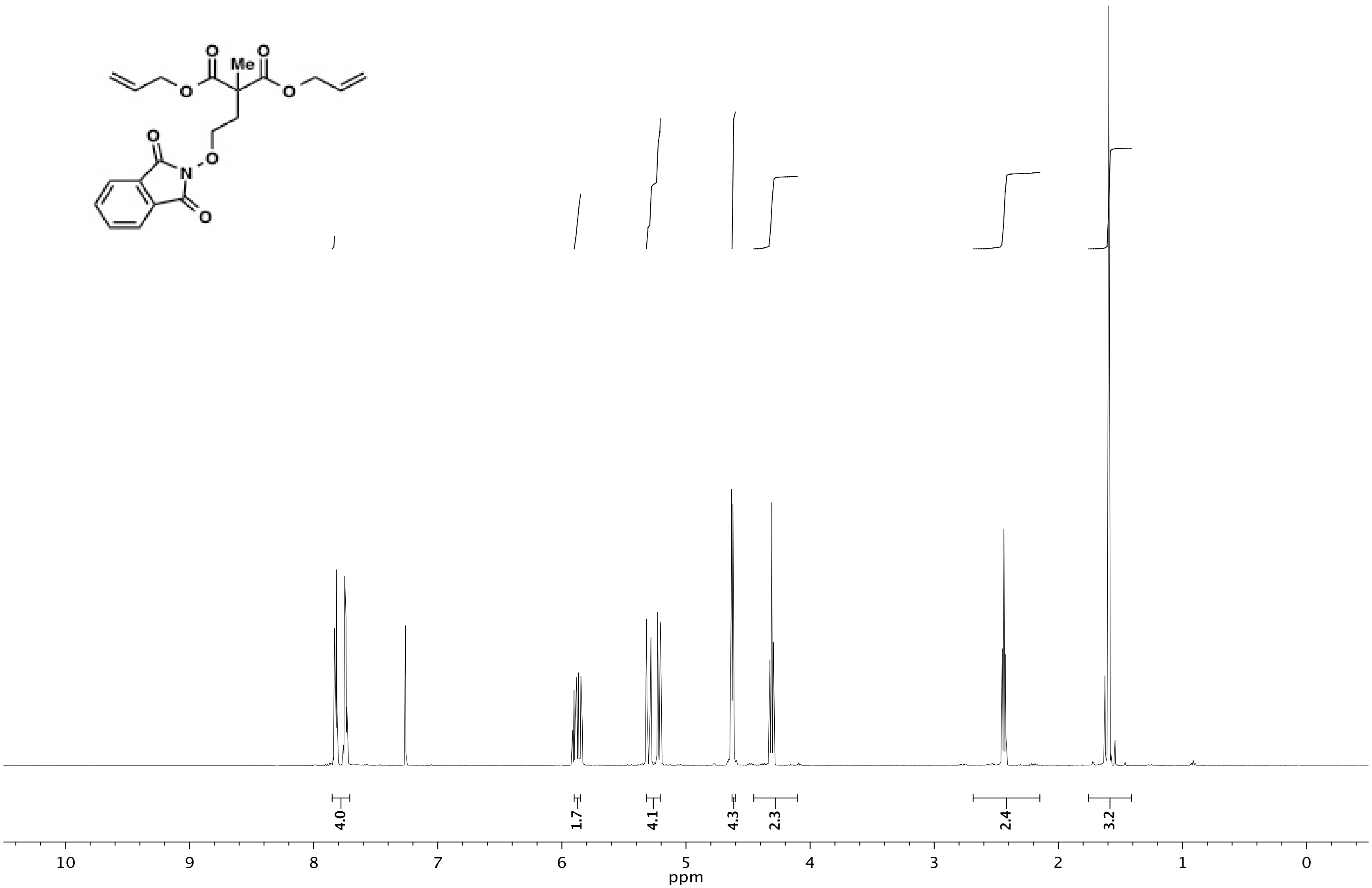
^{13}C NMR (126 MHz, CDCl$_3$) of compound **3c**.



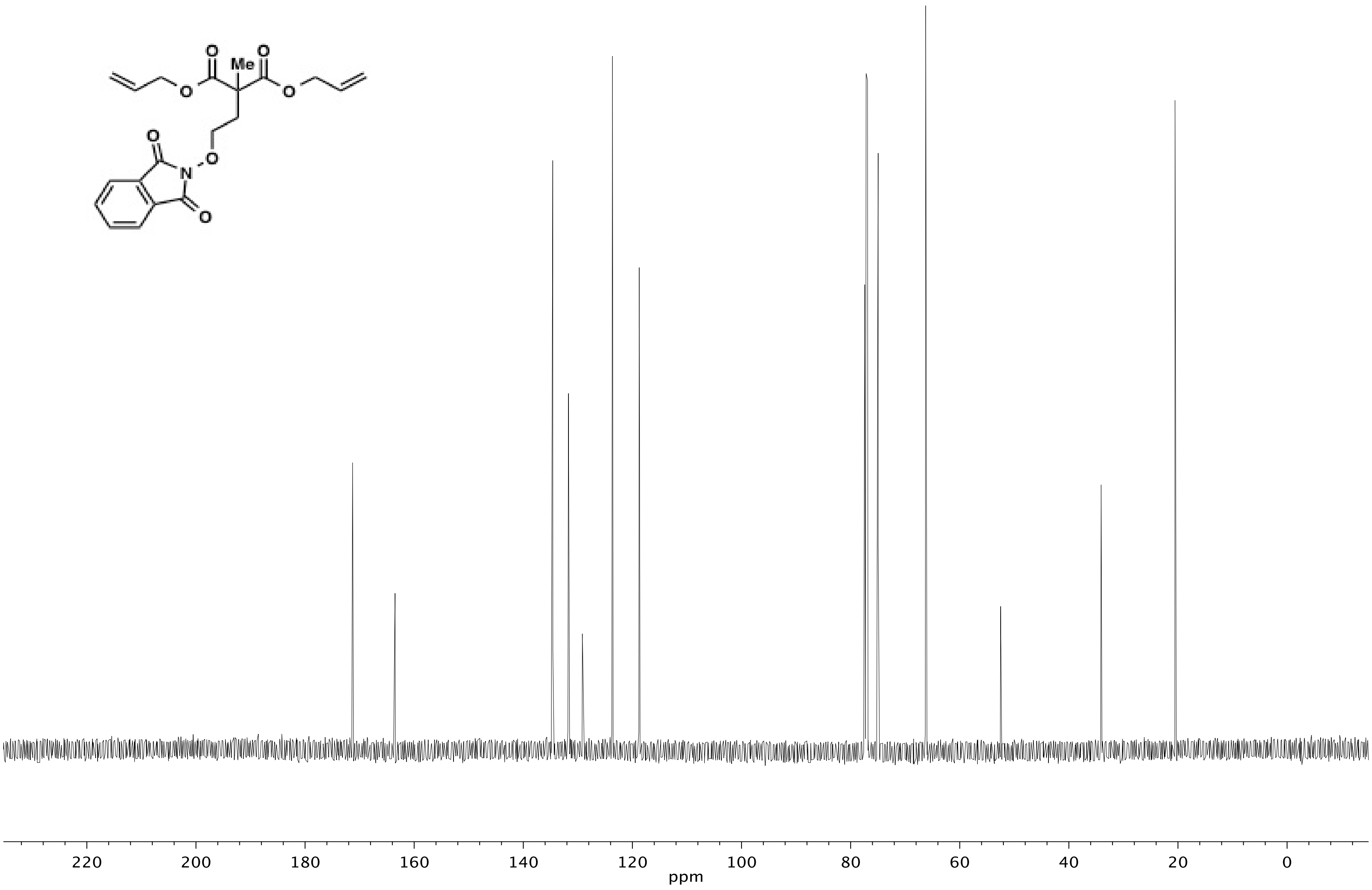
^{1}H NMR (500 MHz, $CDCl_3$) of compound **SI-14**.



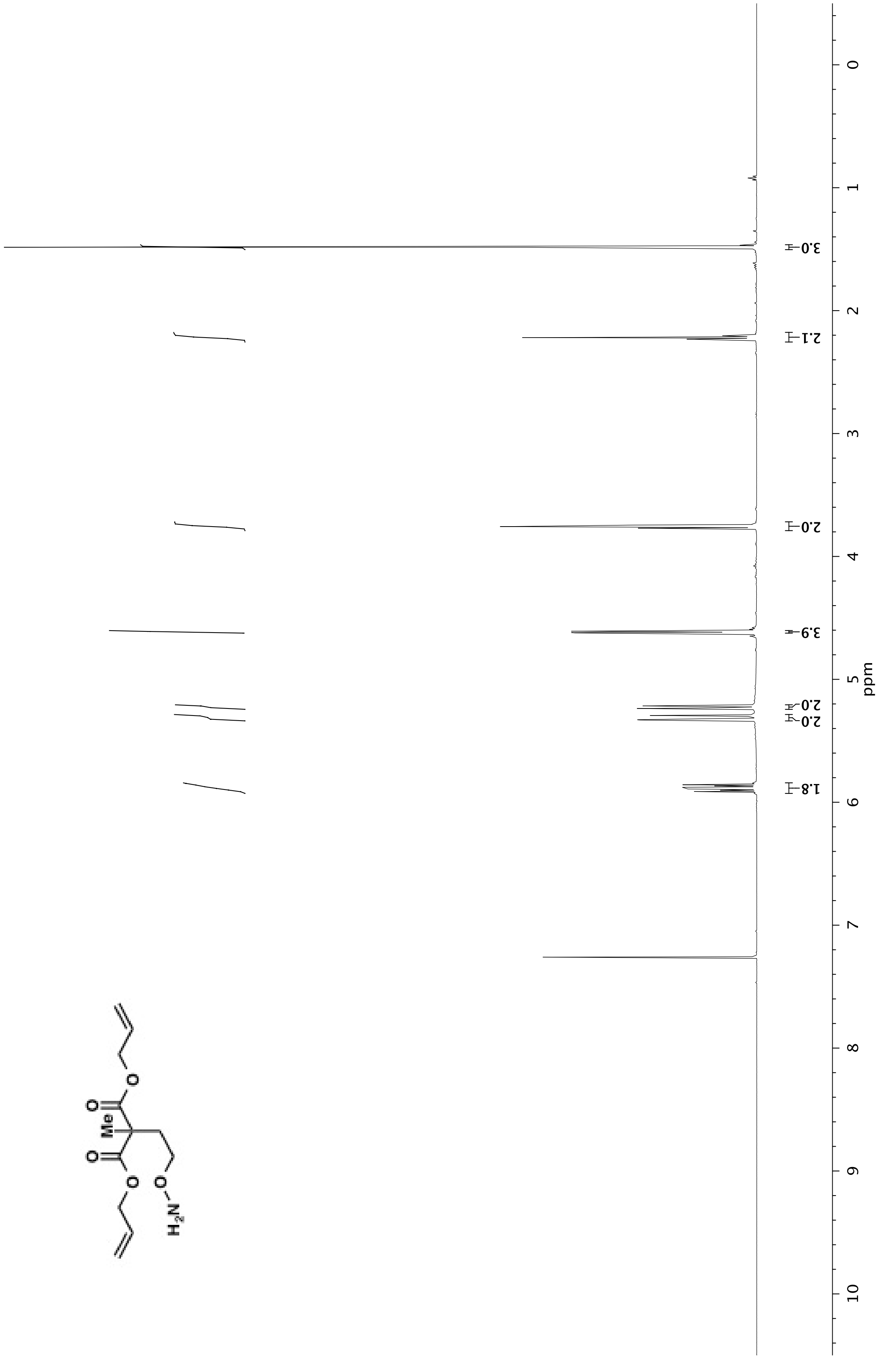
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-14**.



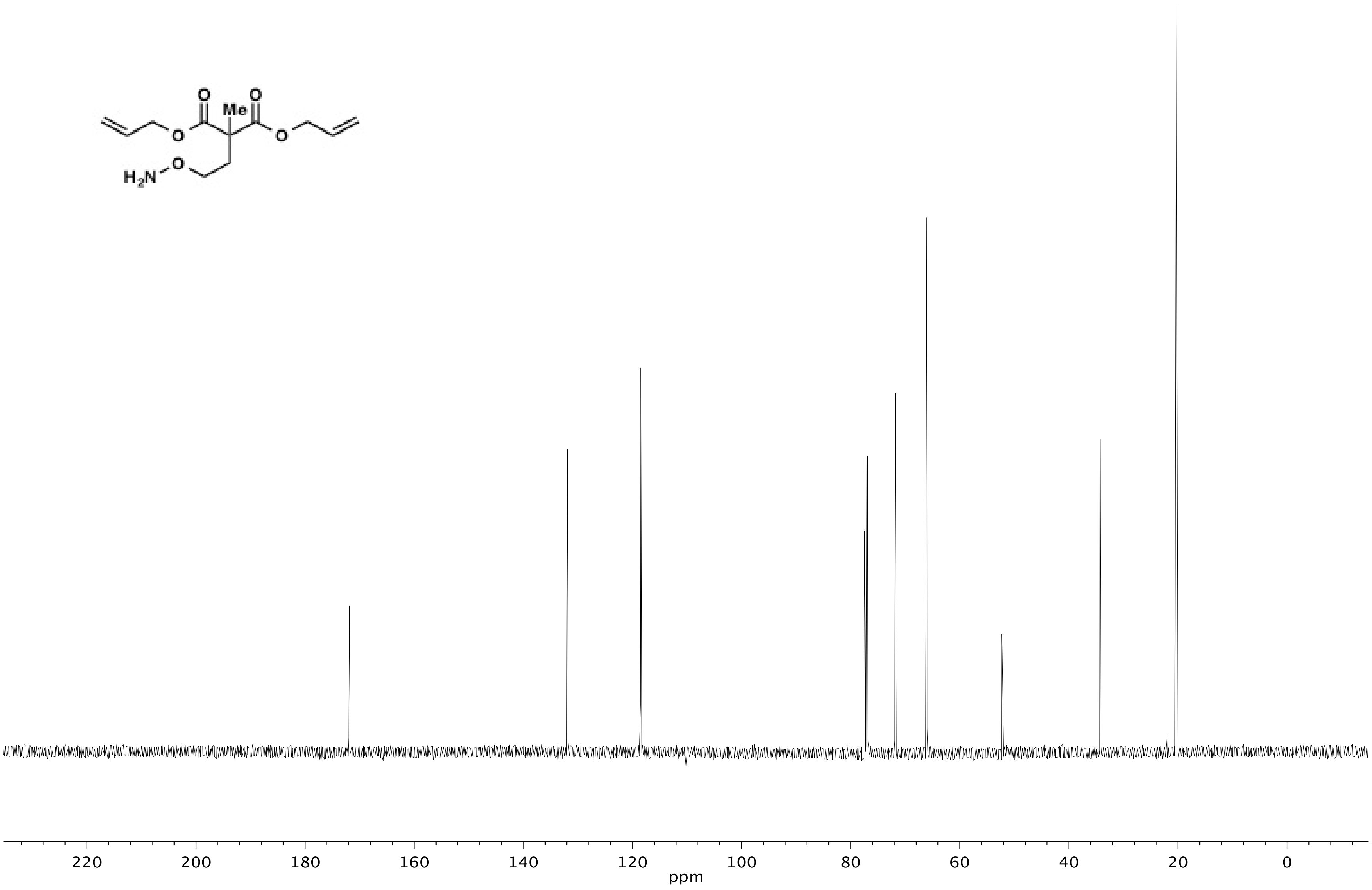
^{1}H NMR (500 MHz, CDCl$_3$) of compound **SI-15**.



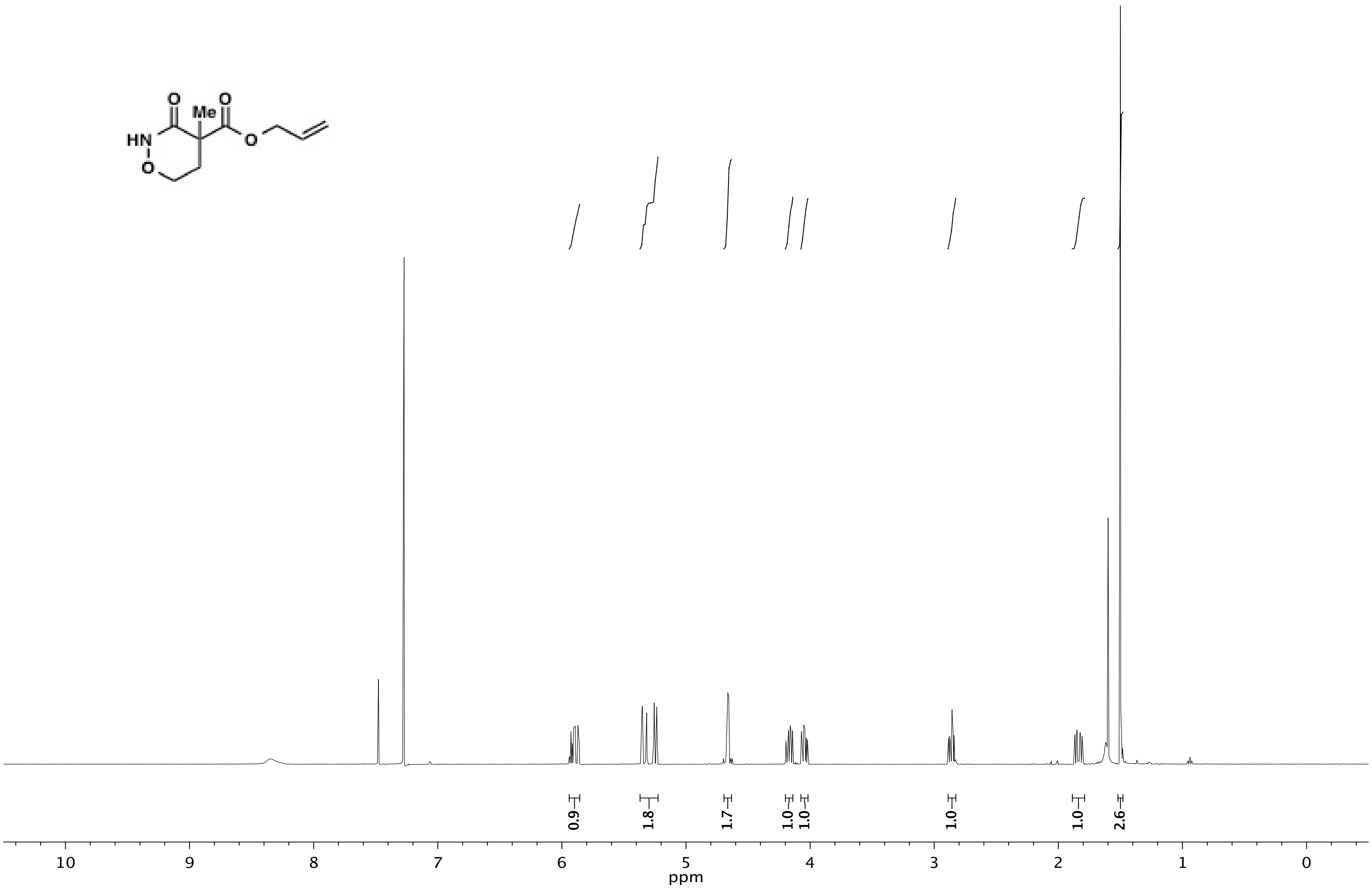
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-15**.



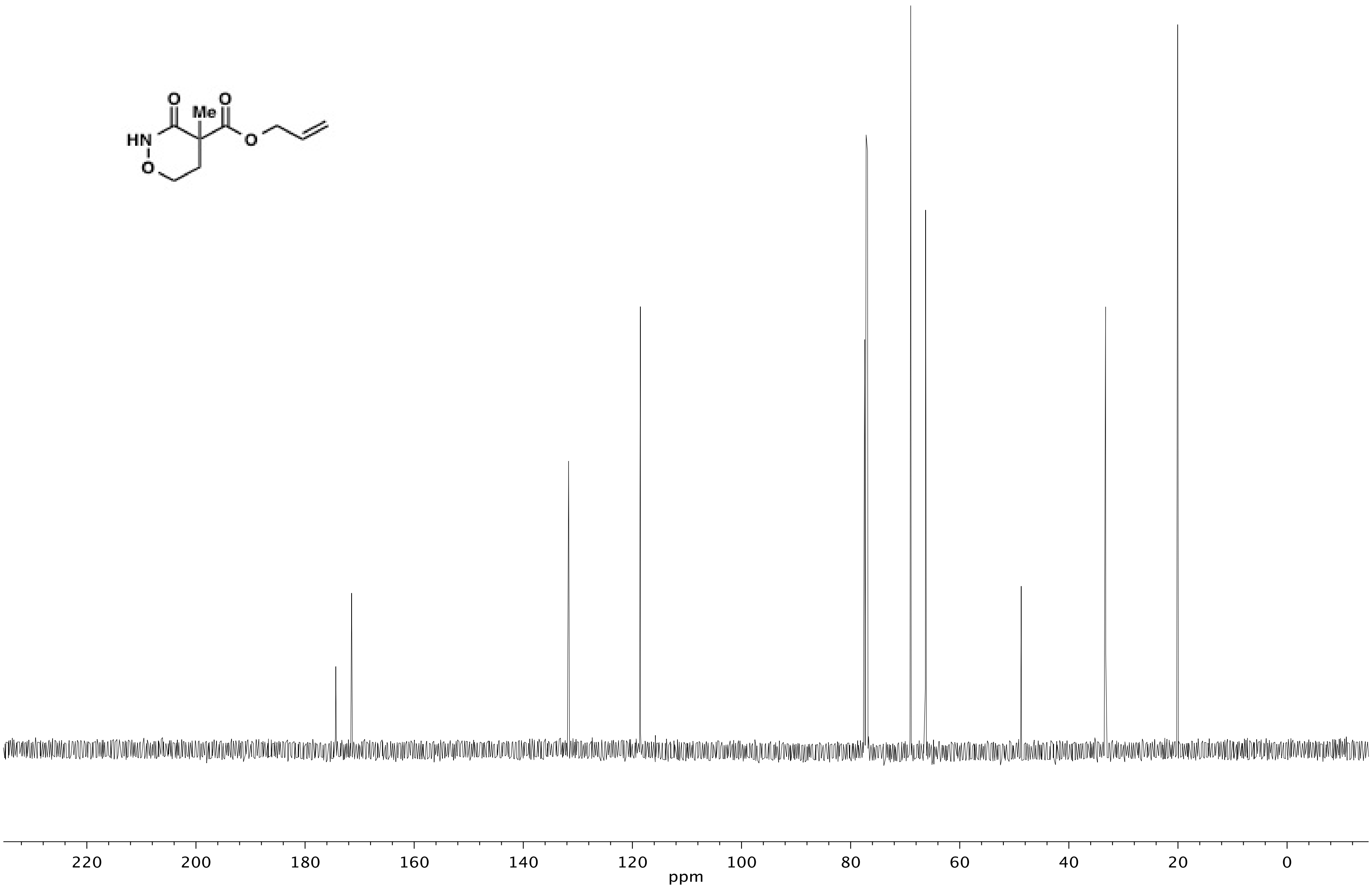
^{1}H NMR (500 MHz, $CDCl_3$) of compound **SI-16**.



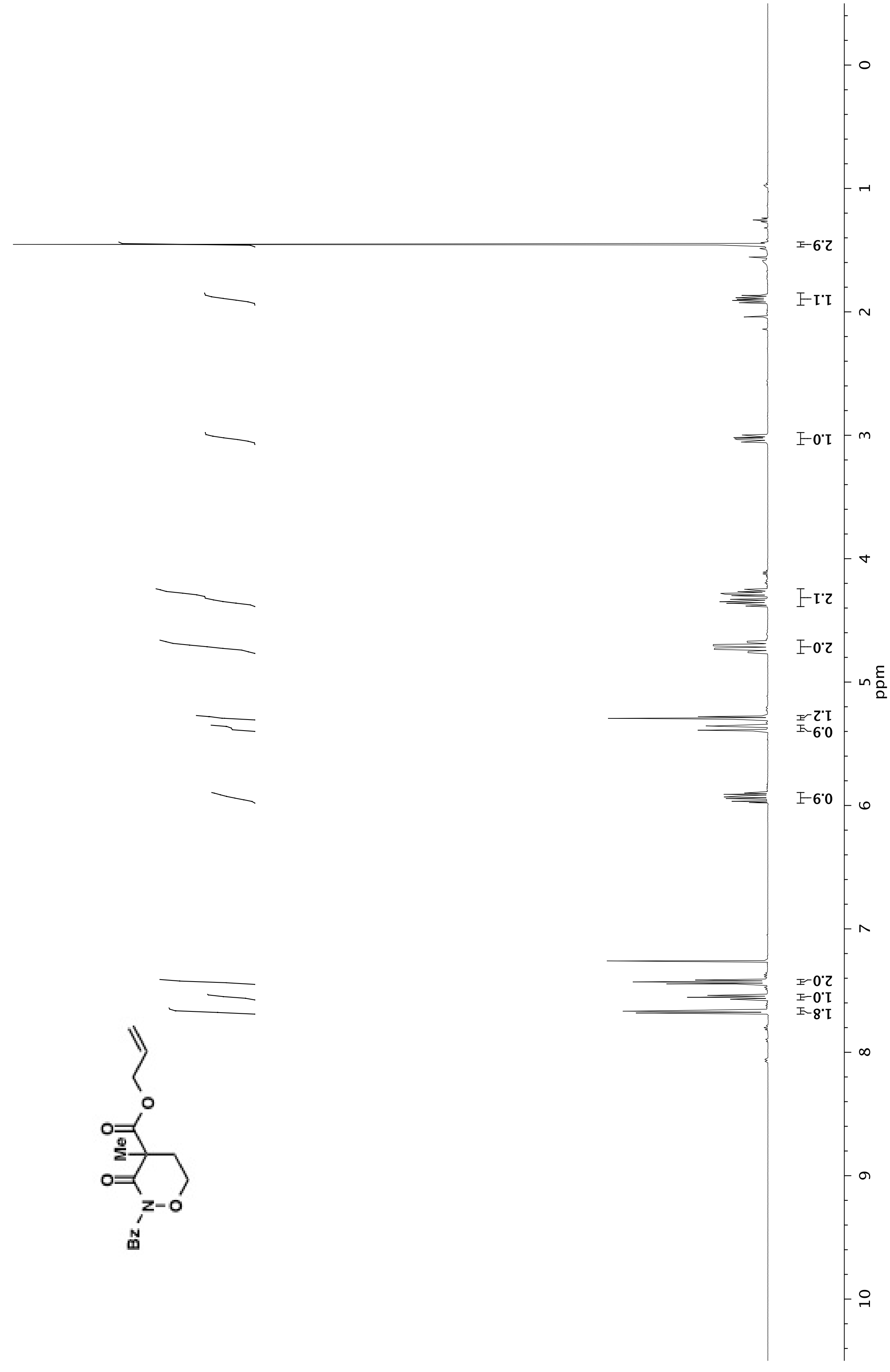
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-16**.



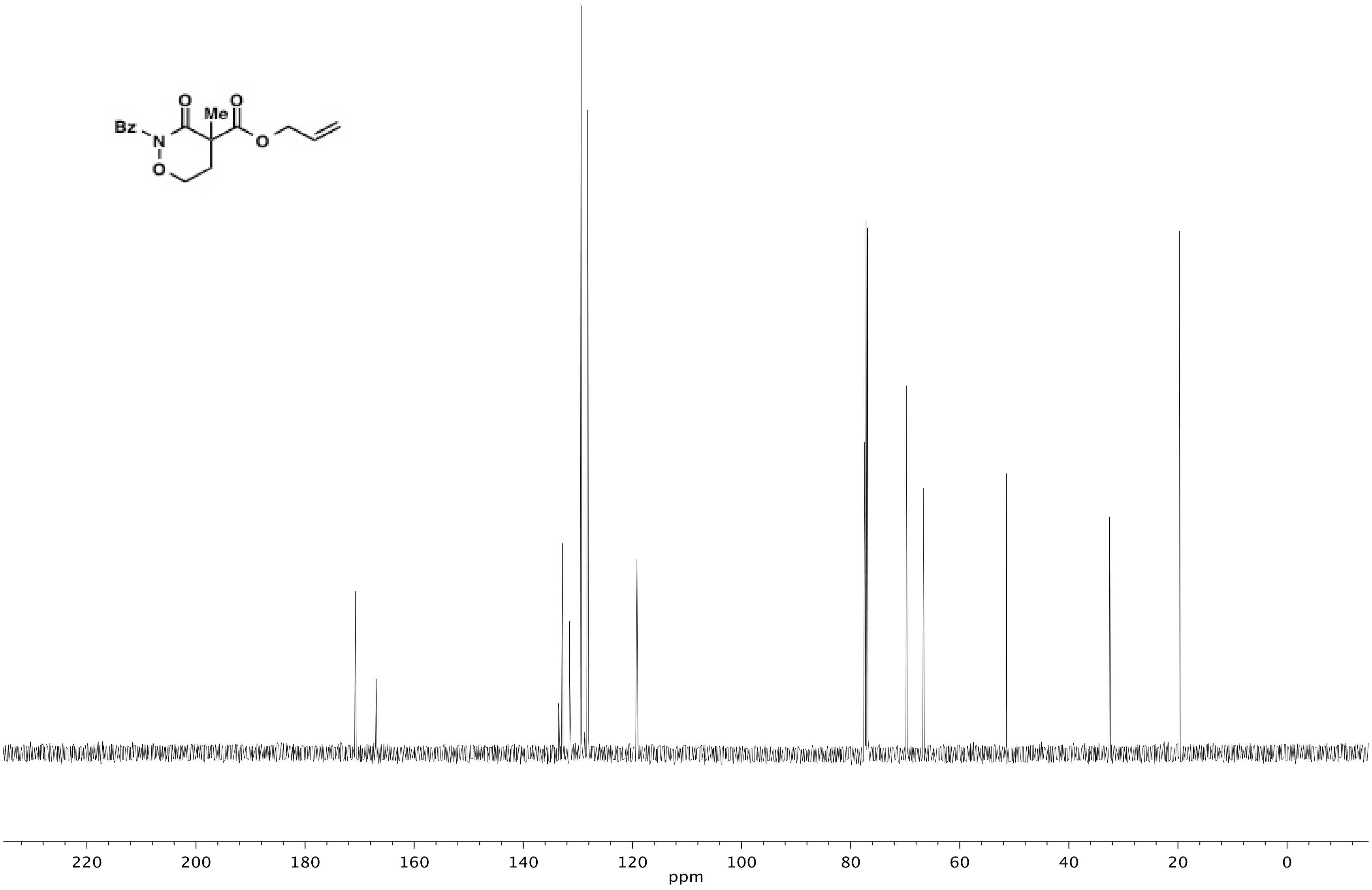
^{1}H NMR (500 MHz, $CDCl_3$) of compound **SI-17**.



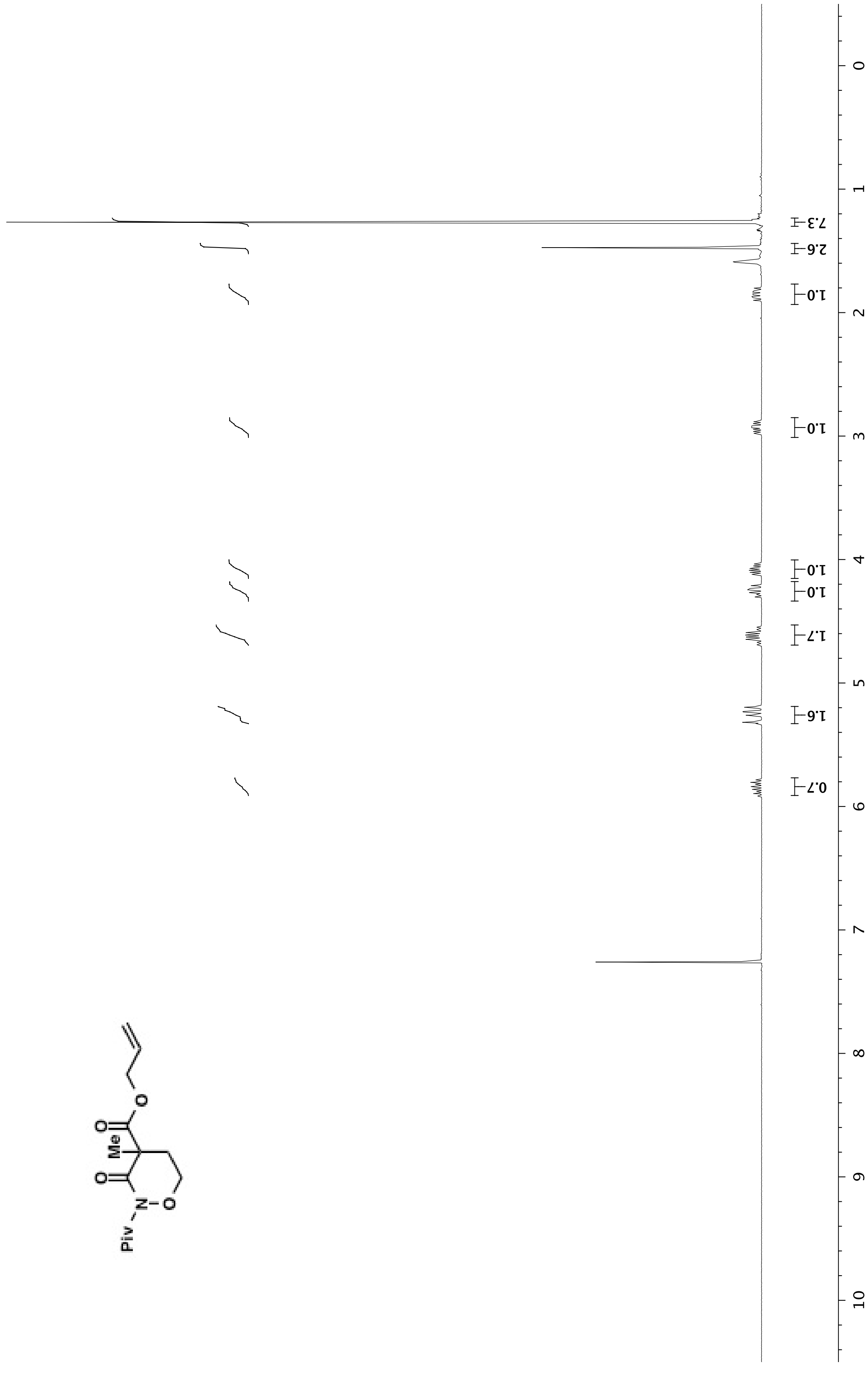
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-17**.



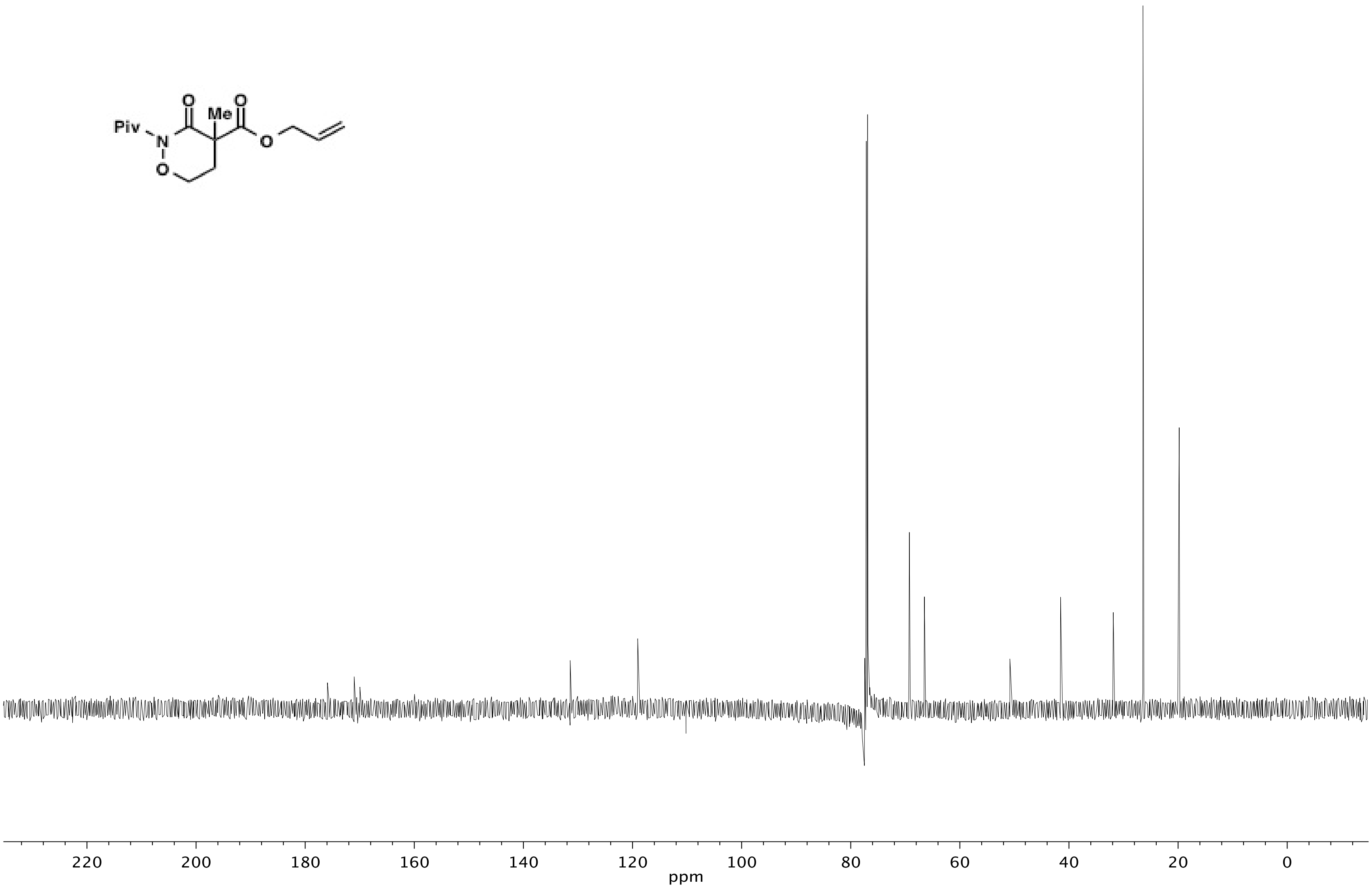
^{1}H NMR (500 MHz, $CDCl_3$) of compound **3d**.



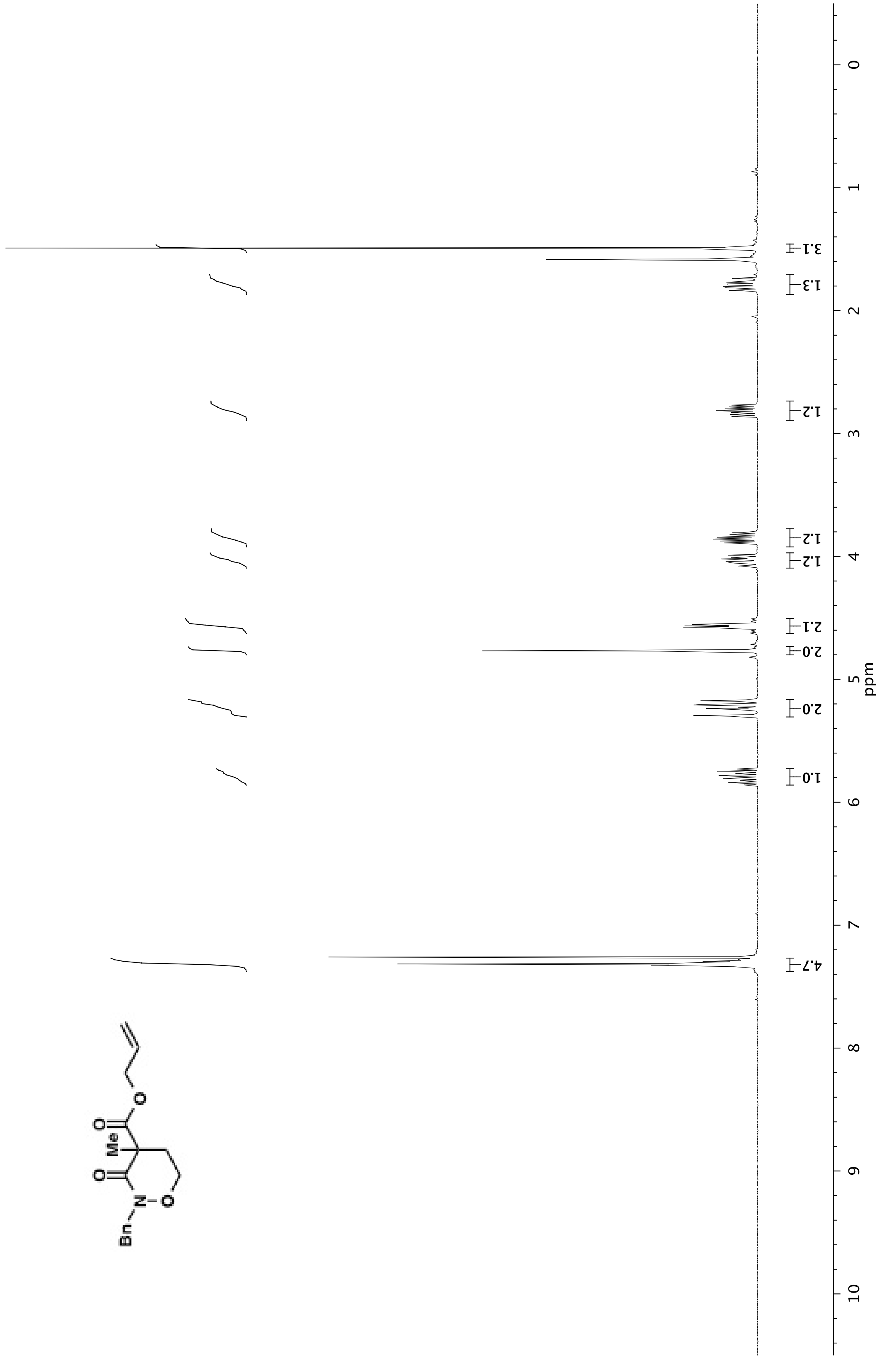
^{13}C NMR (126 MHz, CDCl$_3$) of compound **3d**.



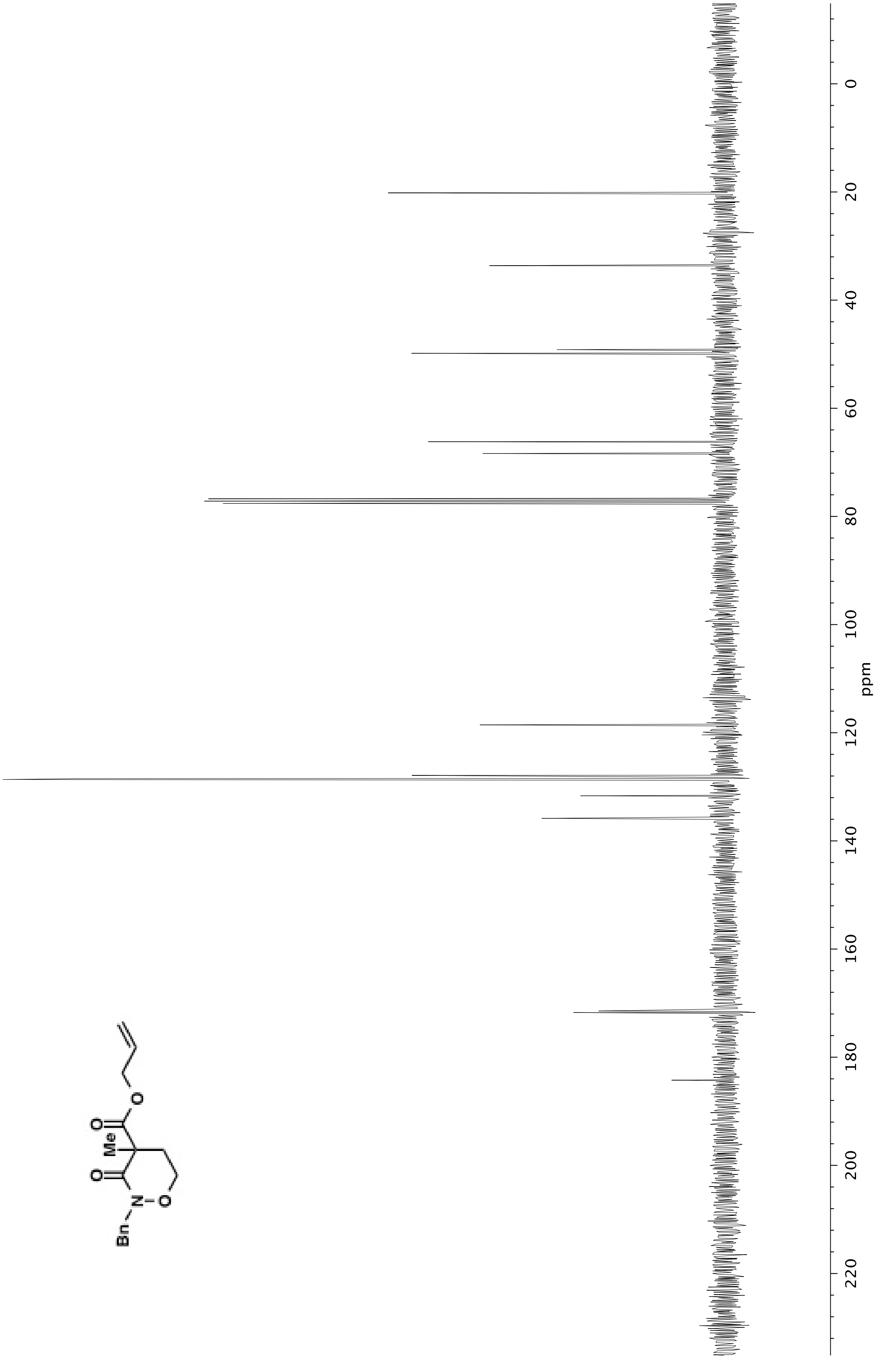
^{1}H NMR (300 MHz, CDCl$_3$) of compound **3e**.



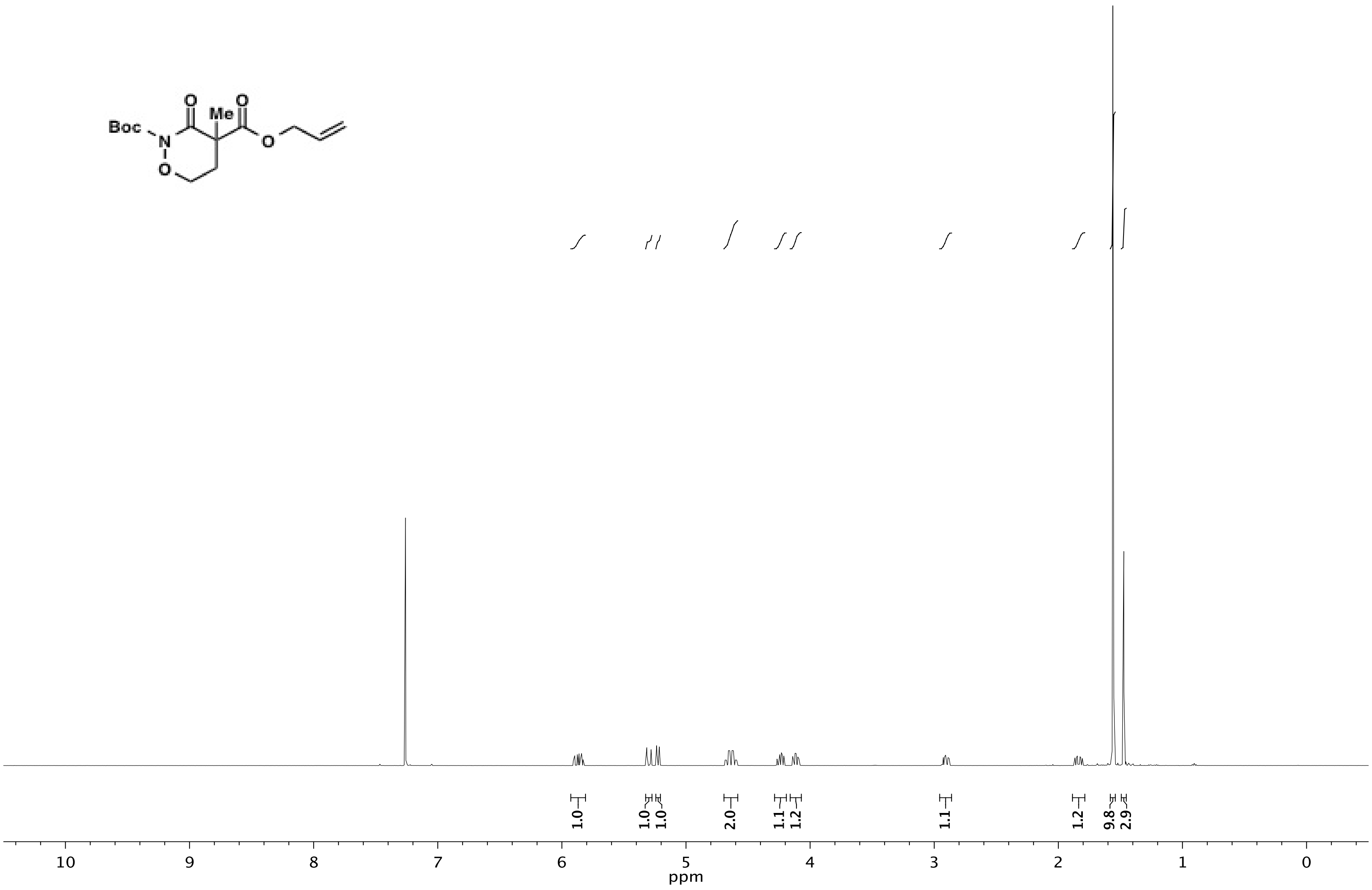
^{13}C NMR (126 MHz, $CDCl_3$) of compound **3e**.



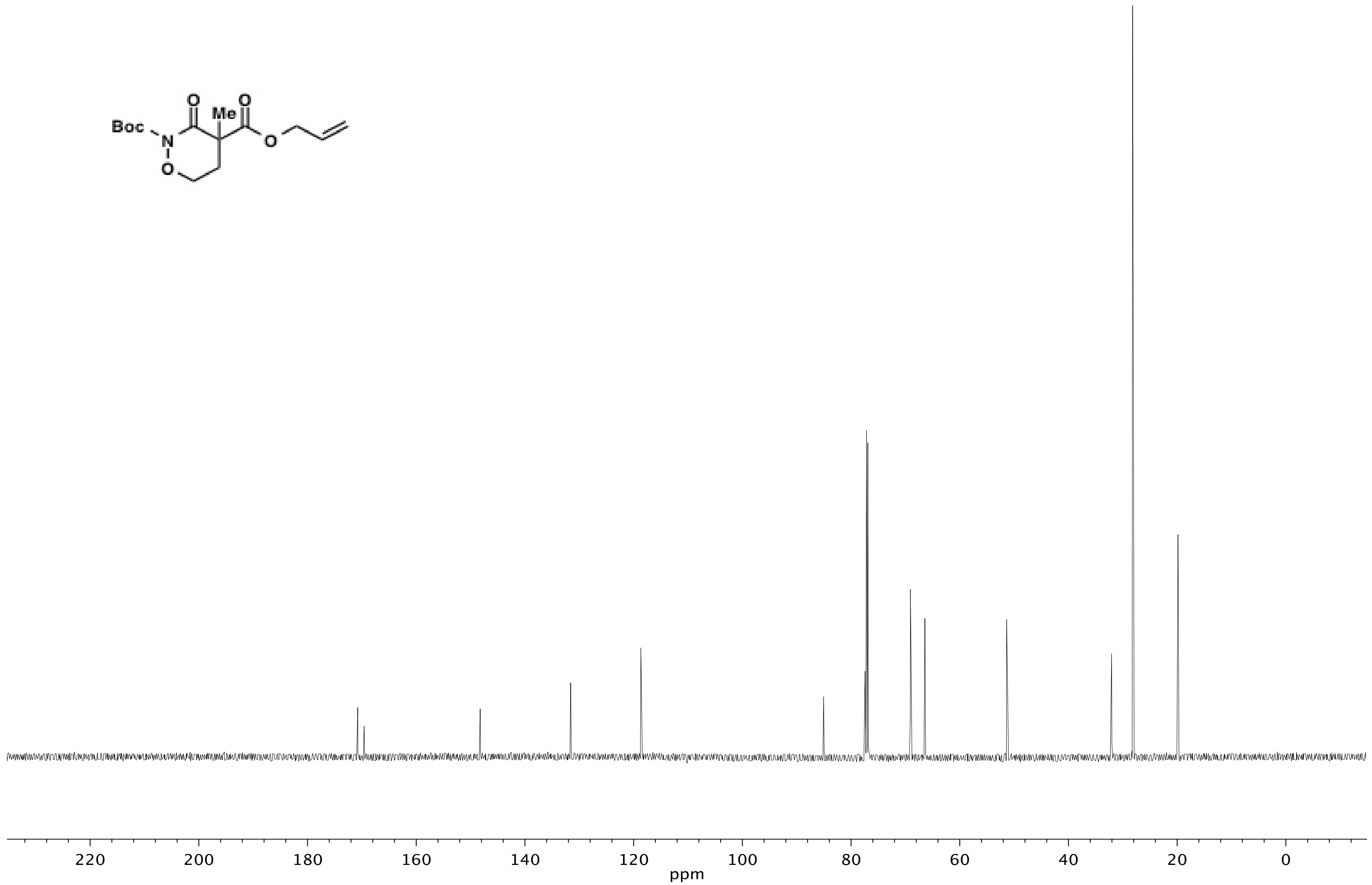
^{1}H NMR (300 MHz, CDCl$_3$) of compound **3f**.



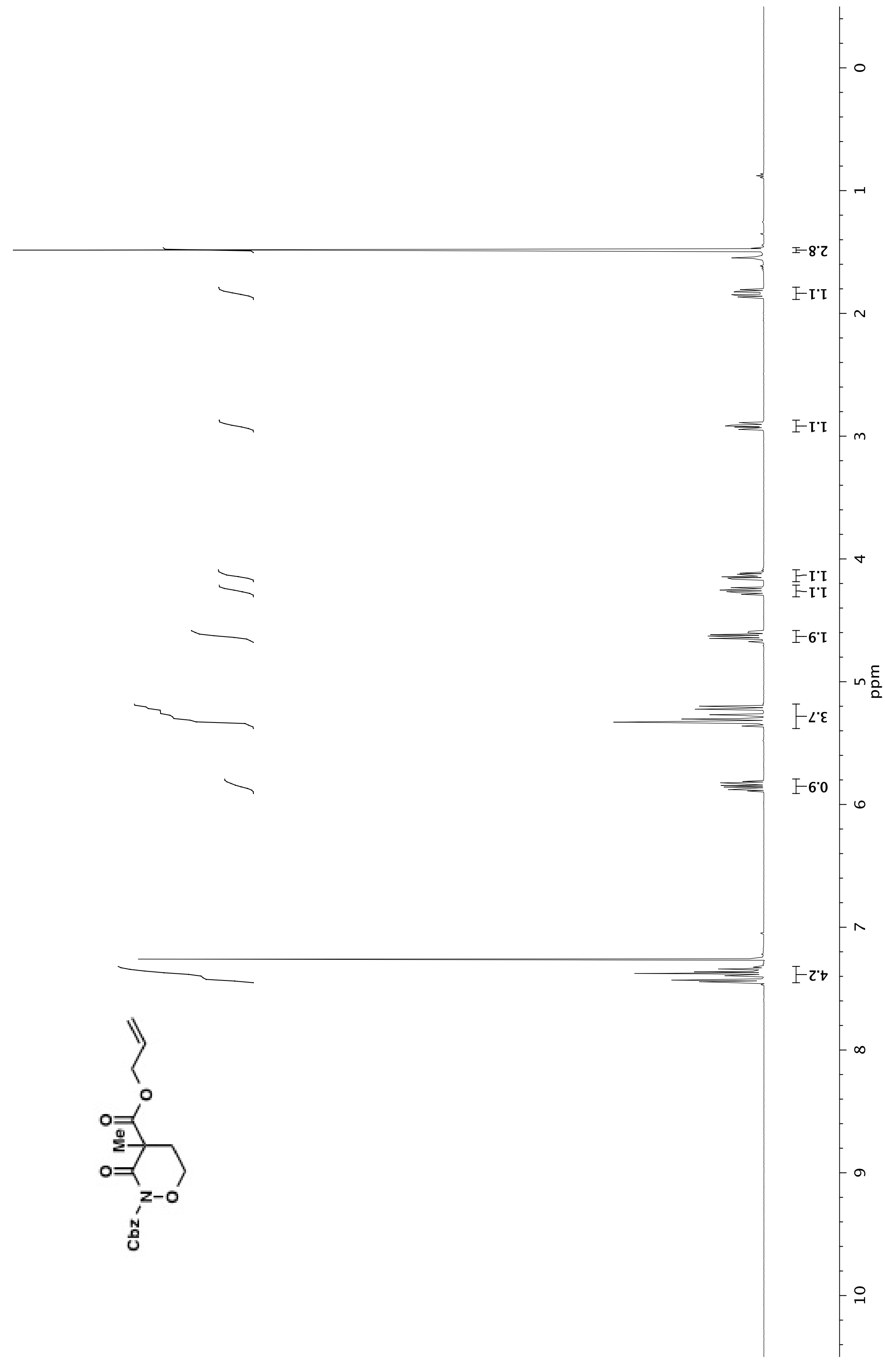
^{13}C NMR (75 MHz, $CDCl_3$) of compound **3f**.



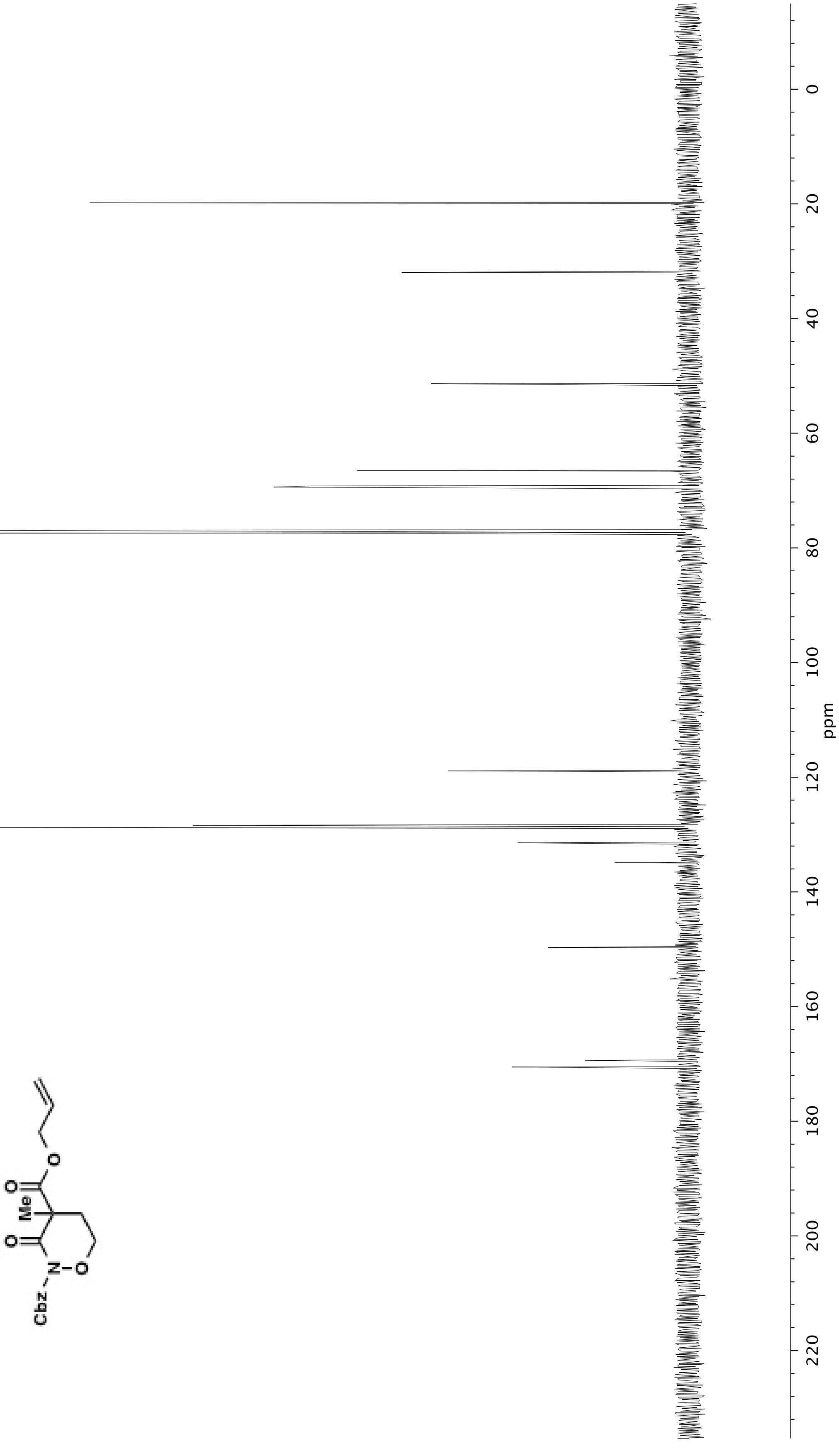
^{1}H NMR (500 MHz, $CDCl_3$) of compound **3g**.



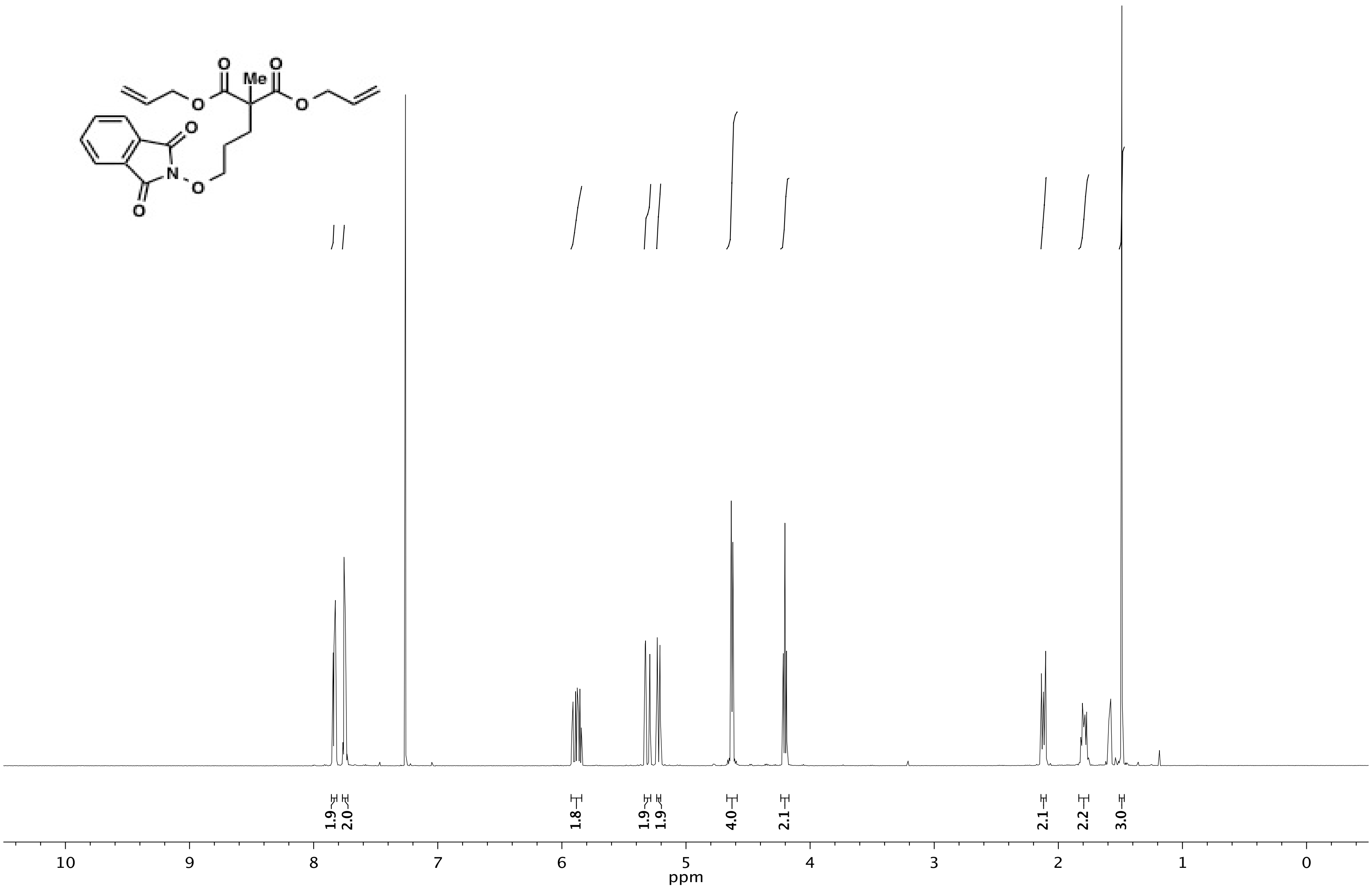
^{13}C NMR (126 MHz, CDCl$_3$) of compound **3g**.



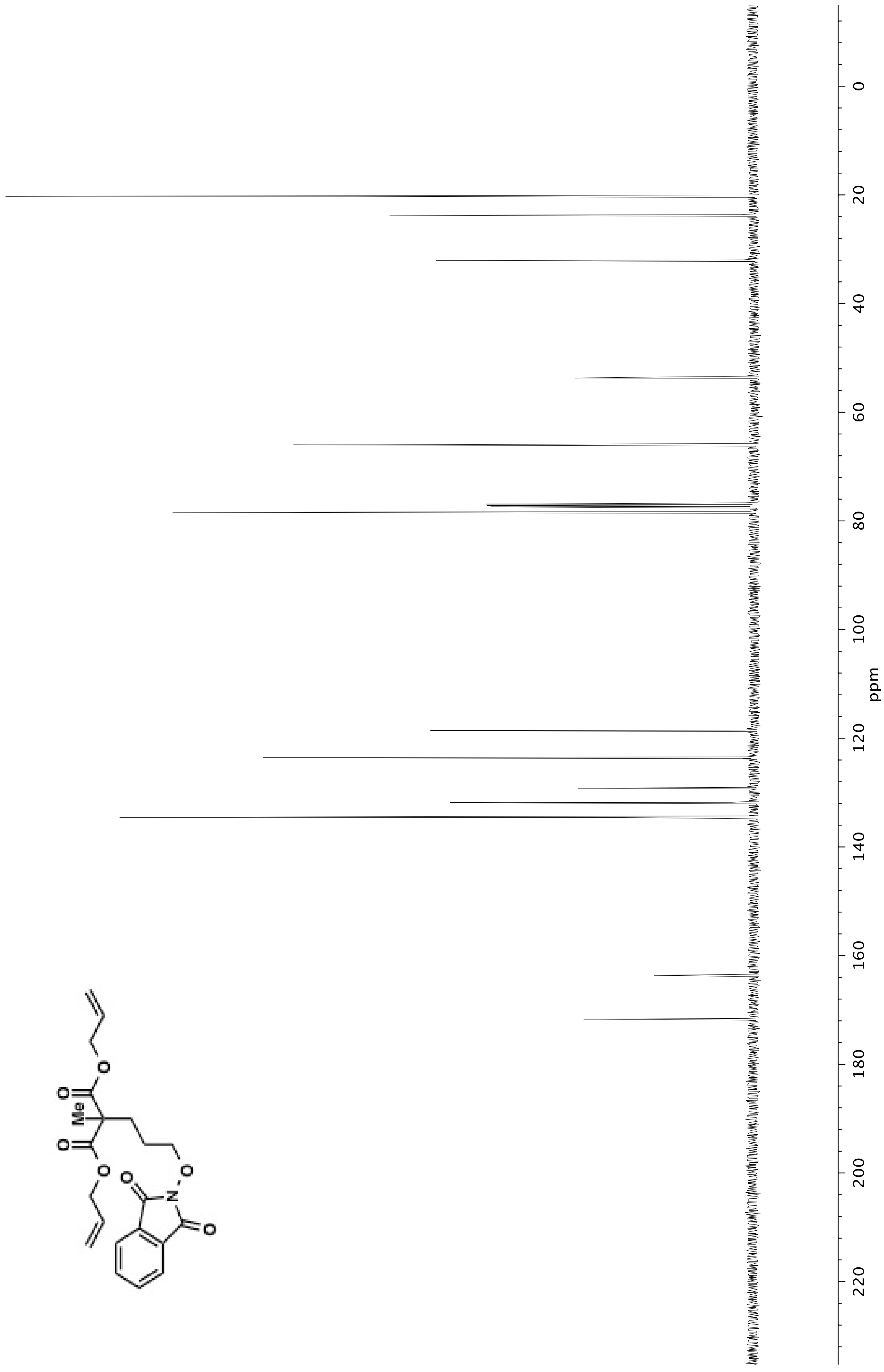
^{1}H NMR (500 MHz, $CDCl_3$) of compound **3h**.



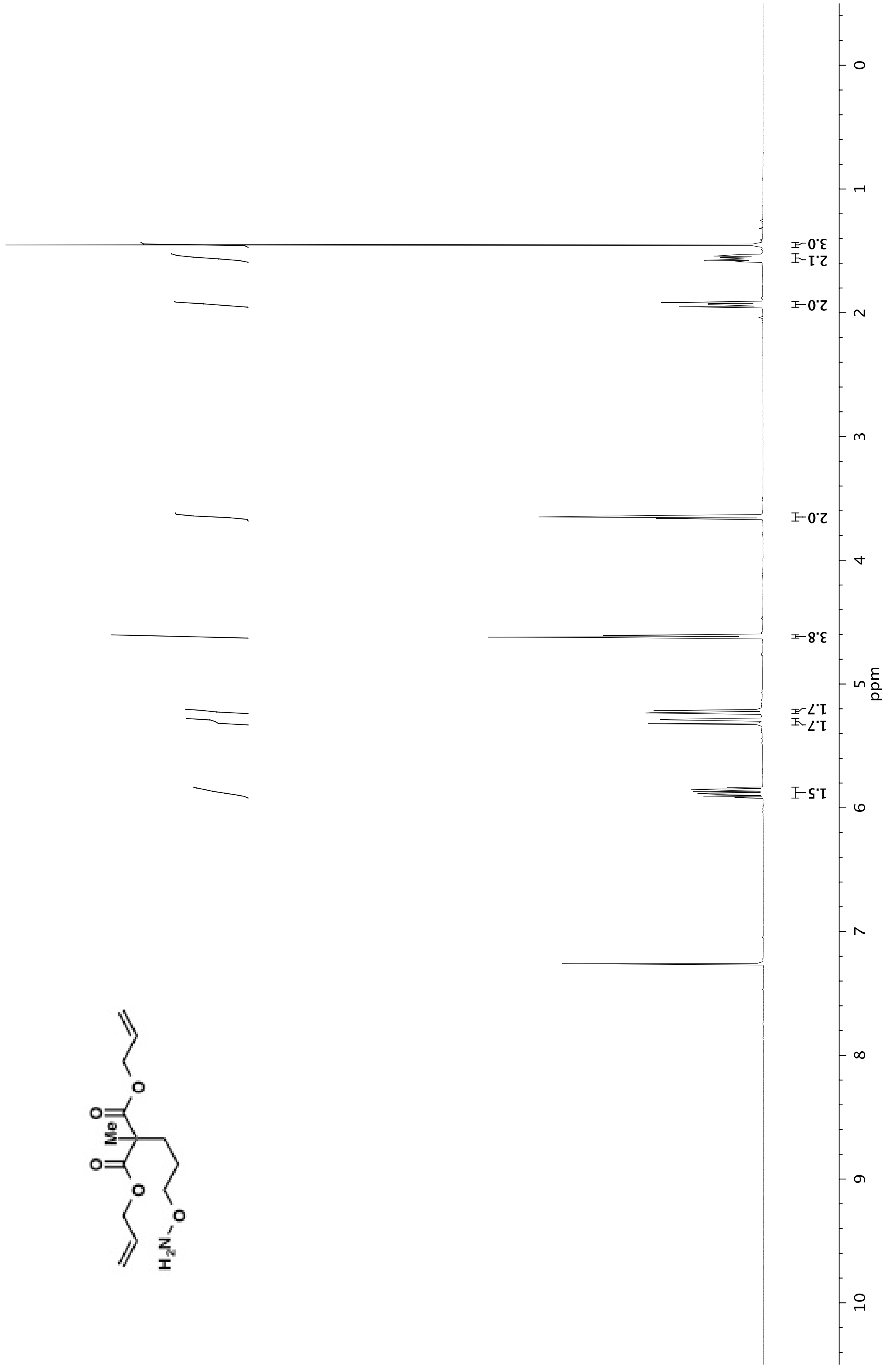
^{13}C NMR (126 MHz, CDCl$_3$) of compound **3h**.



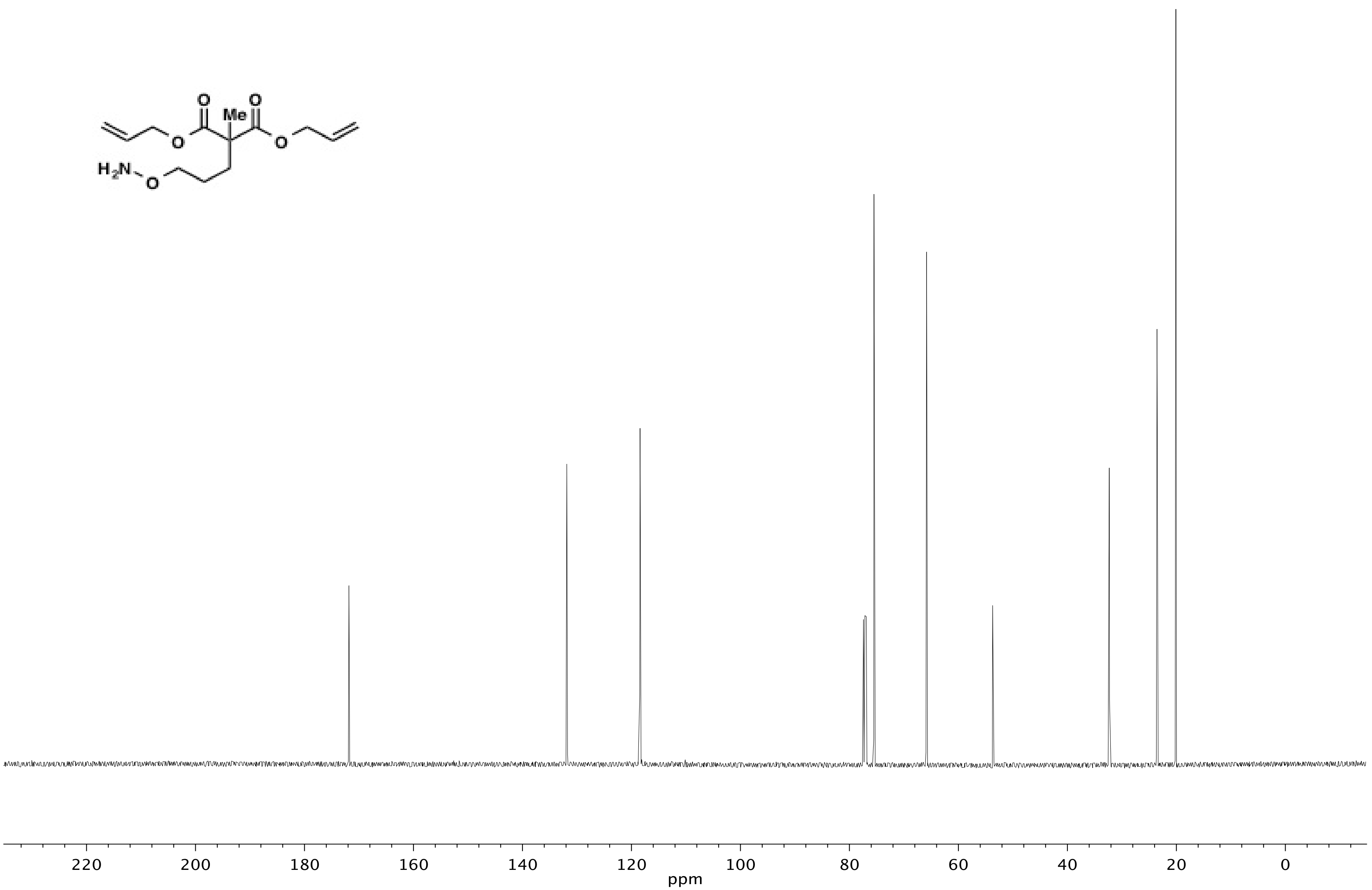
^{1}H NMR (500 MHz, $CDCl_3$) of compound **SI-19**.



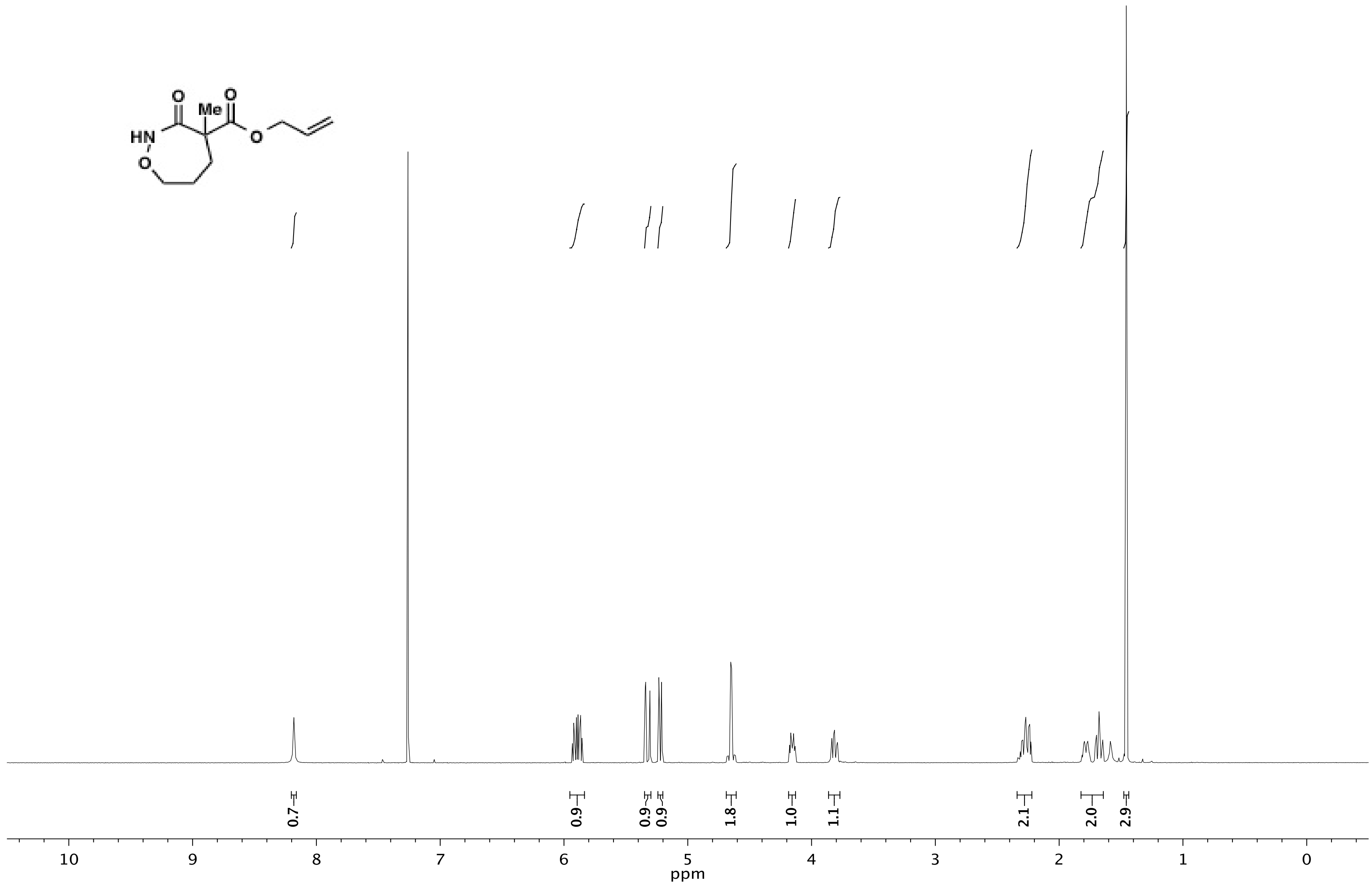
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-19**.



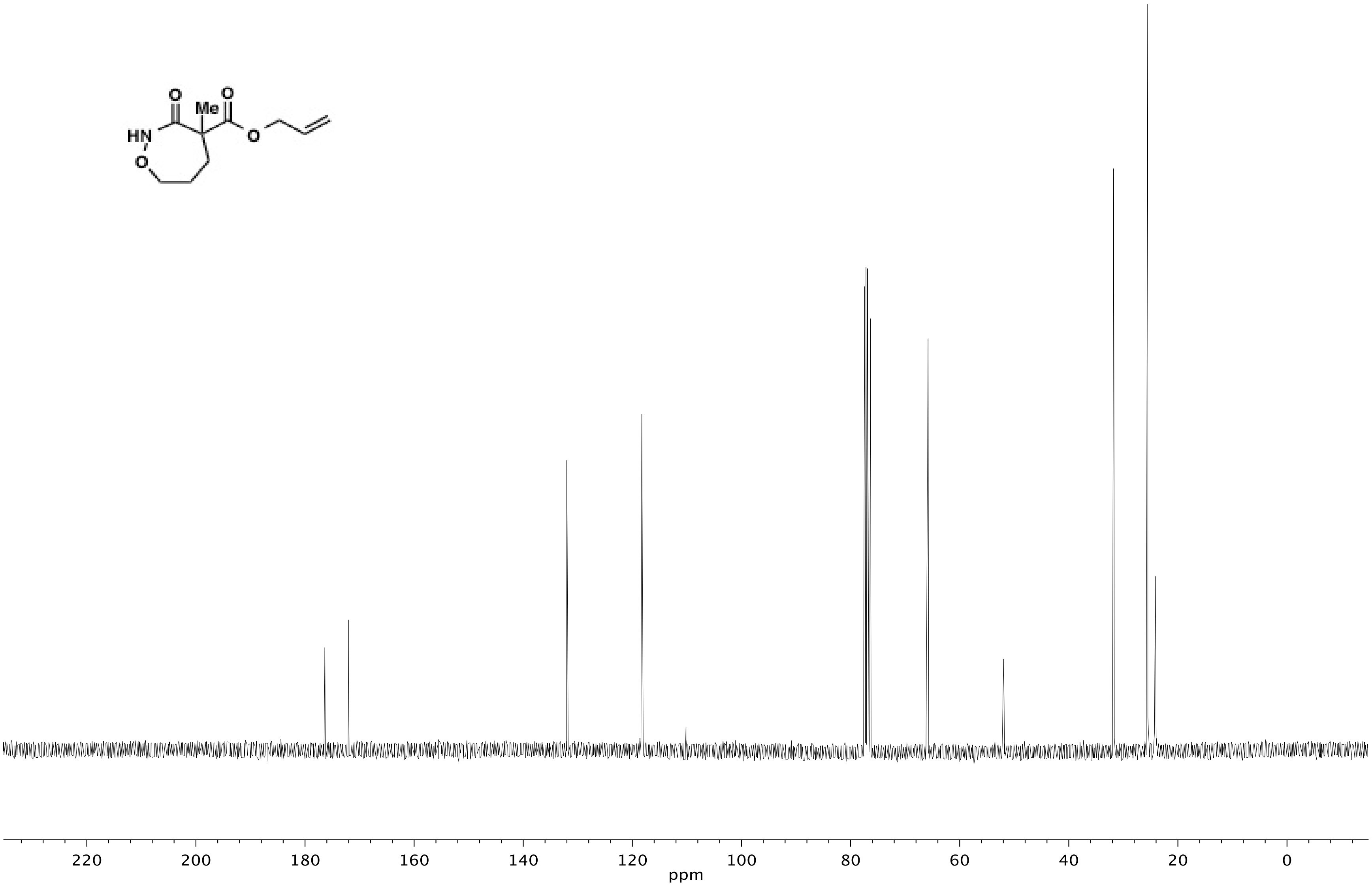
^{1}H NMR (500 MHz, CDCl$_3$) of compound **SI-20**.



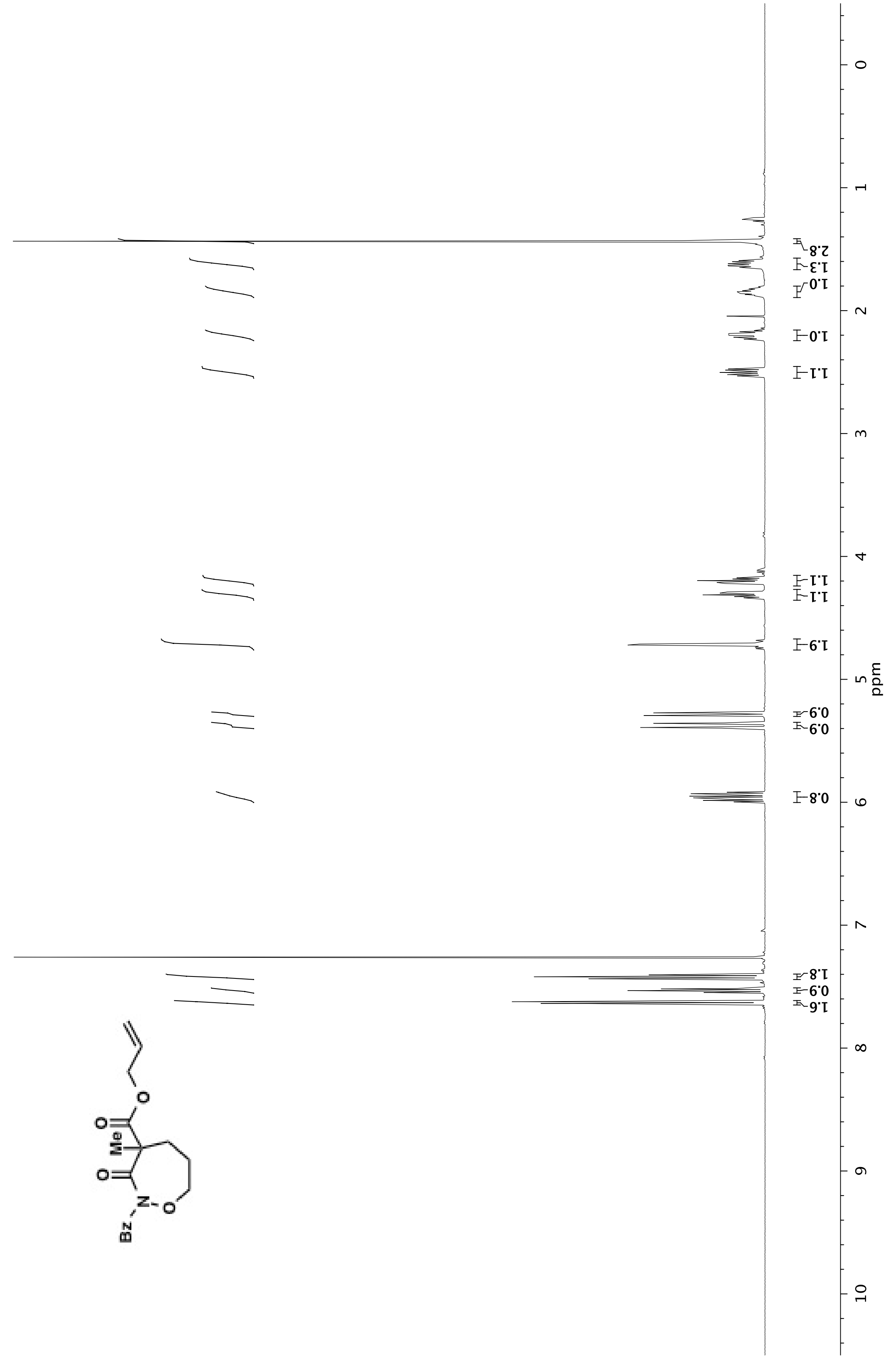
^{13}C NMR (126 MHz, $CDCl_3$) of compound **SI-20**.



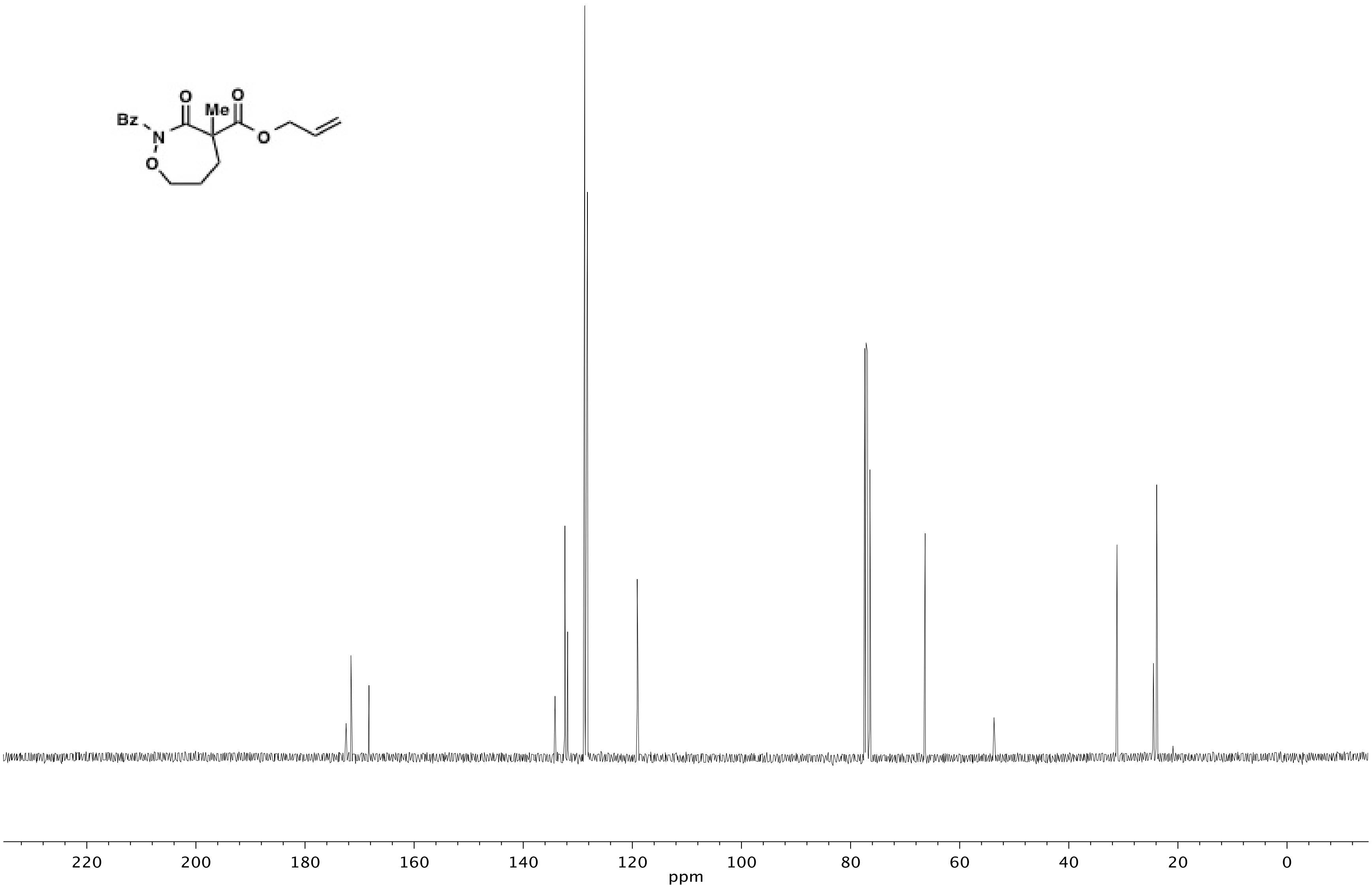
^{1}H NMR (500 MHz, $CDCl_3$) of compound **SI-21**.



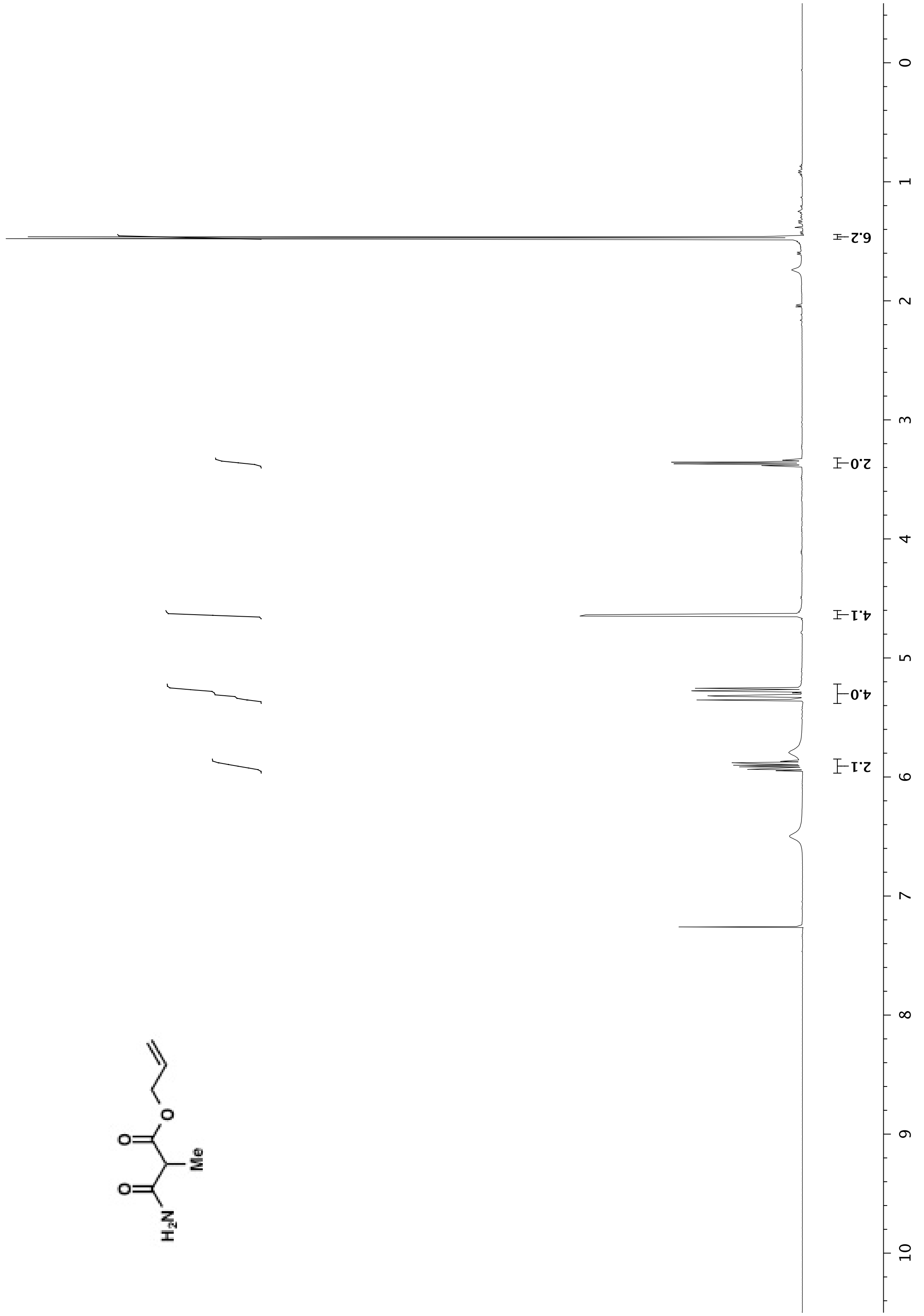
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-21**.



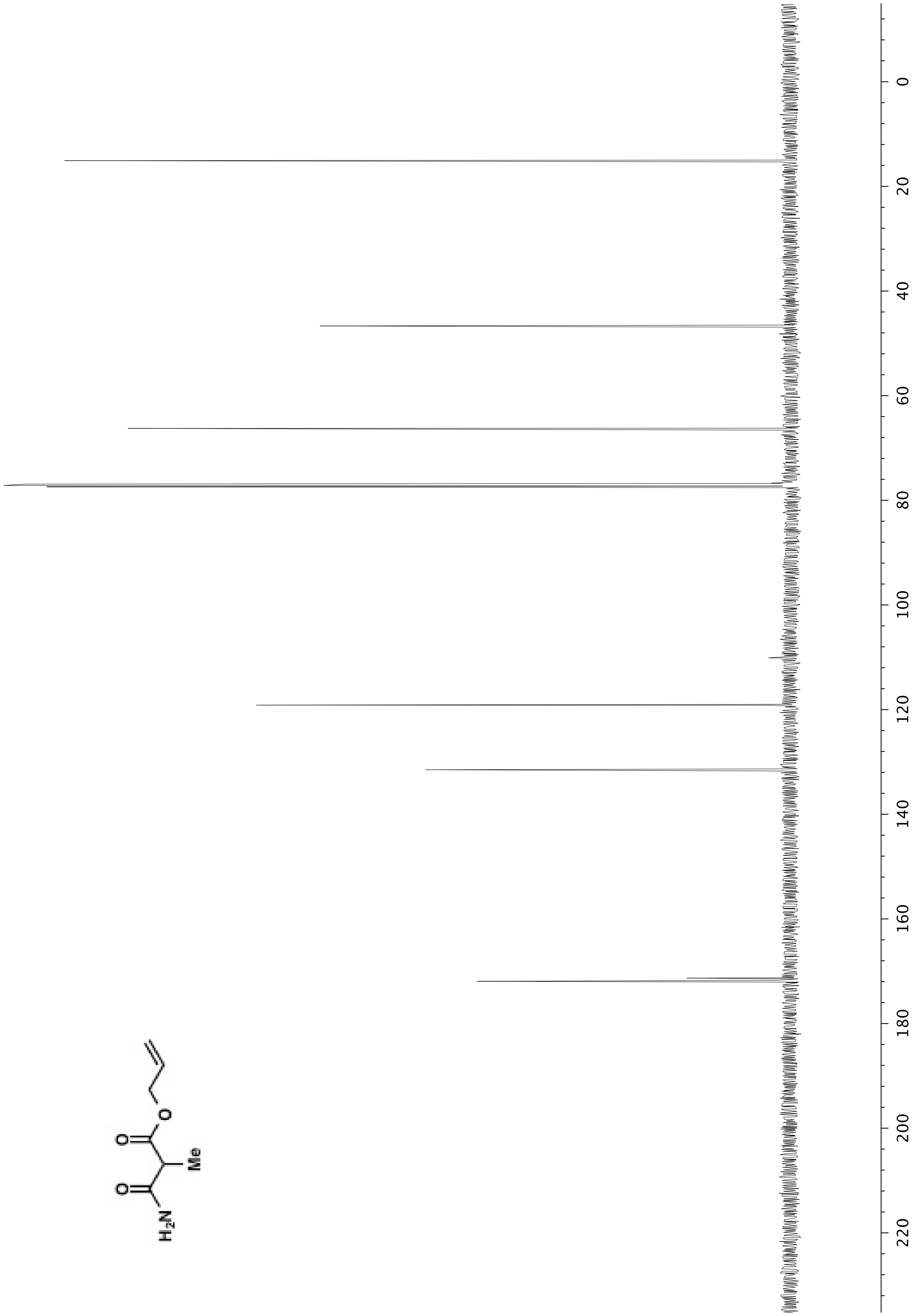
^{1}H NMR (500 MHz, CDCl$_3$) of compound **3j**.



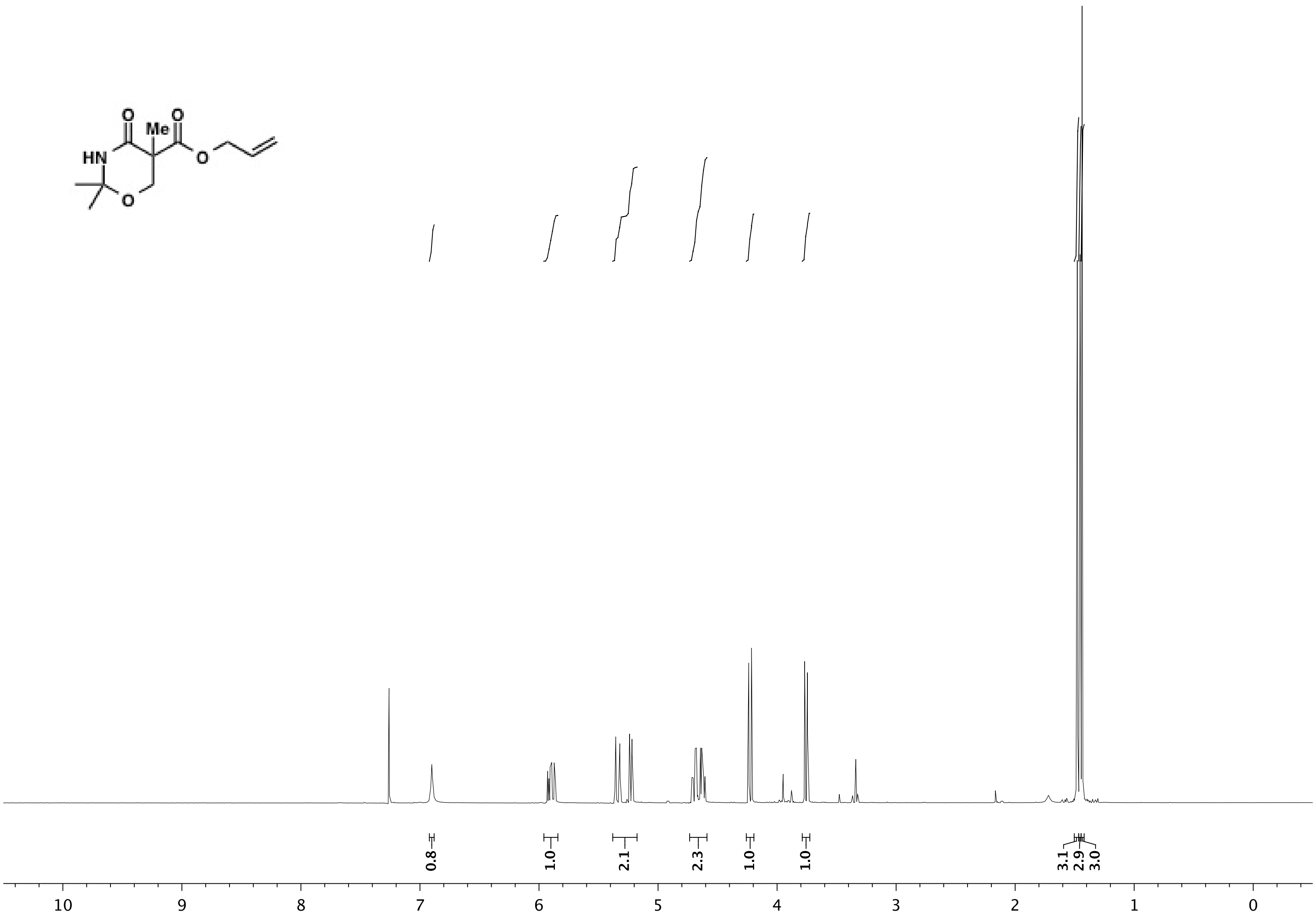
^{13}C NMR (126 MHz, CDCl$_3$) of compound **3j**.



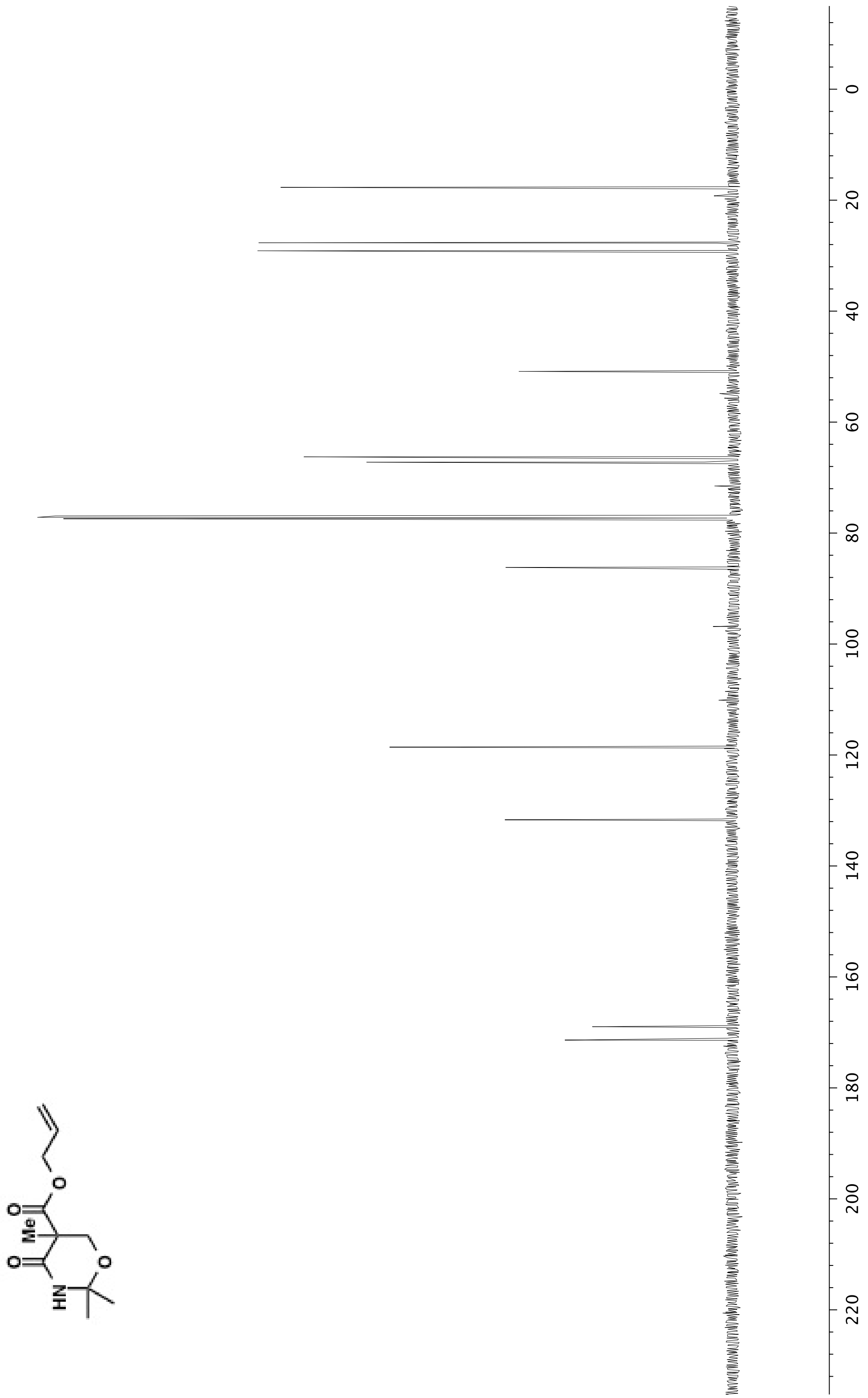
^{1}H NMR (500 MHz, CDCl$_3$) of compound **SI-22**.



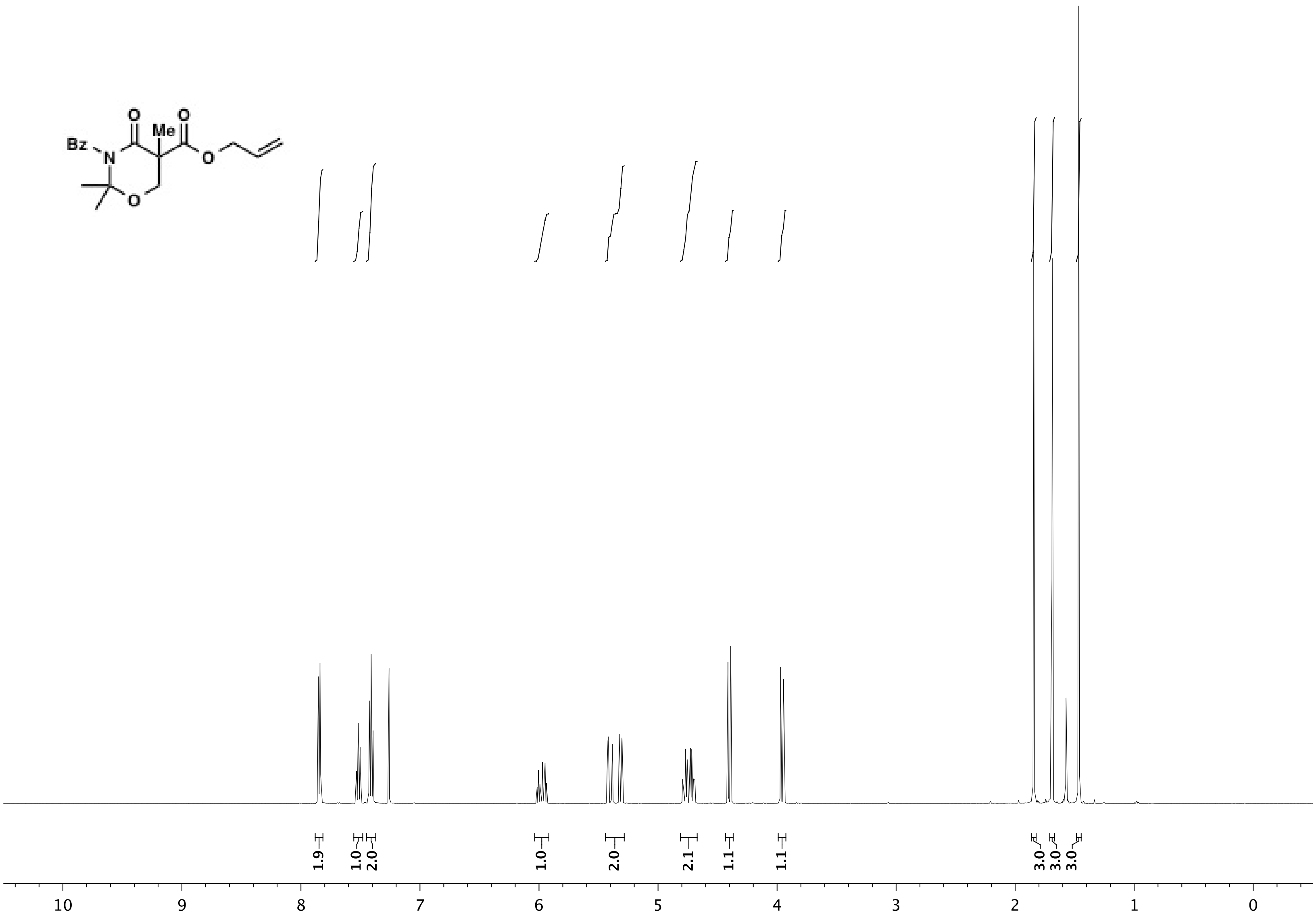
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-22**.



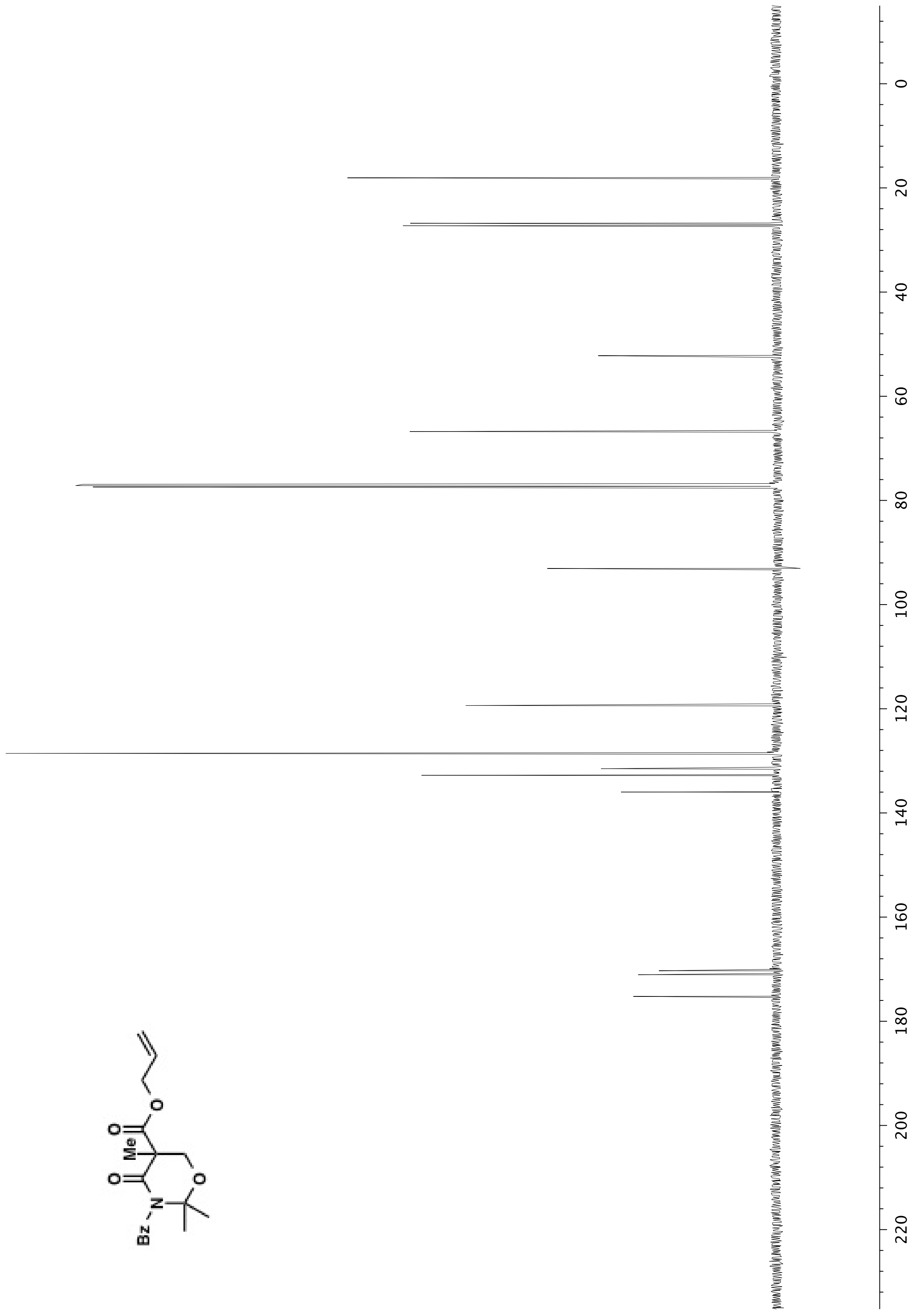
^{1}H NMR (500 MHz, $CDCl_3$) of compound **SI-23**.



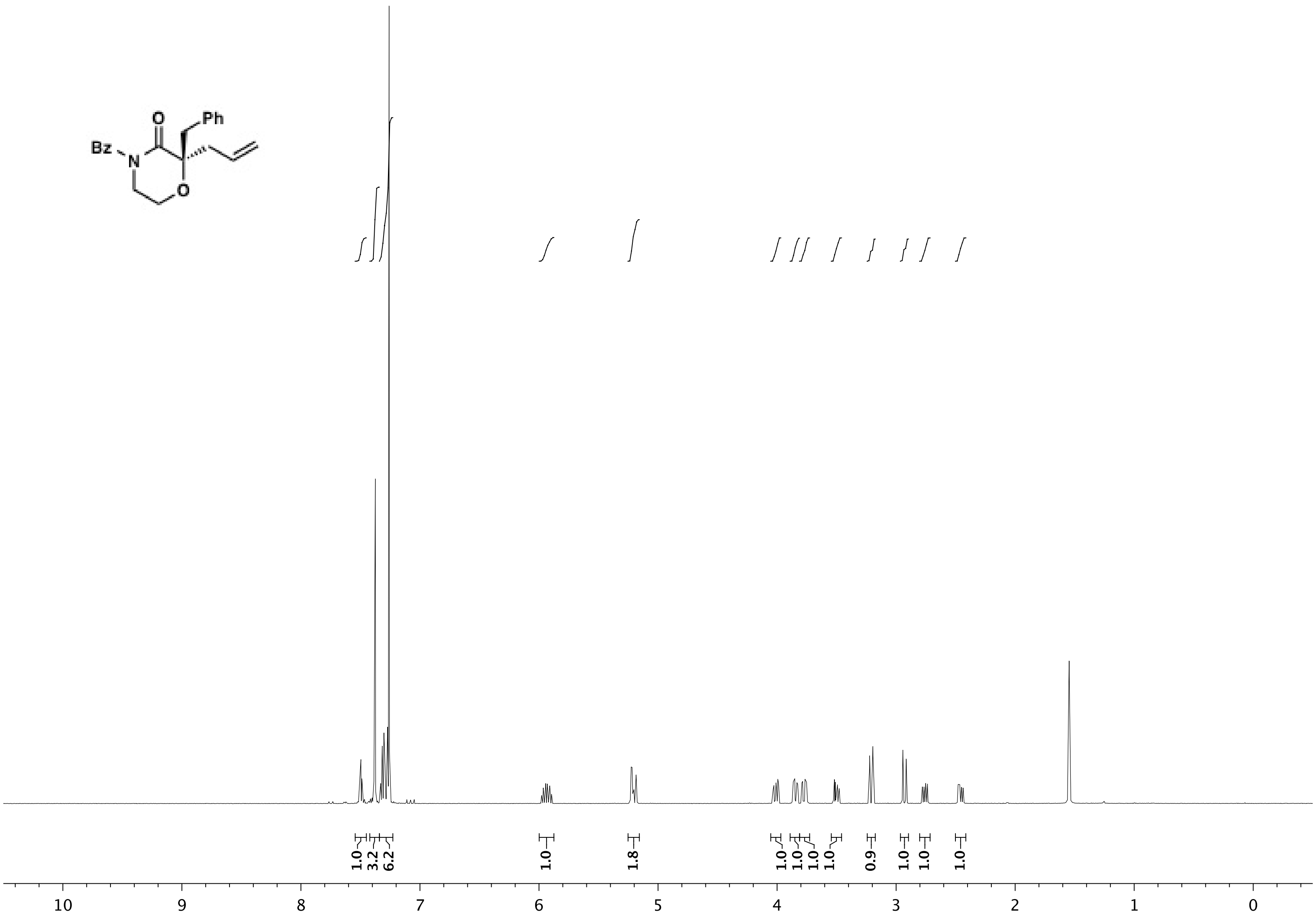
^{13}C NMR (126 MHz, $CDCl_3$) of compound **SI-23**.



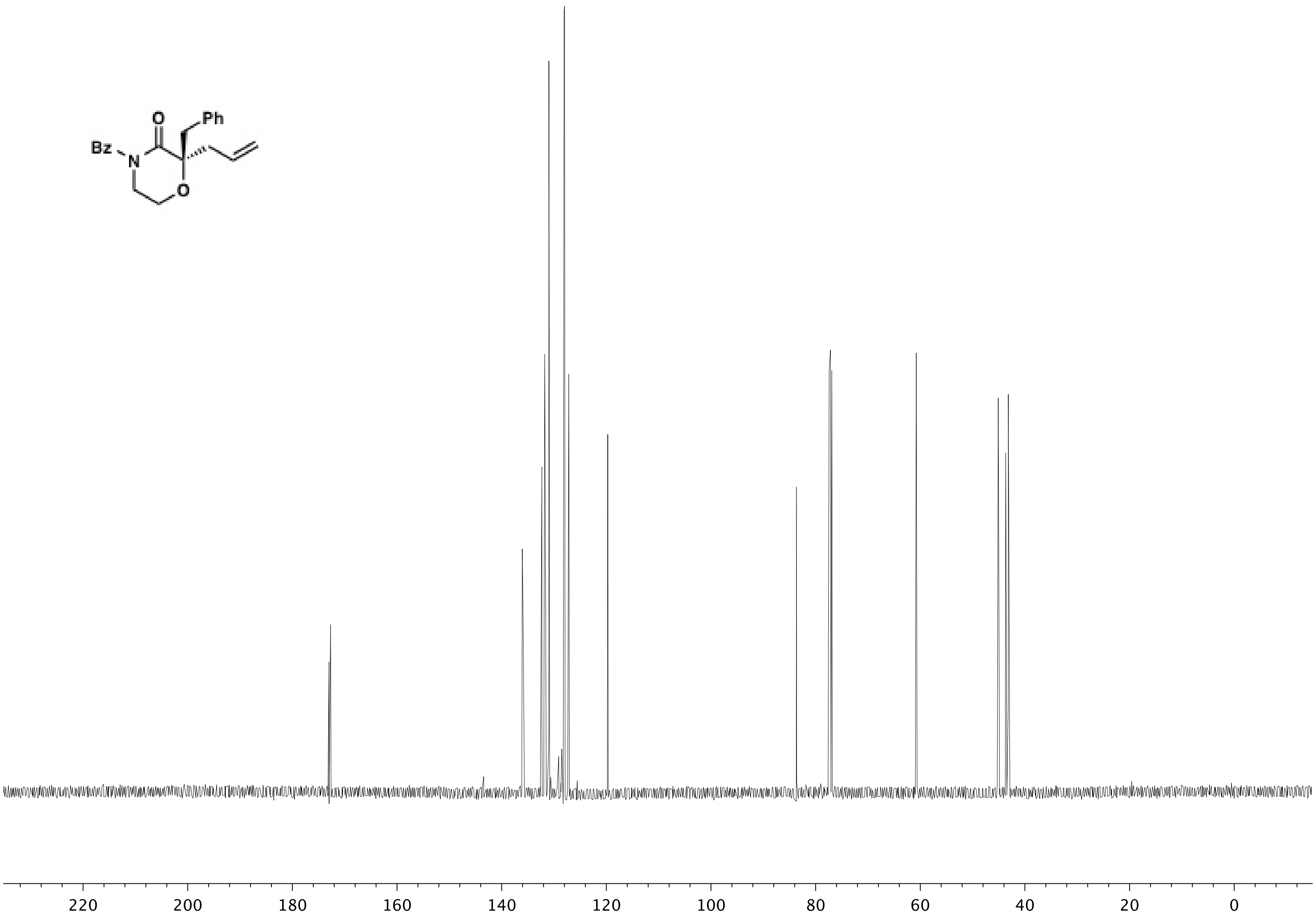
^{1}H NMR (500 MHz, $CDCl_3$) of compound **5**.



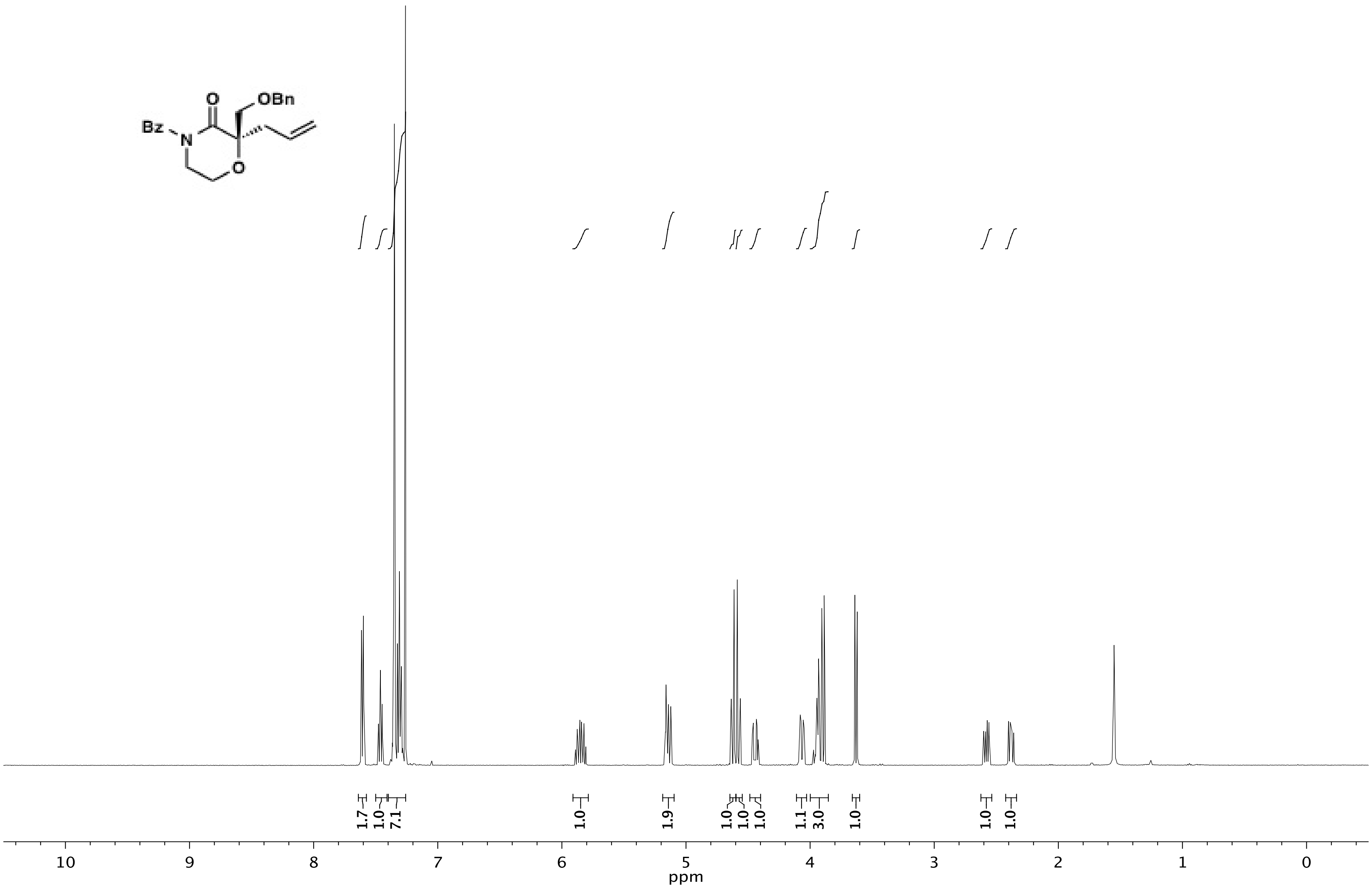
^{13}C NMR (126 MHz, $CDCl_3$) of compound **5**.



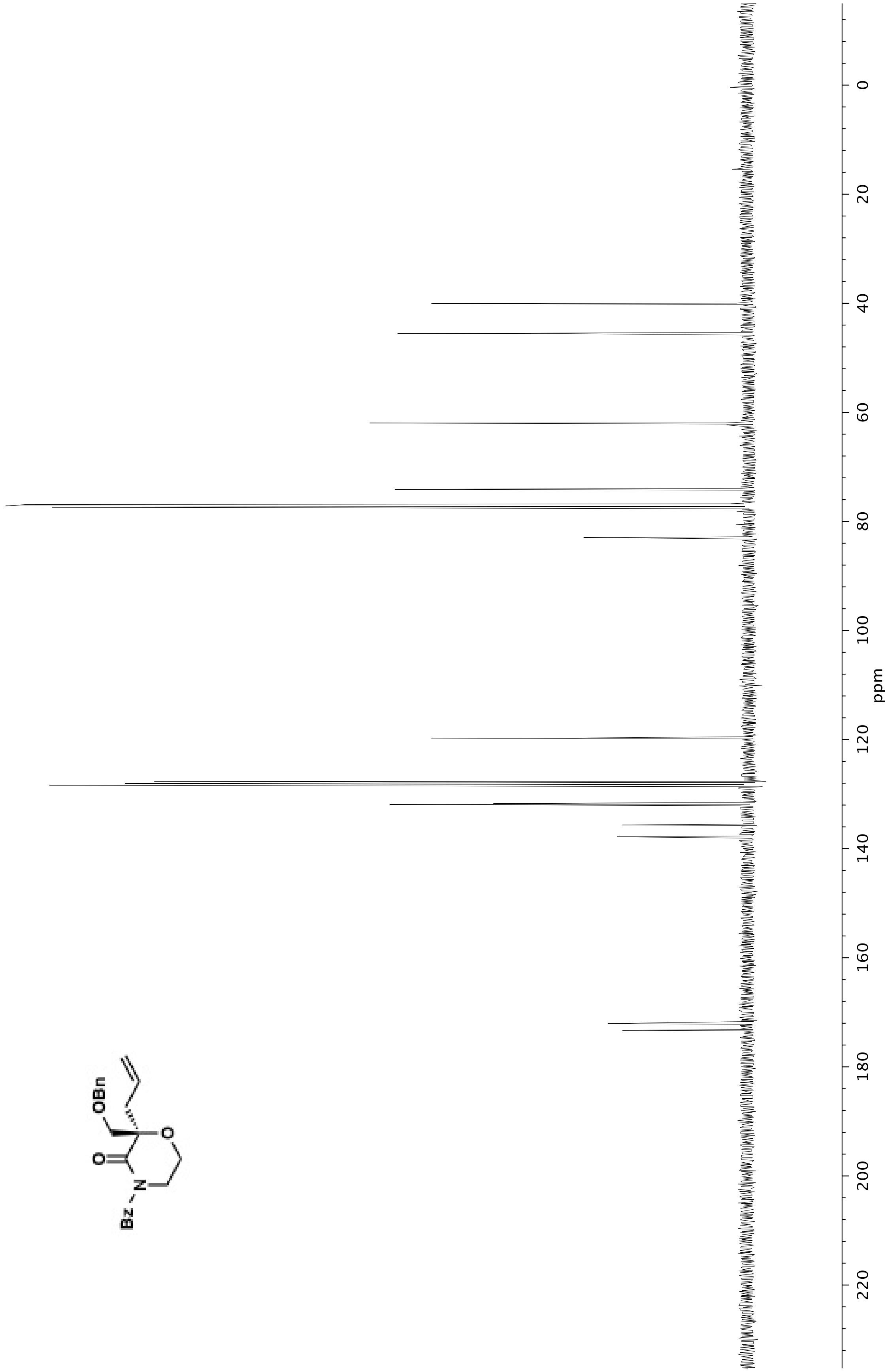
^{1}H NMR (500 MHz, CDCl$_3$) of compound **2b**.



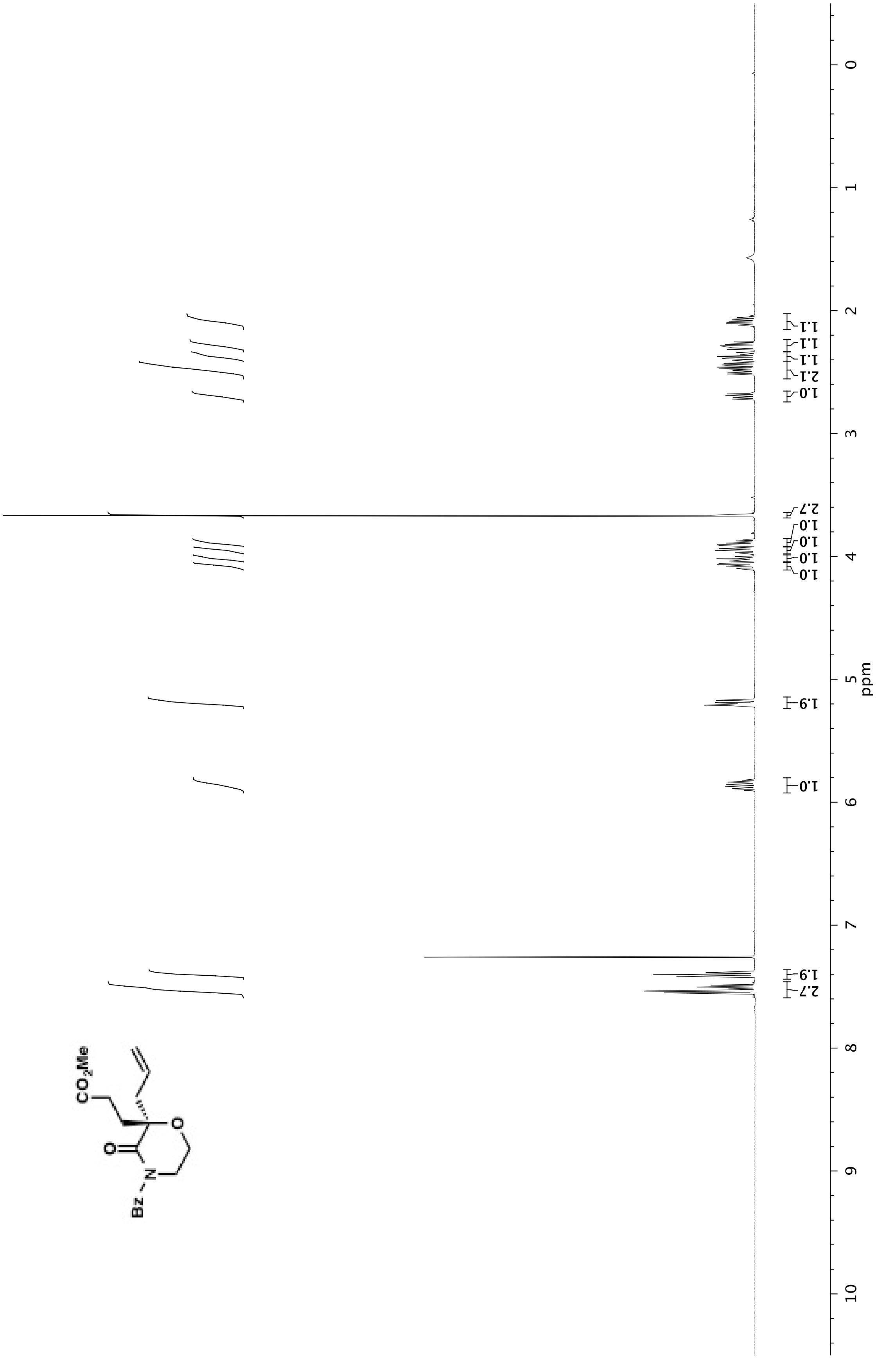
^{13}C NMR (126 MHz, CDCl$_3$) of compound **2b**.



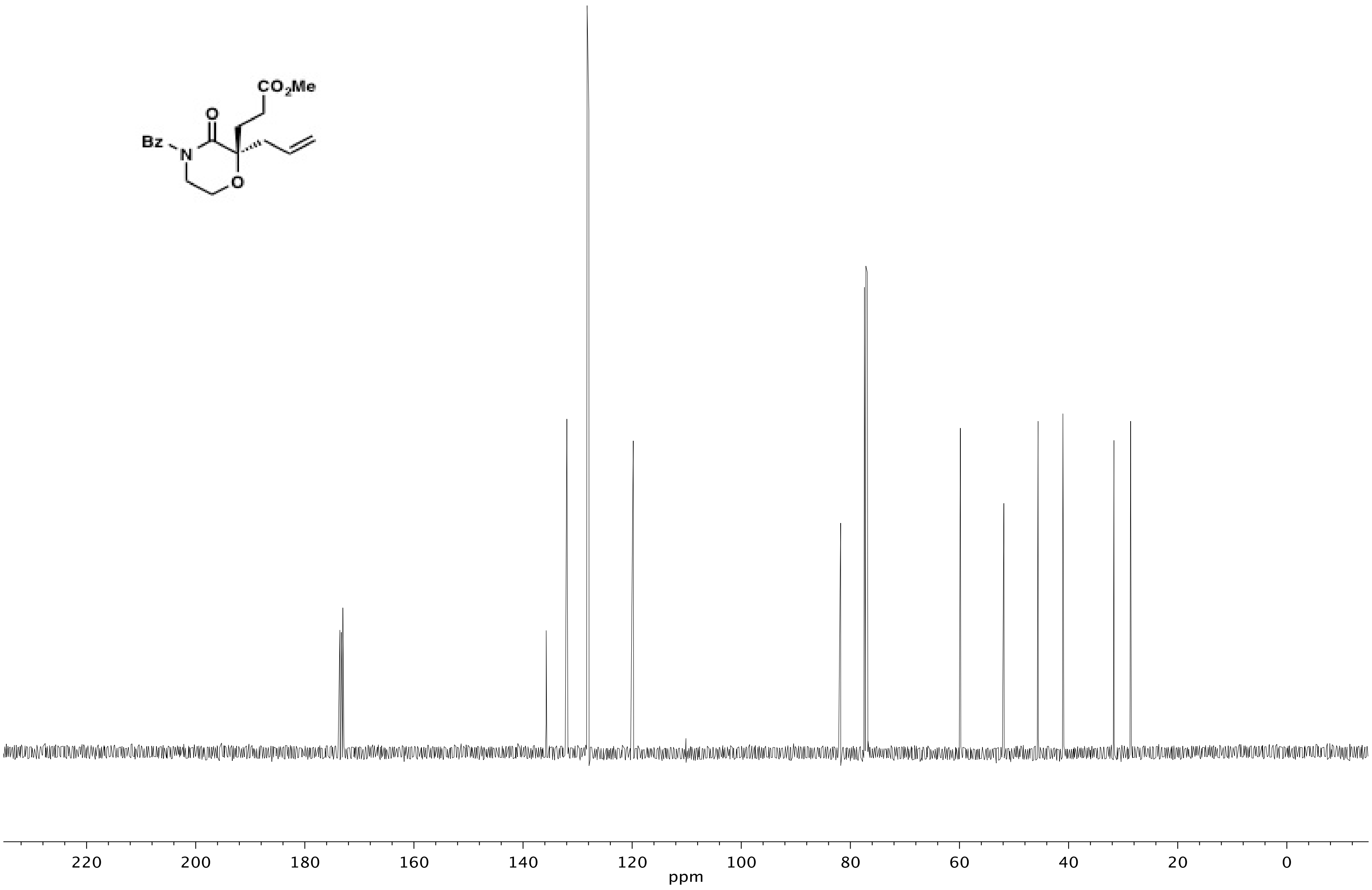
^{1}H NMR (500 MHz, CDCl$_3$) of compound **2c**.



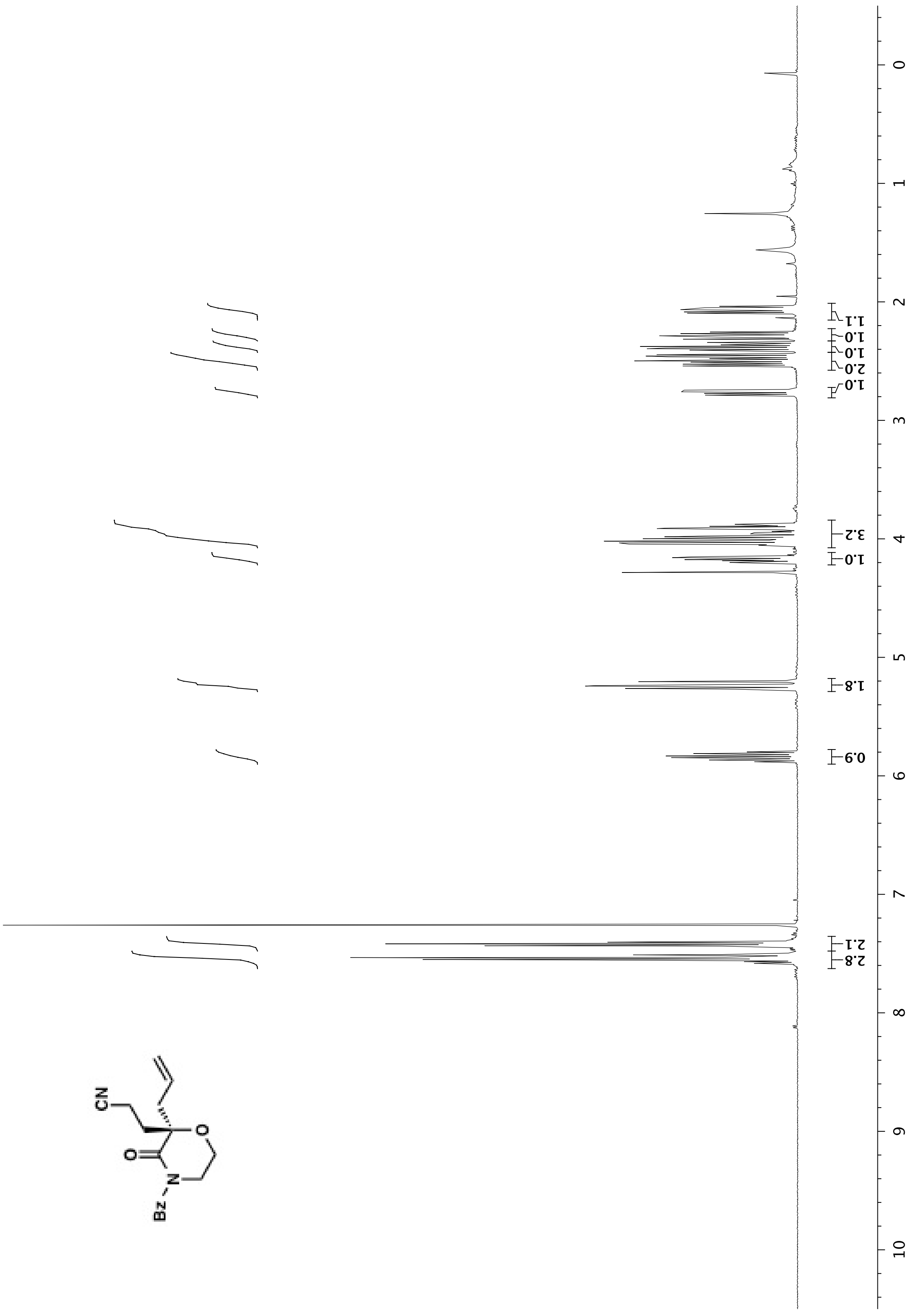
^{13}C NMR (126 MHz, CDCl$_3$) of compound **2c**.



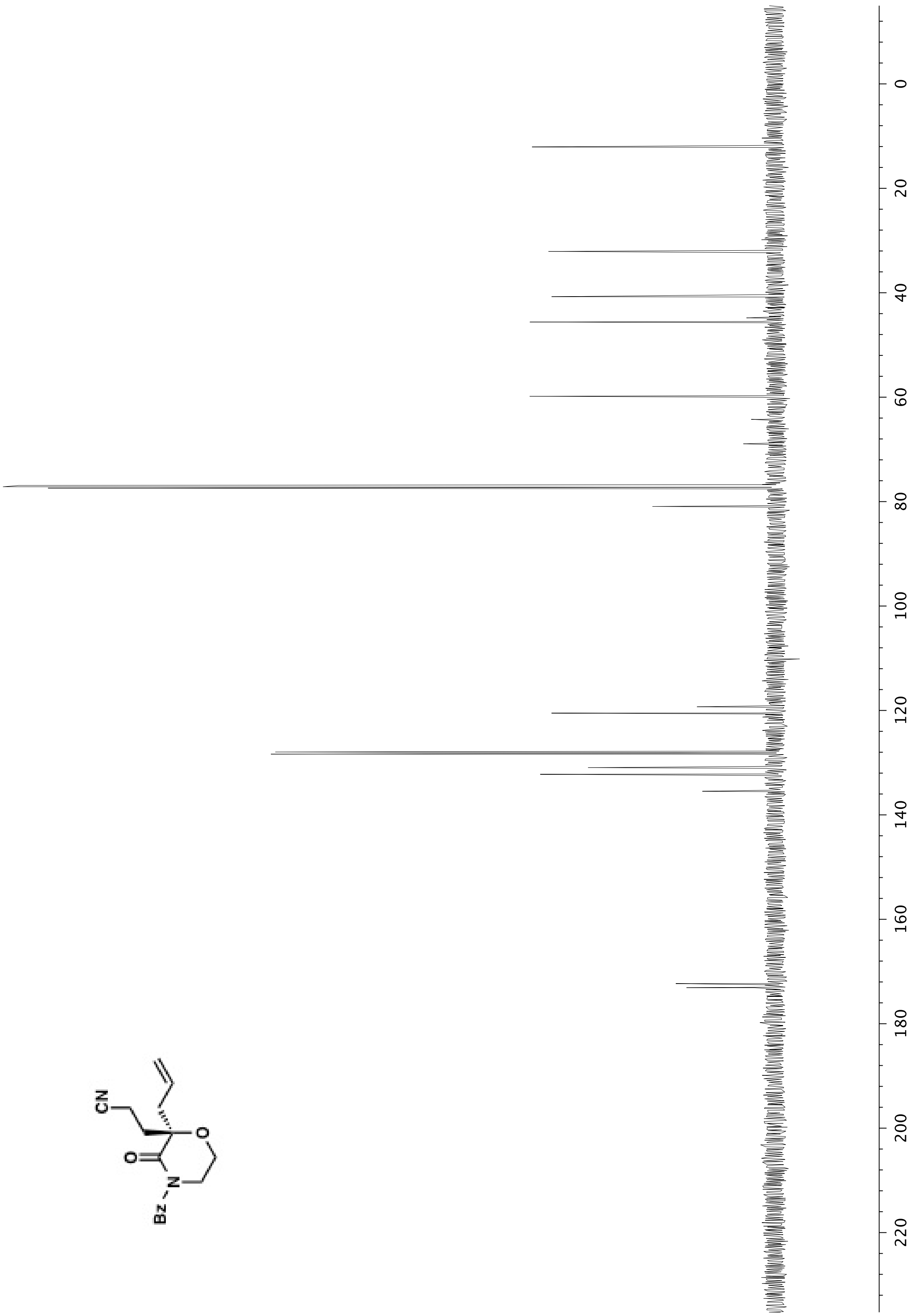
^{1}H NMR (500 MHz, CDCl$_3$) of compound **2d**.



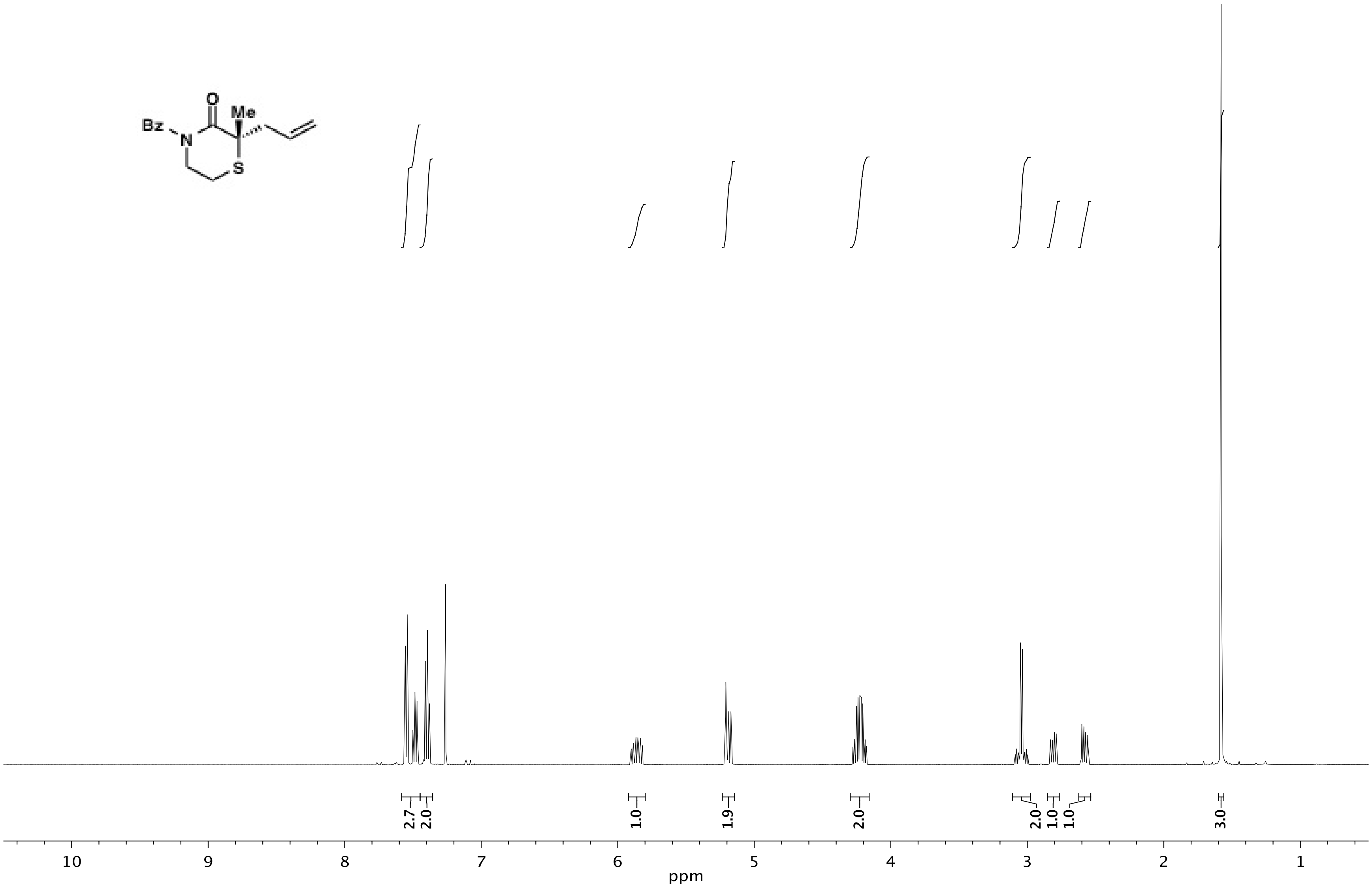
^{13}C NMR (126 MHz, CDCl$_3$) of compound **2d**.



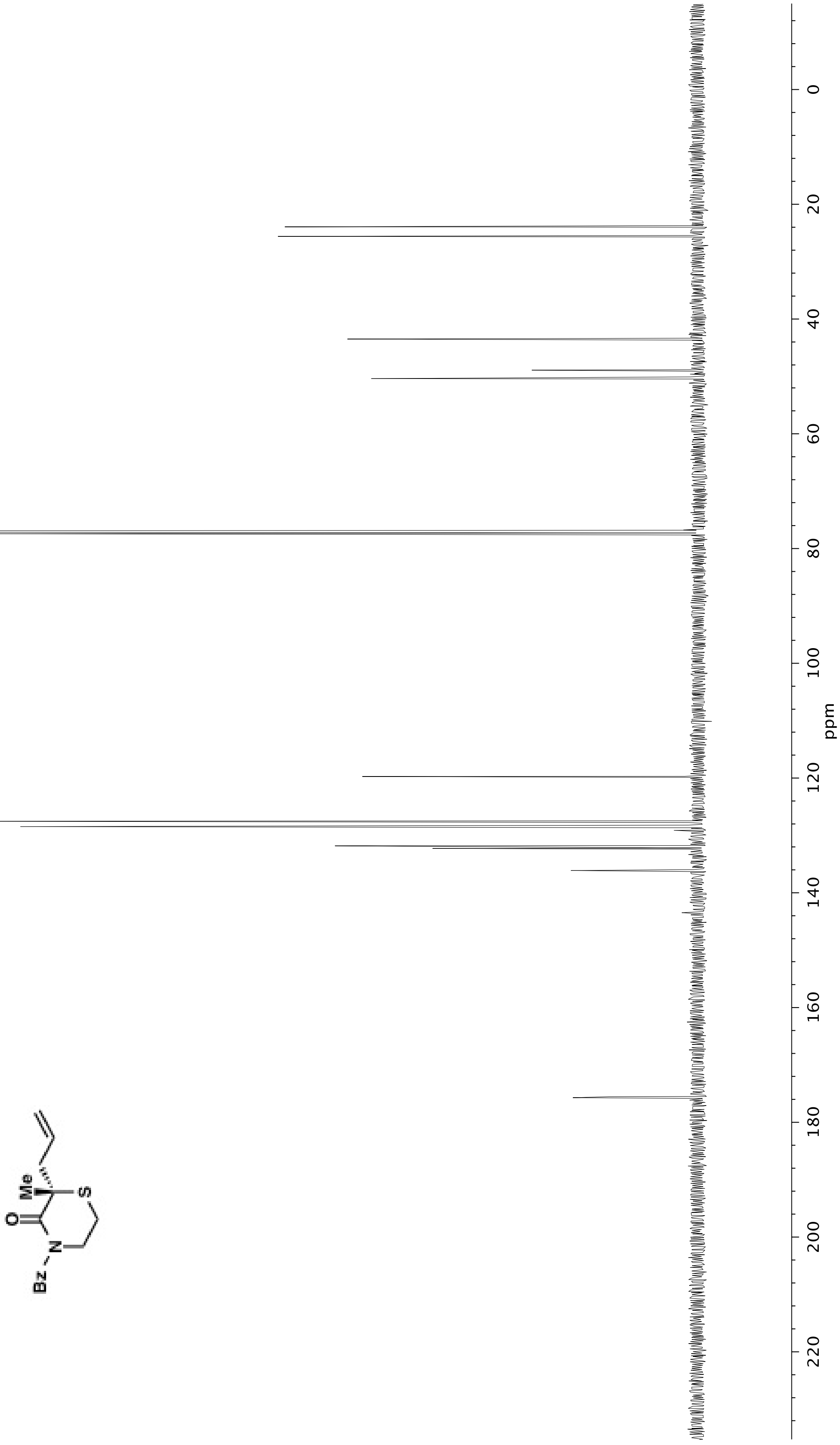
^{1}H NMR (500 MHz, $CDCl_3$) of compound **2e**.



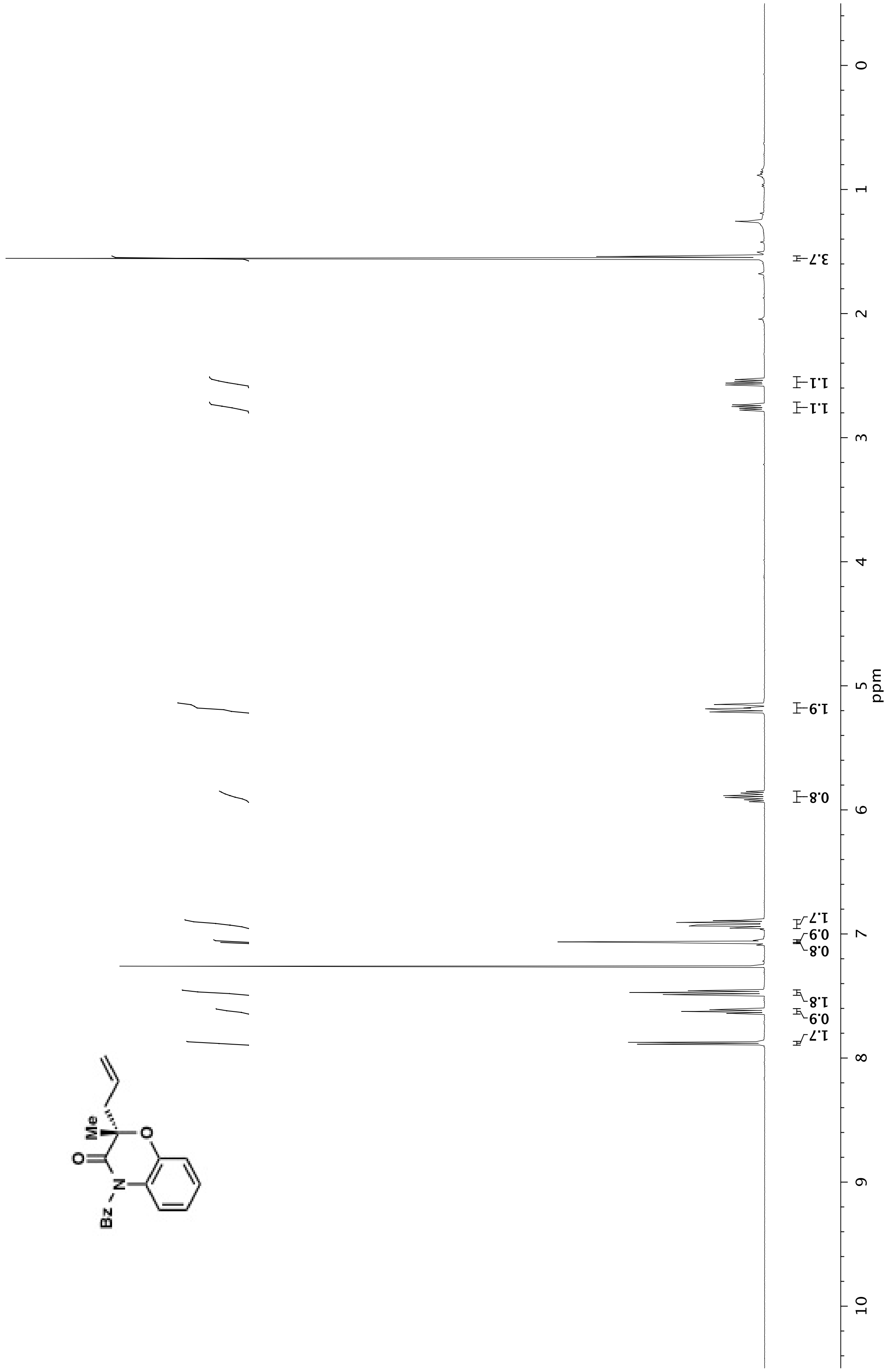
^{13}C NMR (126 MHz, CDCl$_3$) of compound **2e**.



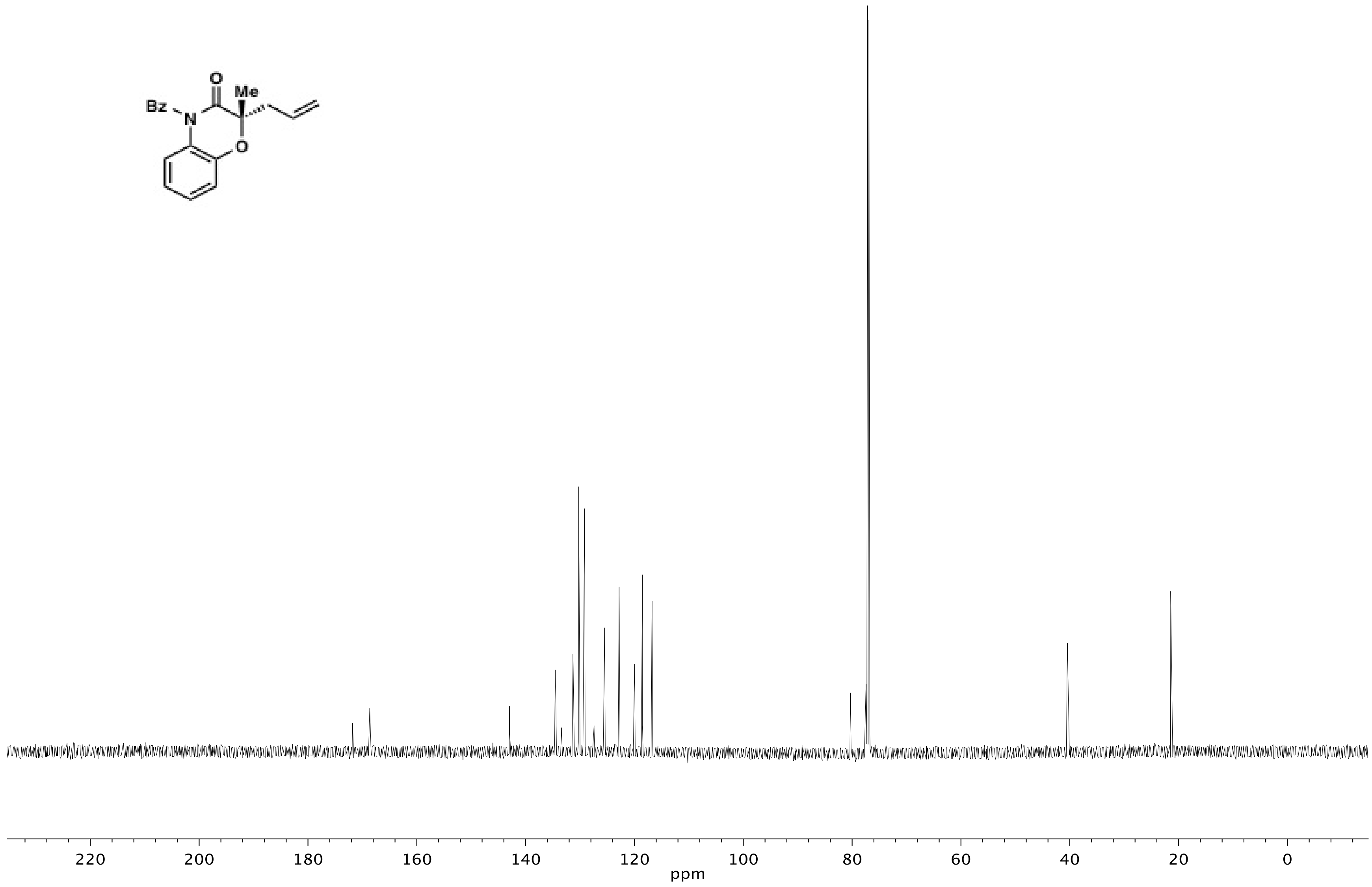
^{1}H NMR (500 MHz, $CDCl_3$) of compound **2f**.



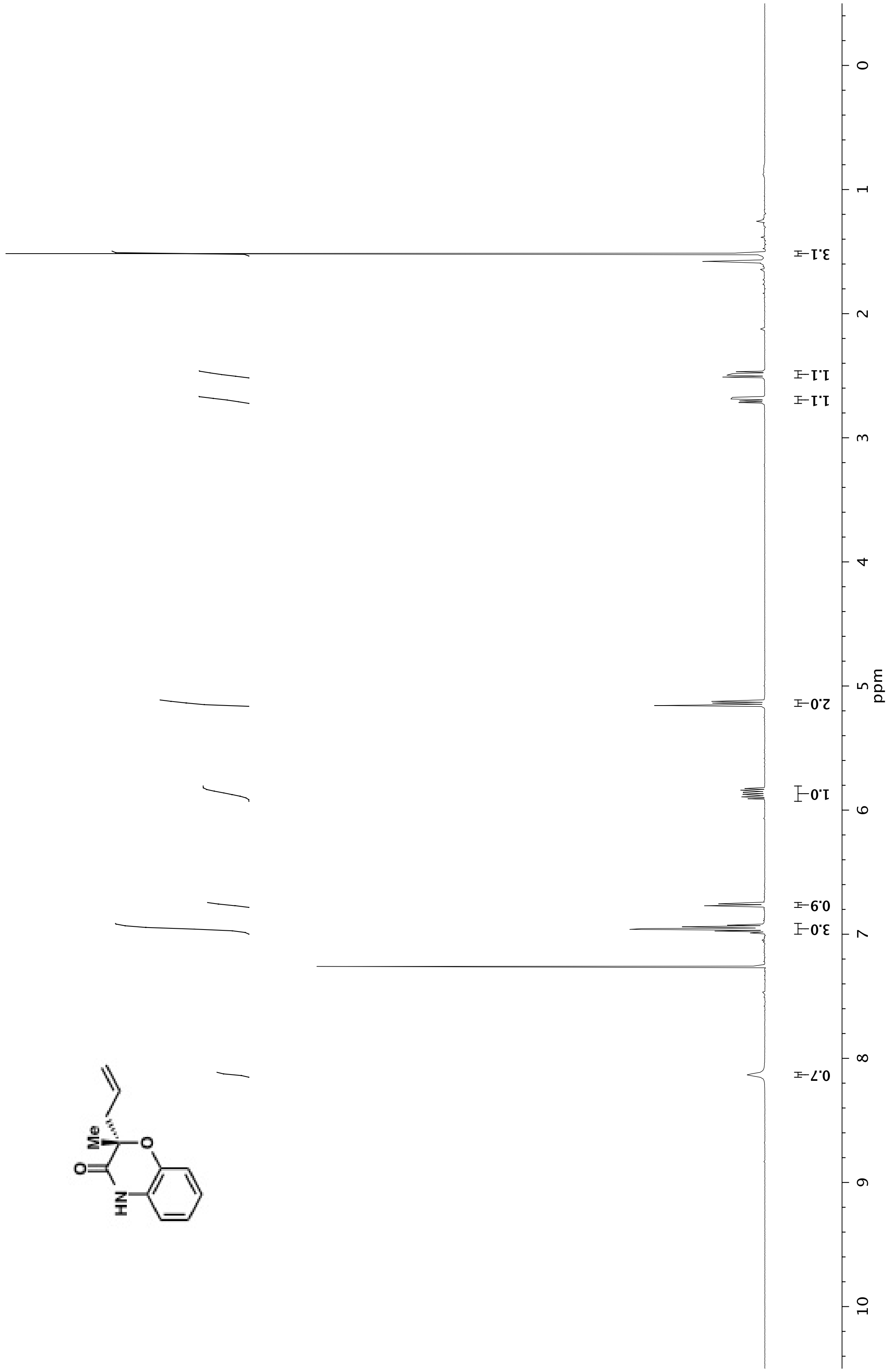
^{13}C NMR (126 MHz, CDCl$_3$) of compound **2f**.



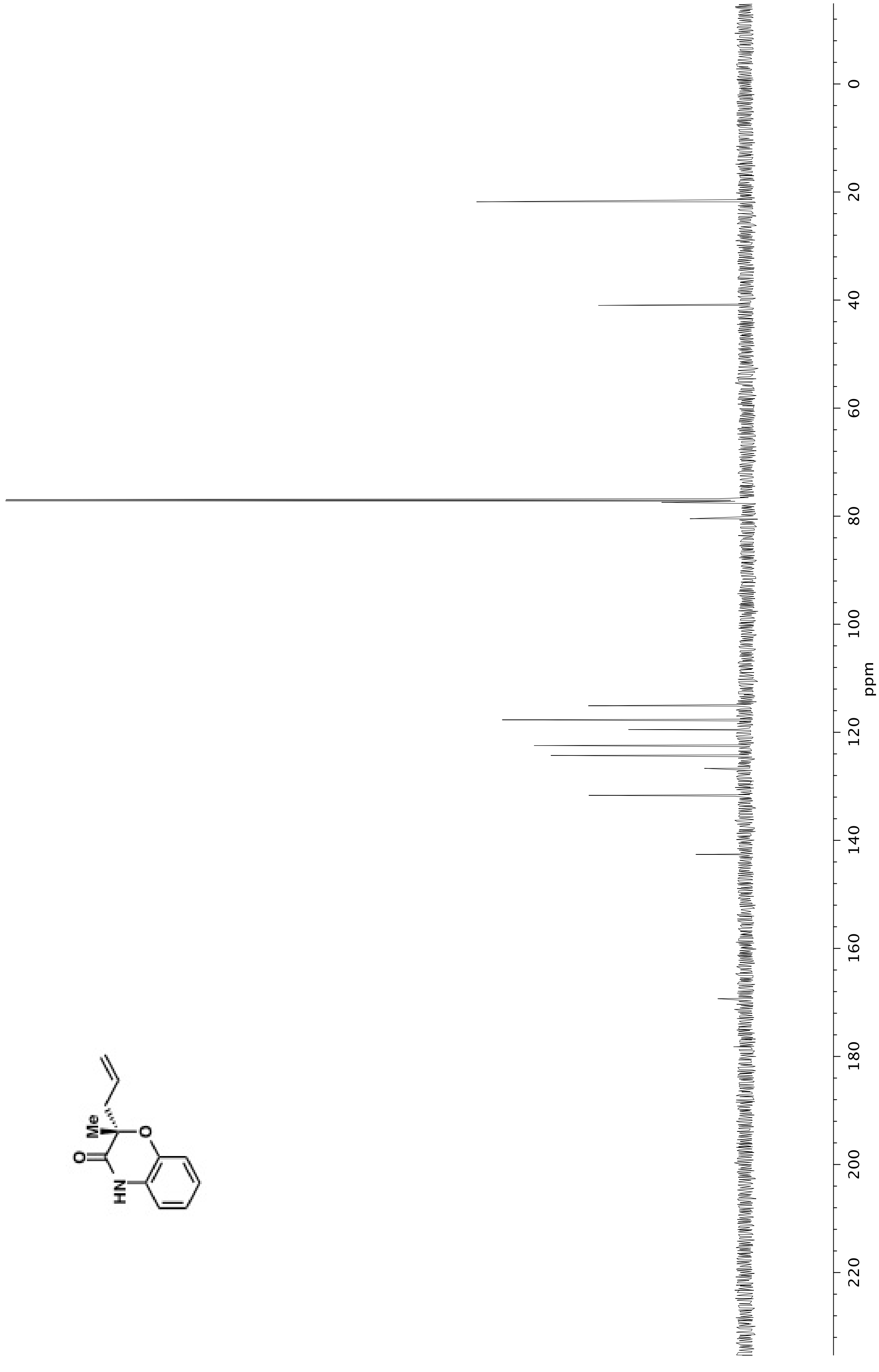
^{1}H NMR (500 MHz, CDCl$_3$) of compound **2g**.



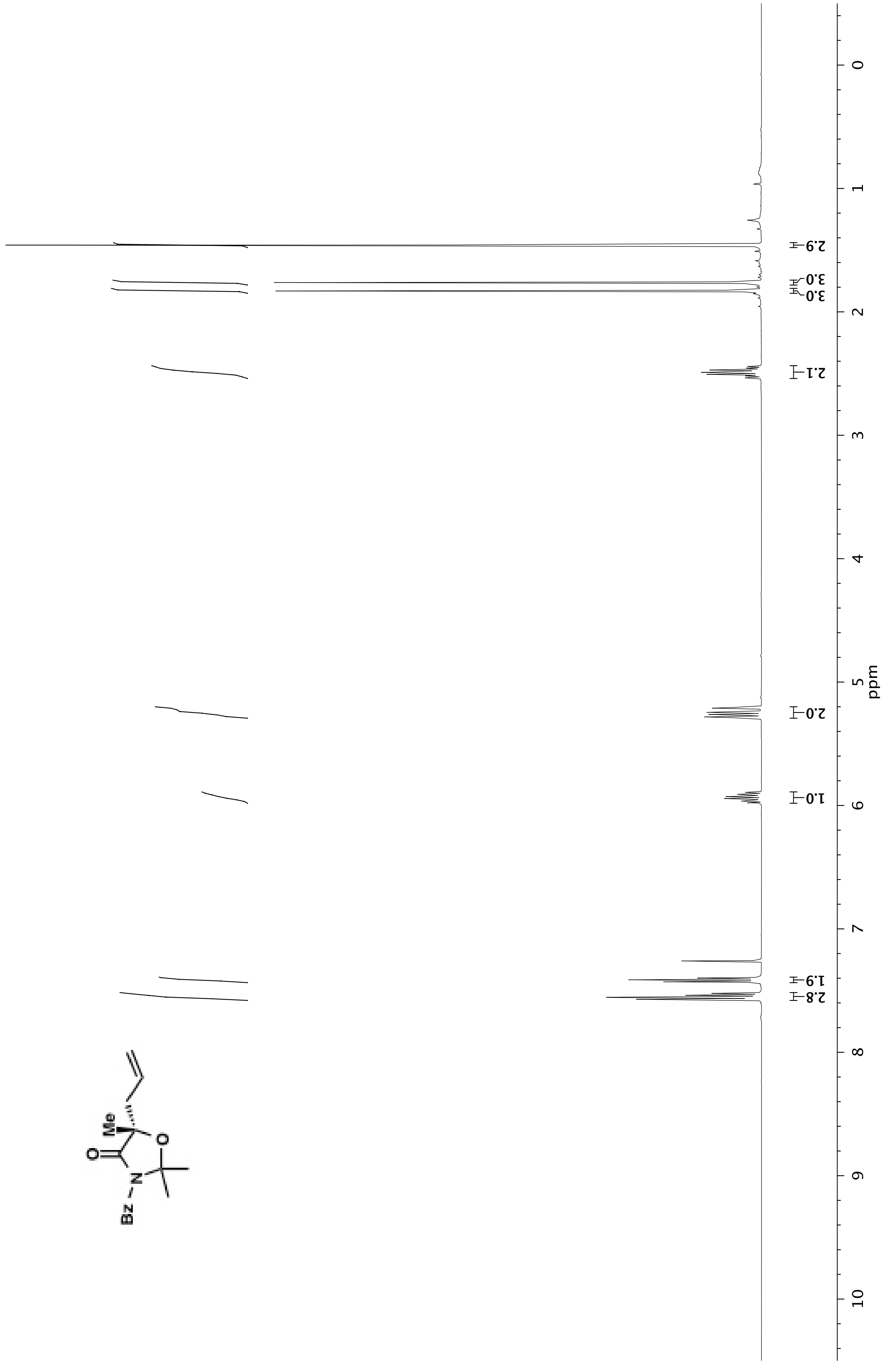
^{13}C NMR (126 MHz, CDCl$_3$) of compound **2g**.



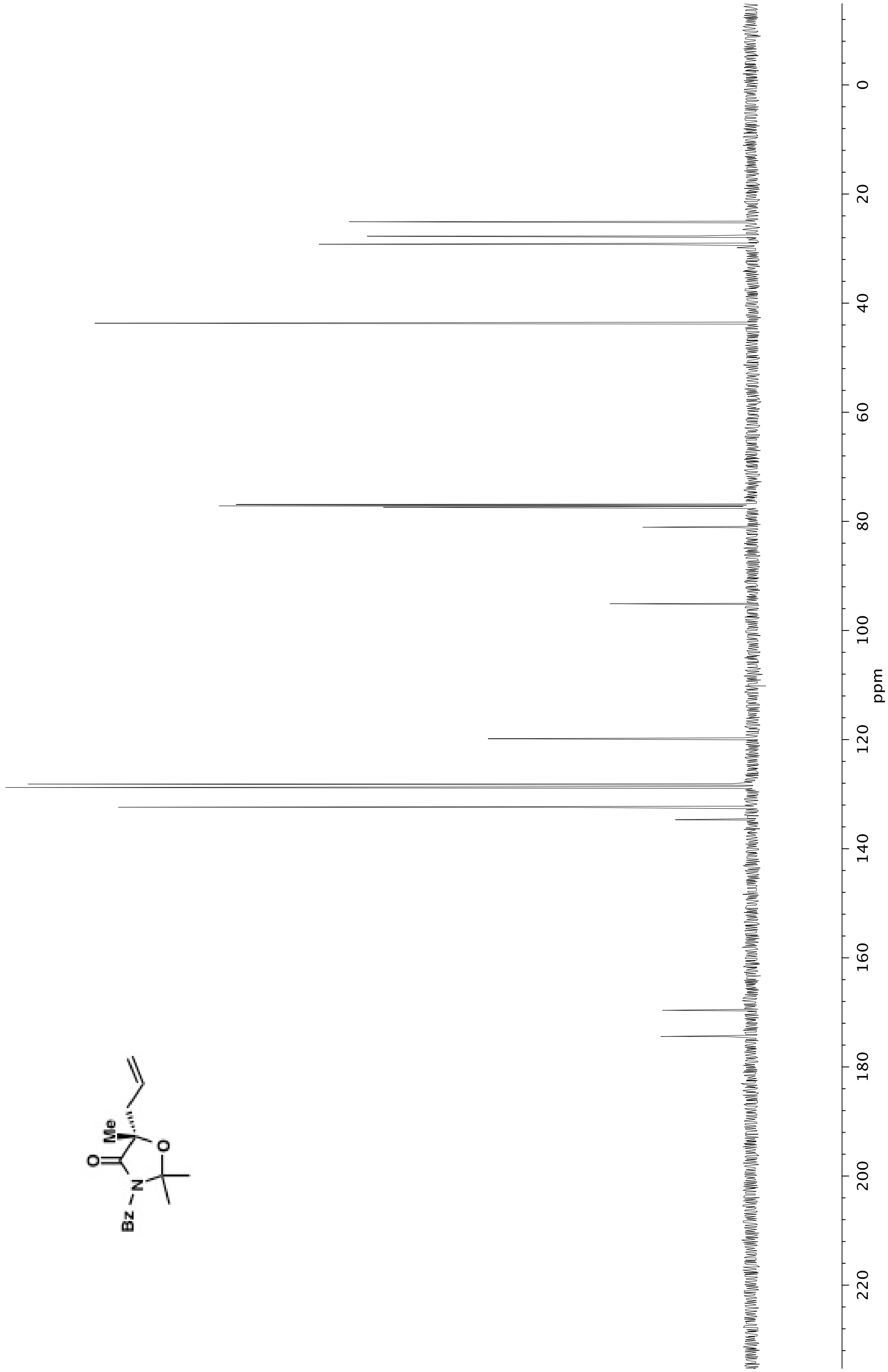
^{1}H NMR (500 MHz, CDCl$_3$) of compound **SI-24**.



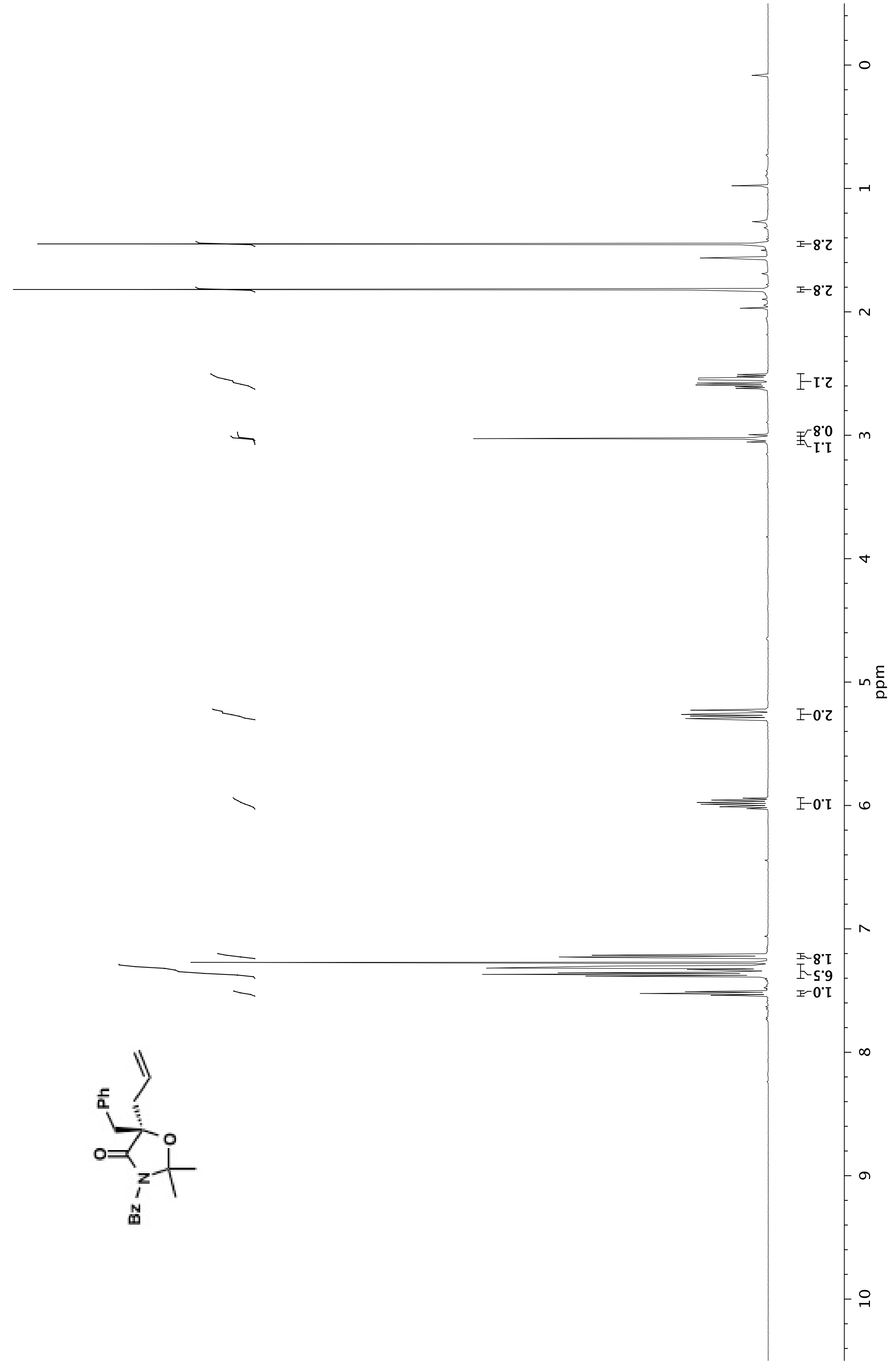
^{13}C NMR (126 MHz, $CDCl_3$) of compound **SI-24**.



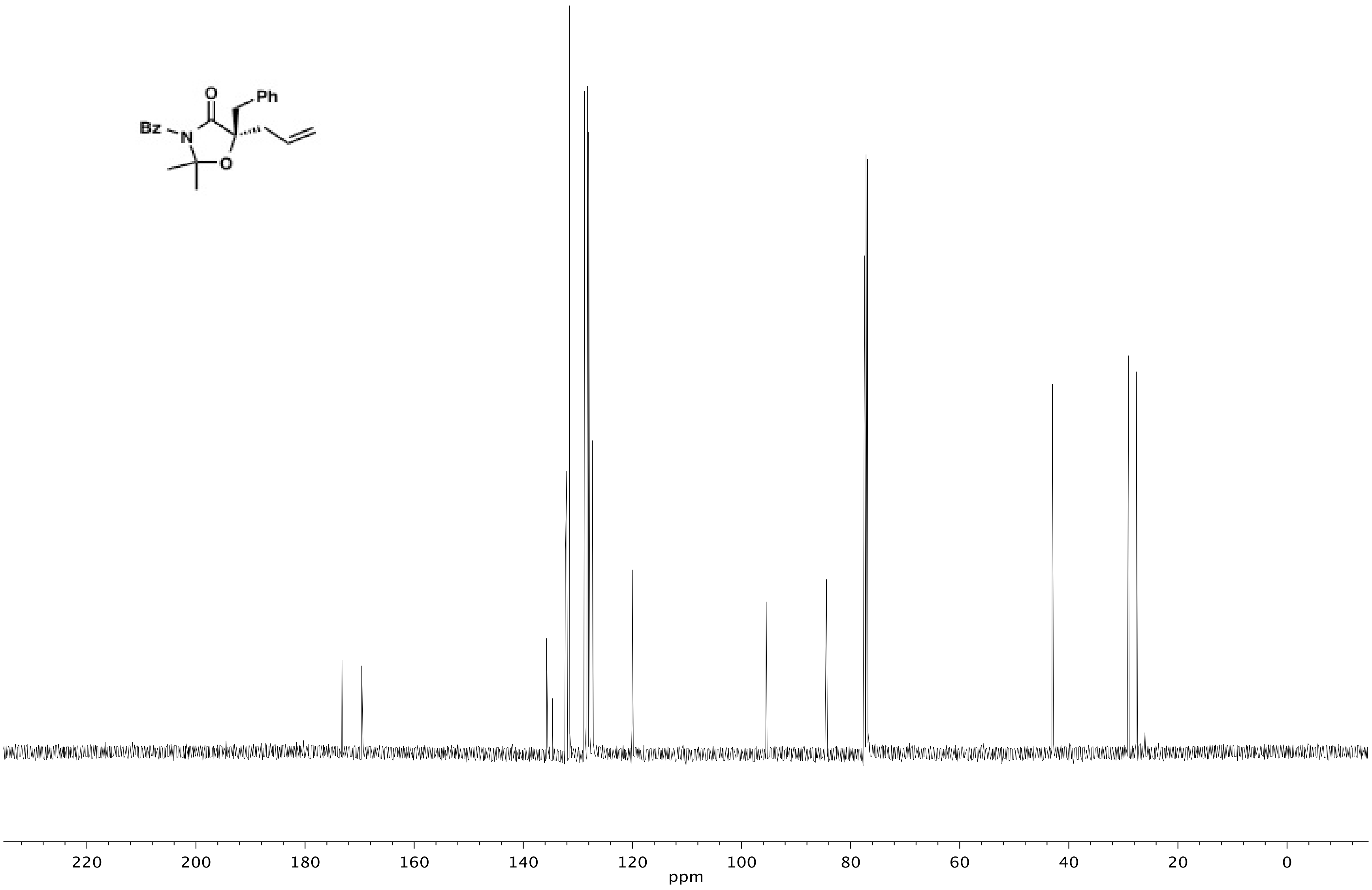
^1H NMR (500 MHz, $CDCl_3$) of compound **2h**.



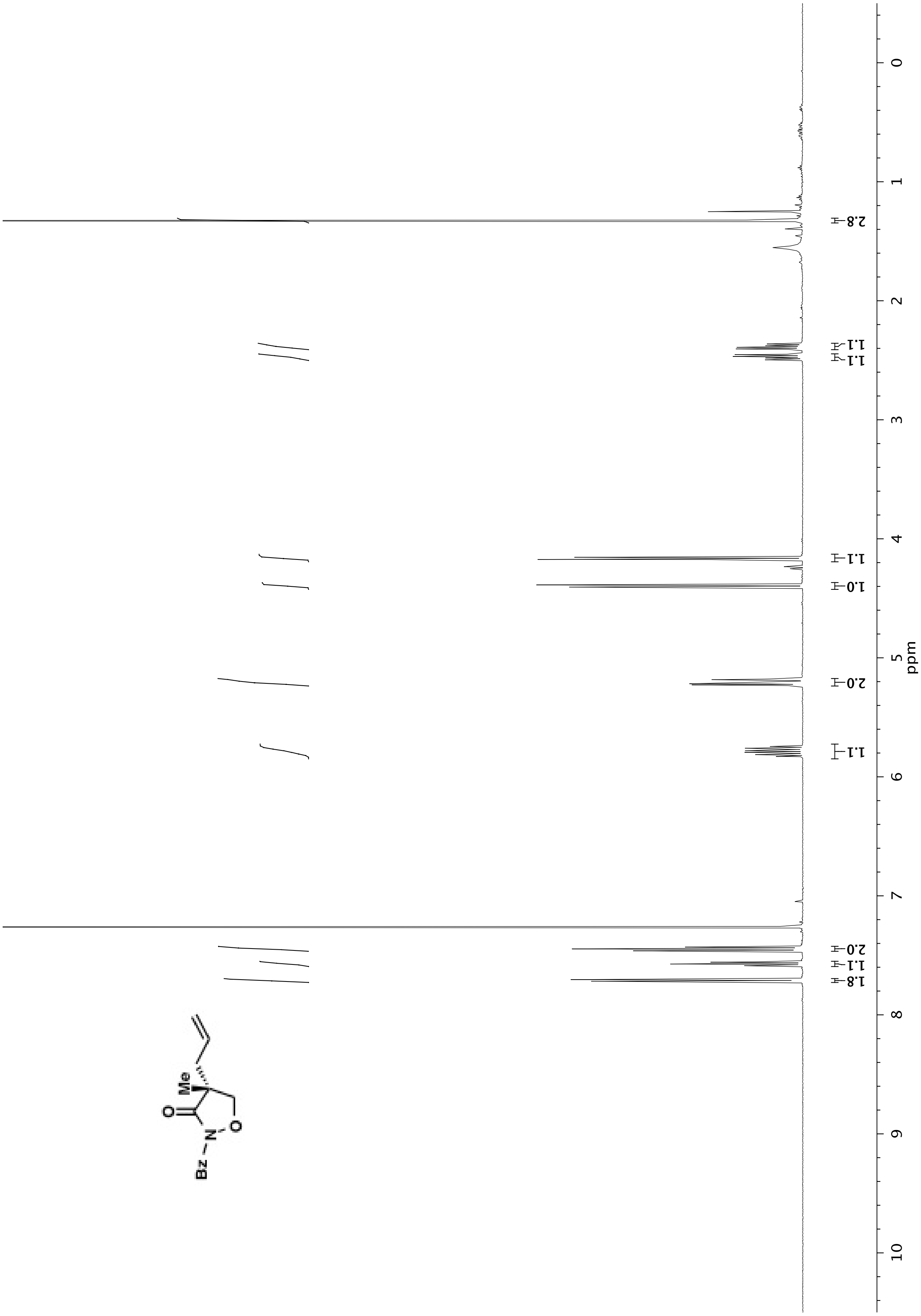
^{13}C NMR (126 MHz, $CDCl_3$) of compound **2h**.



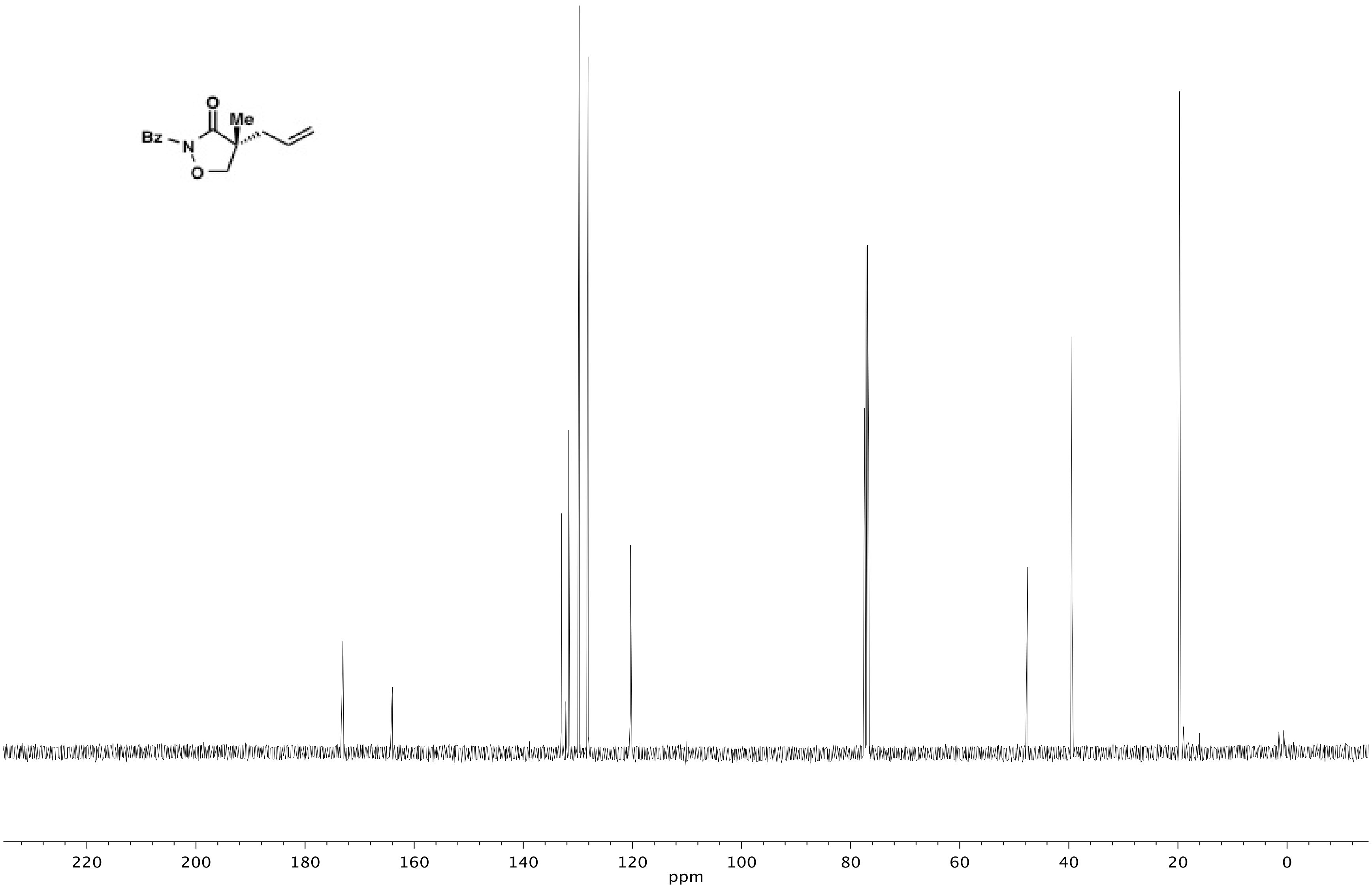
^{1}H NMR (500 MHz, CDCl$_3$) of compound **2i**.



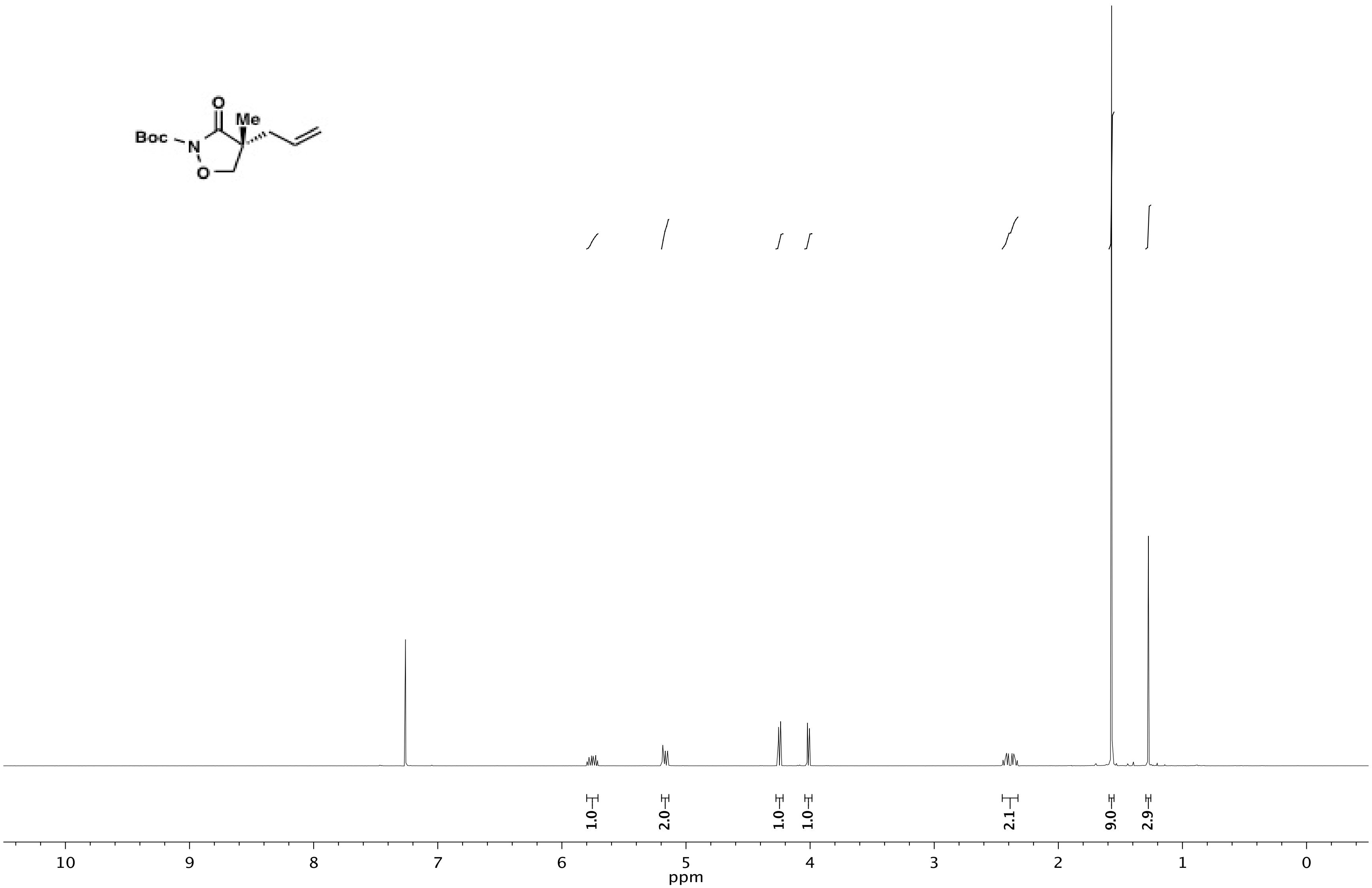
^{13}C NMR (126 MHz, $CDCl_3$) of compound **2i**.



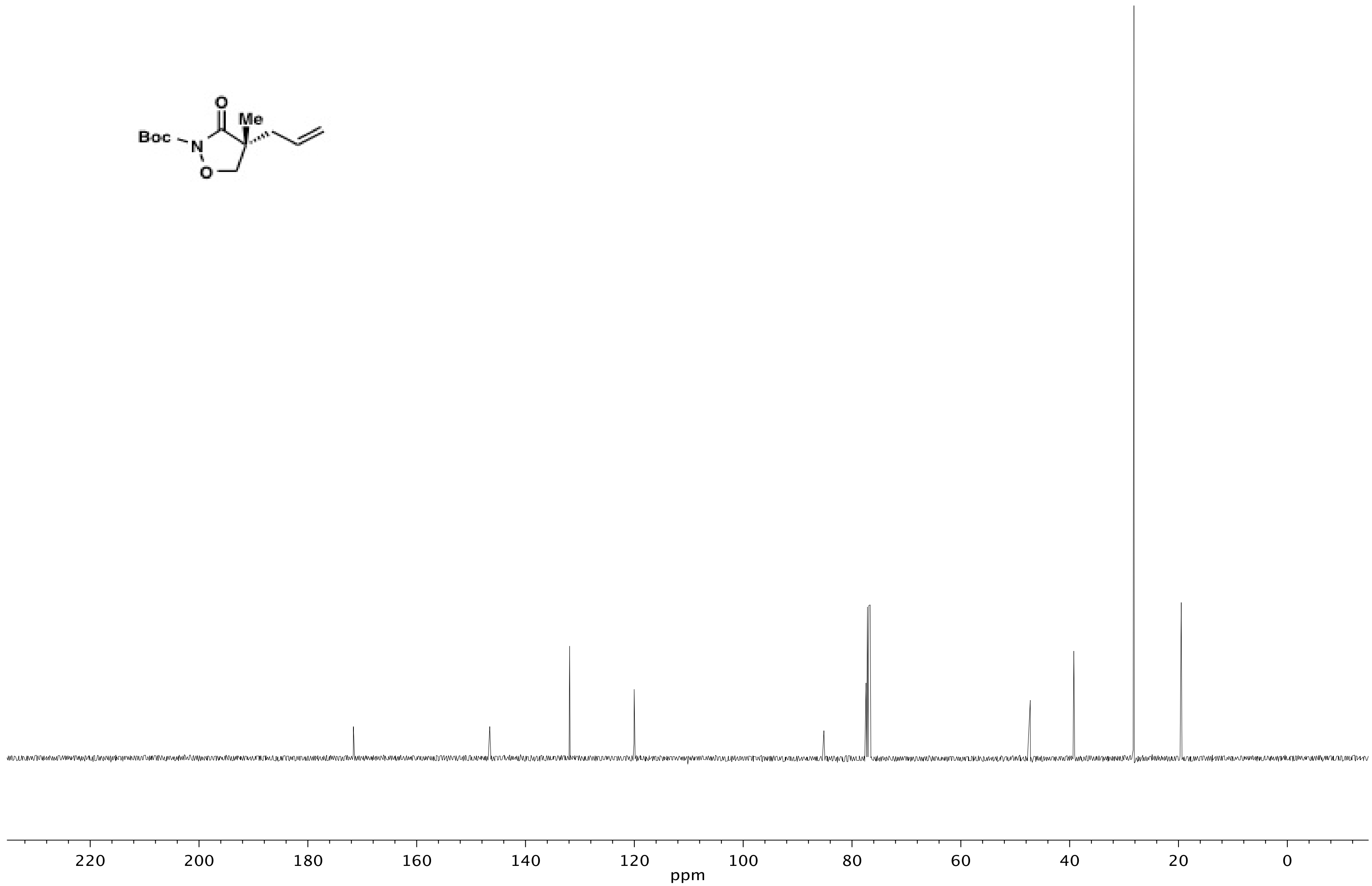
^{1}H NMR (500 MHz, $CDCl_3$) of compound **4a**.



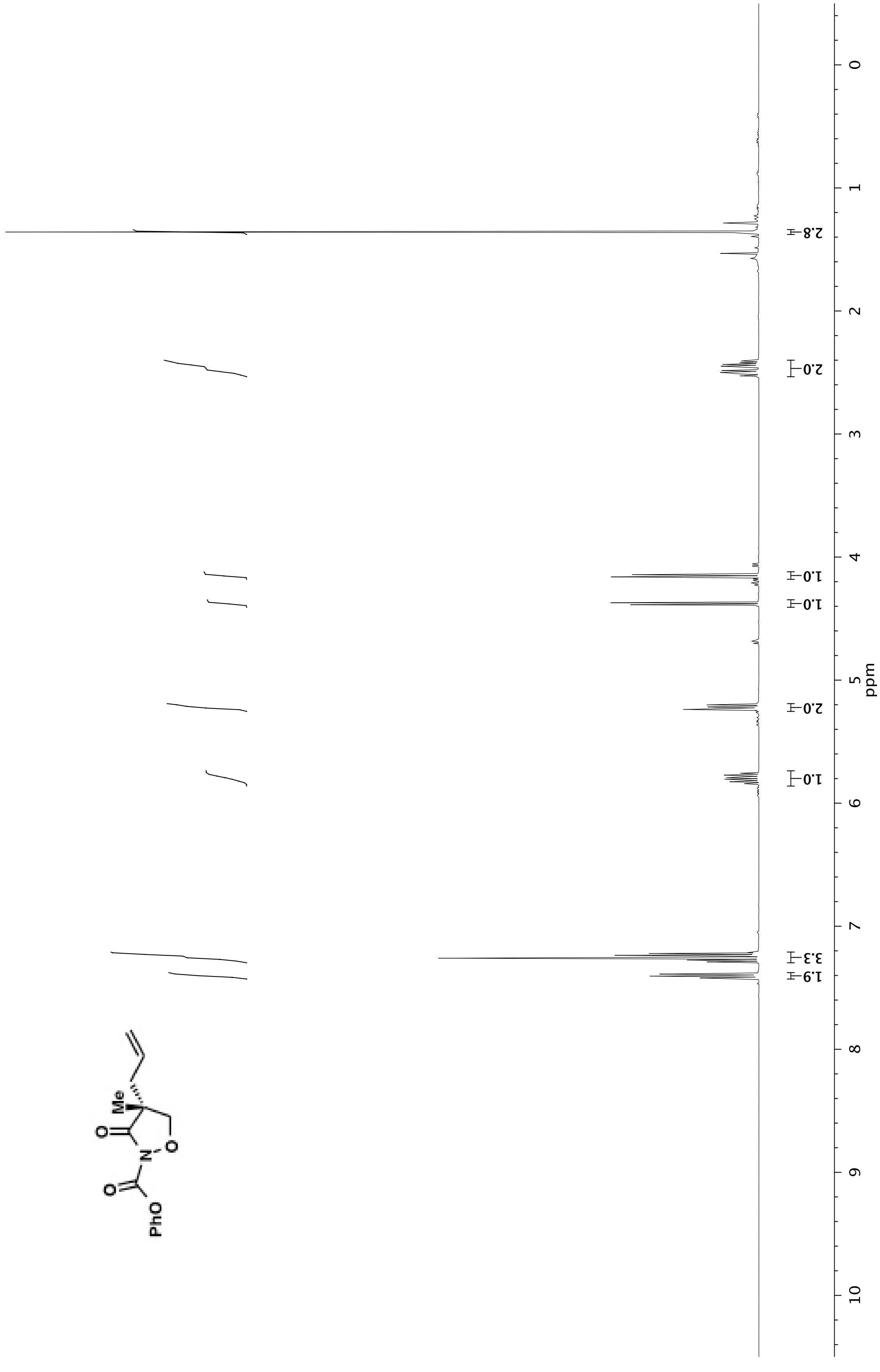
^{13}C NMR (126 MHz, CDCl$_3$) of compound **4a**.



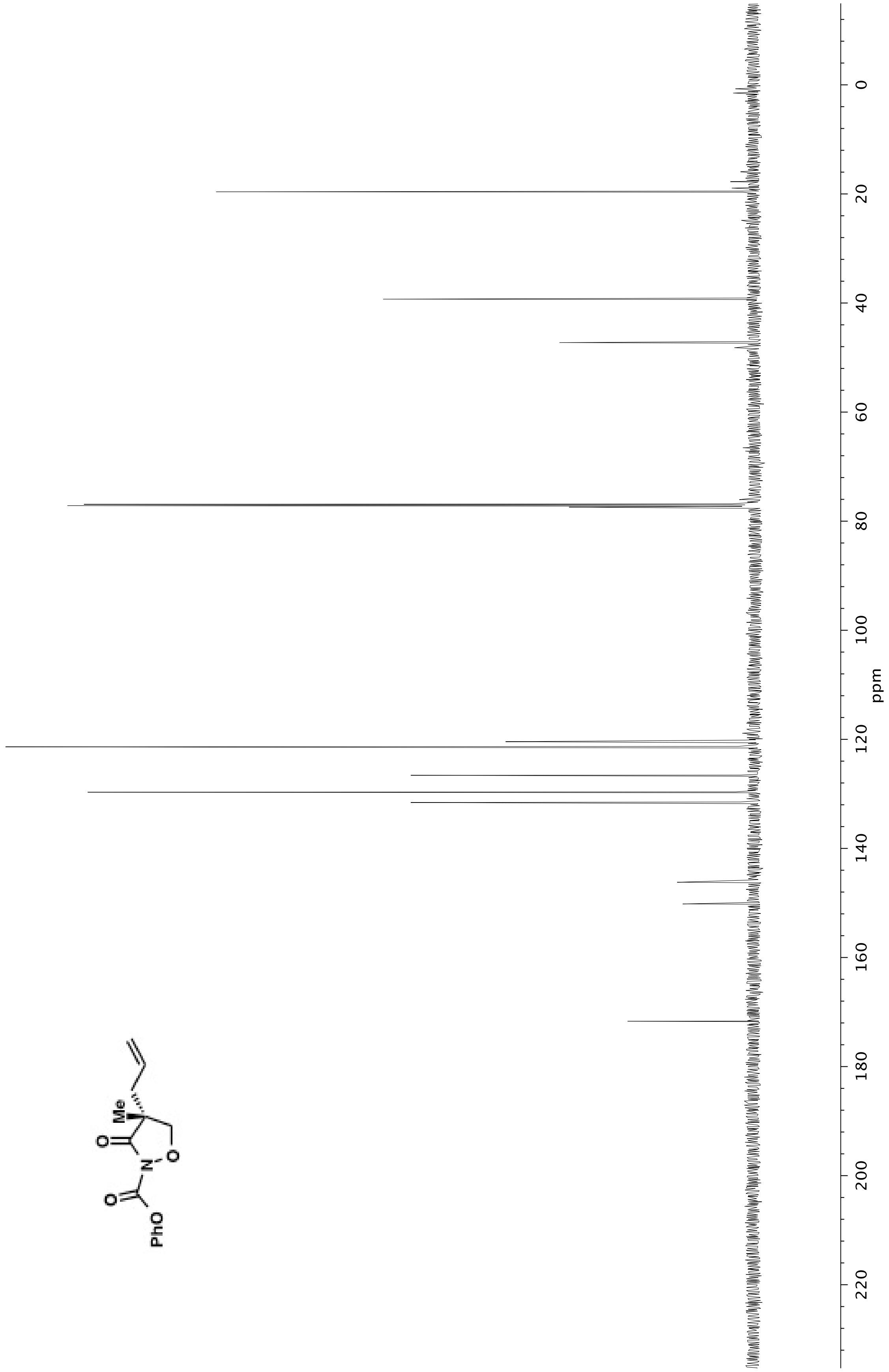
^{1}H NMR (500 MHz, CDCl$_3$) of compound **4b**.



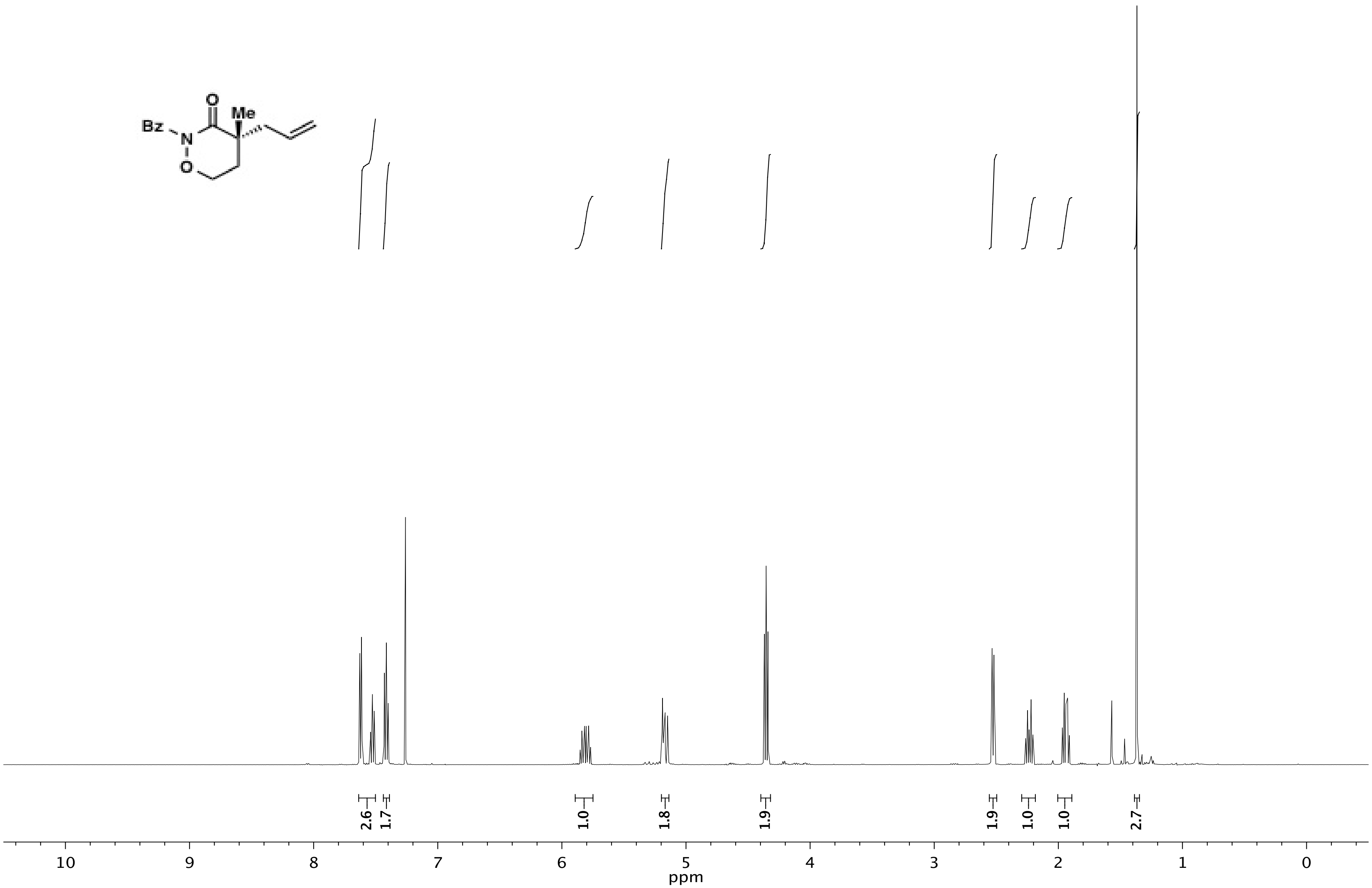
^{13}C NMR (126 MHz, $CDCl_3$) of compound **4b**.



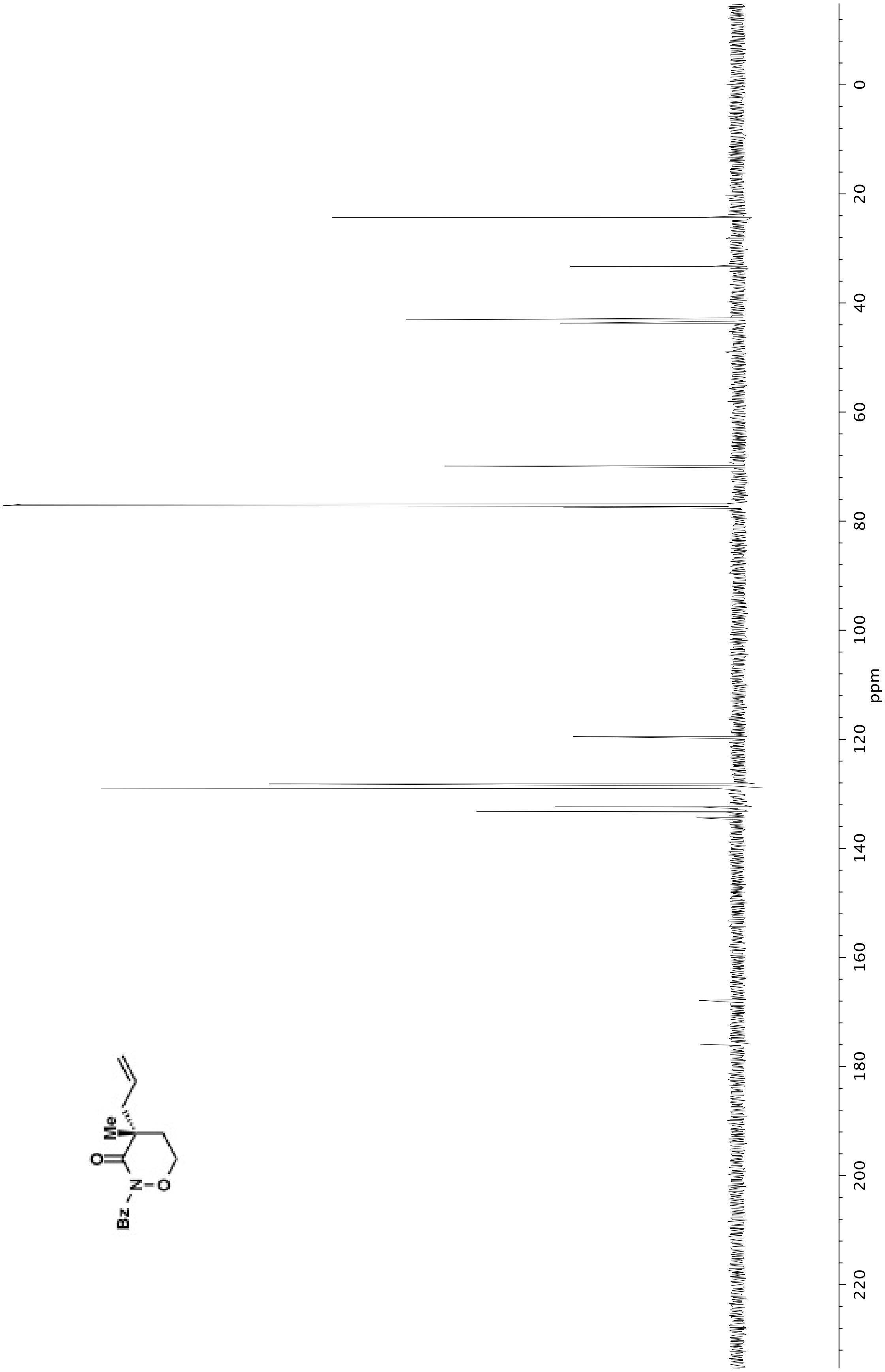
^{1}H NMR (500 MHz, CDCl$_3$) of compound **4c**.



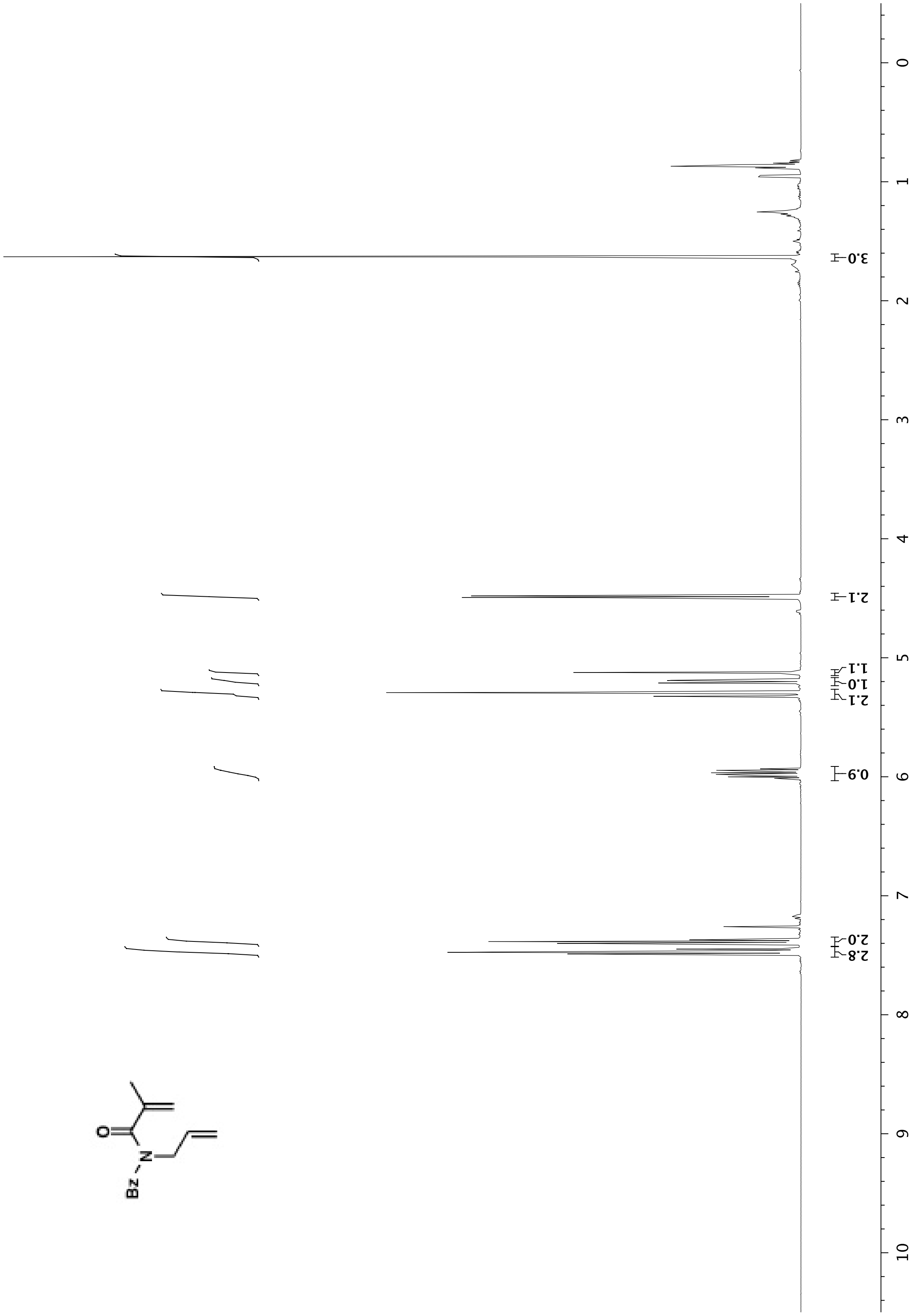
^{13}C NMR (126 MHz, CDCl$_3$) of compound **4c**.



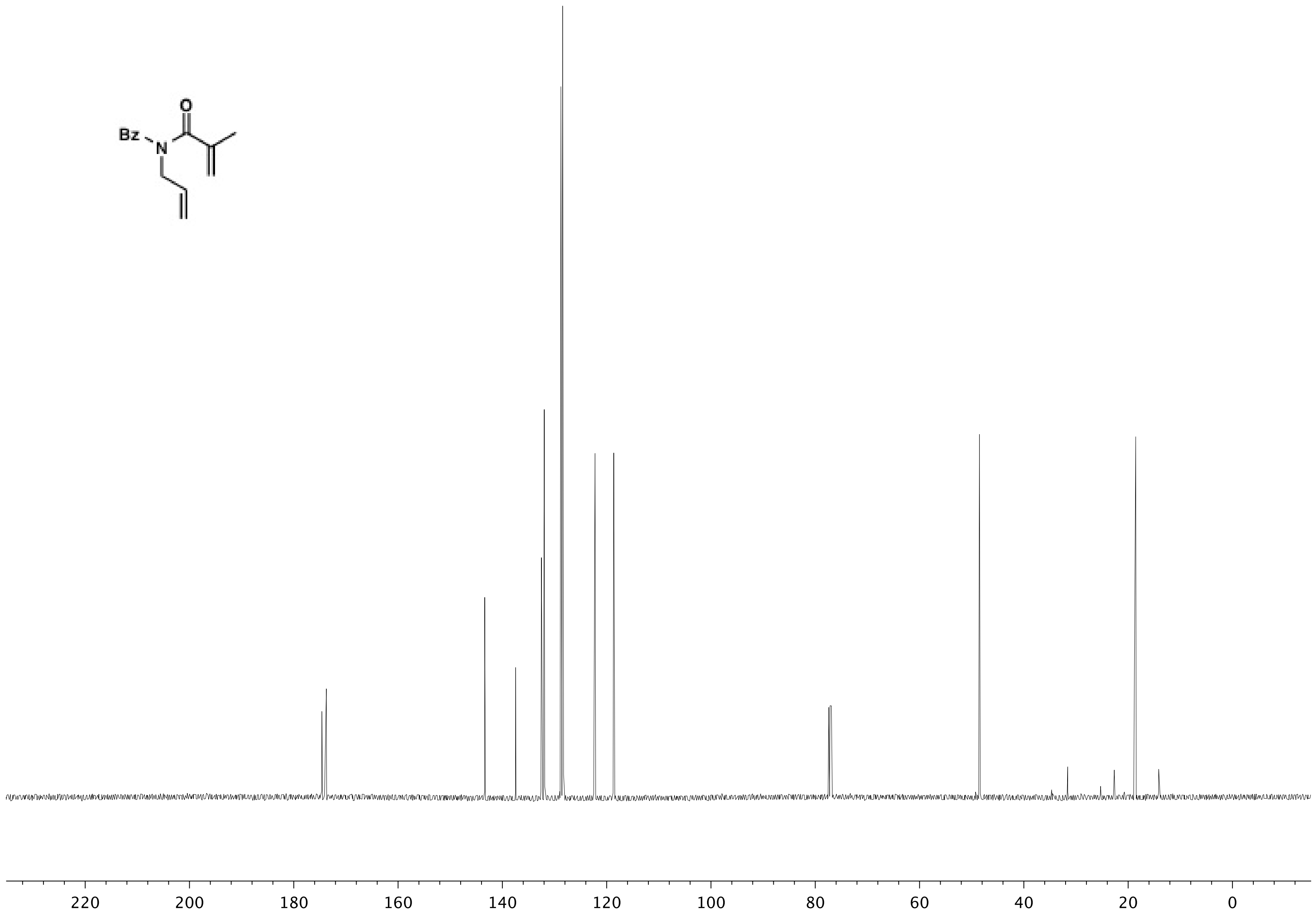
^{1}H NMR (500 MHz, CDCl$_3$) of compound **4d**.



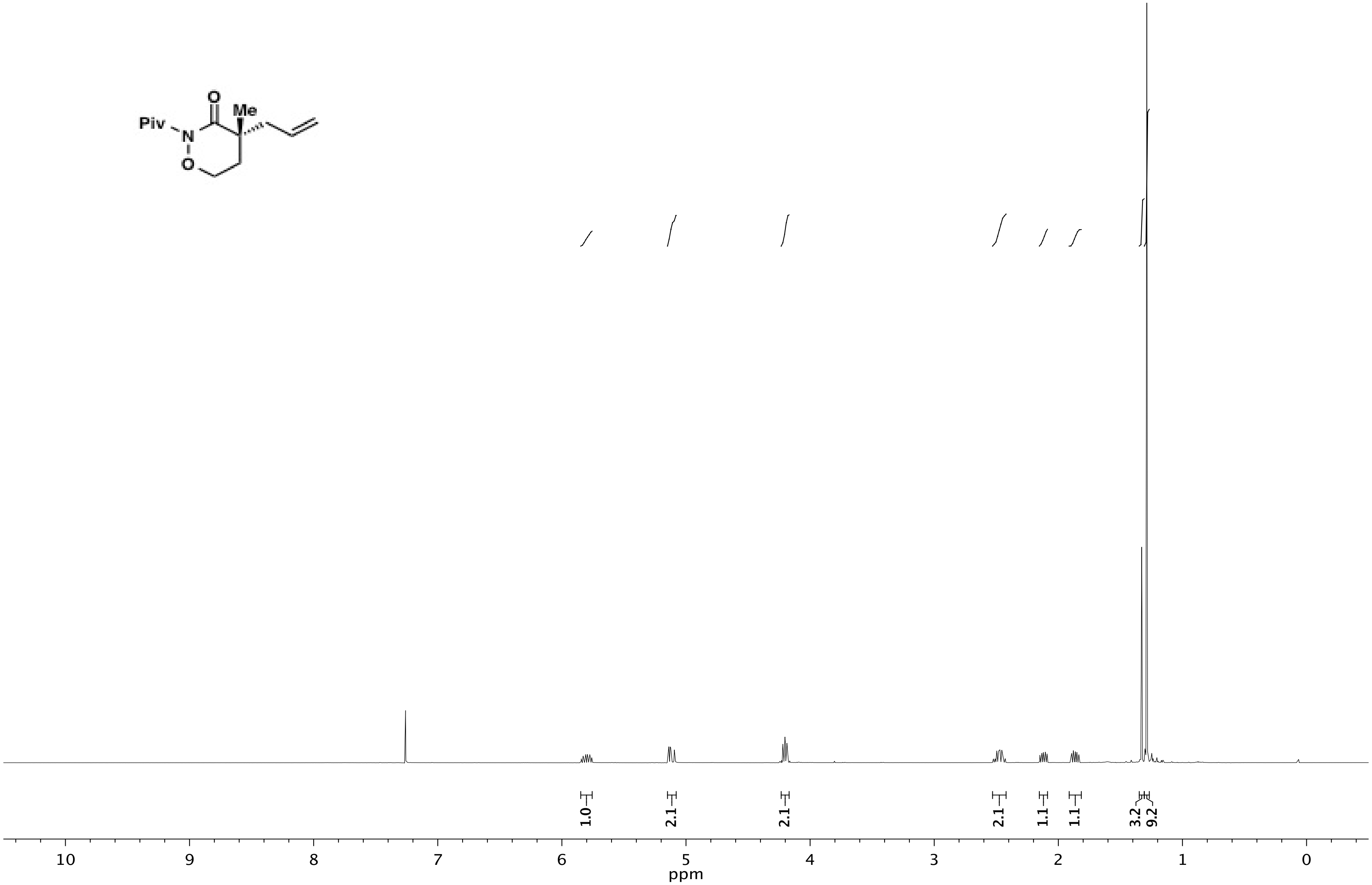
^{13}C NMR (126 MHz, CDCl$_3$) of compound **4d**.



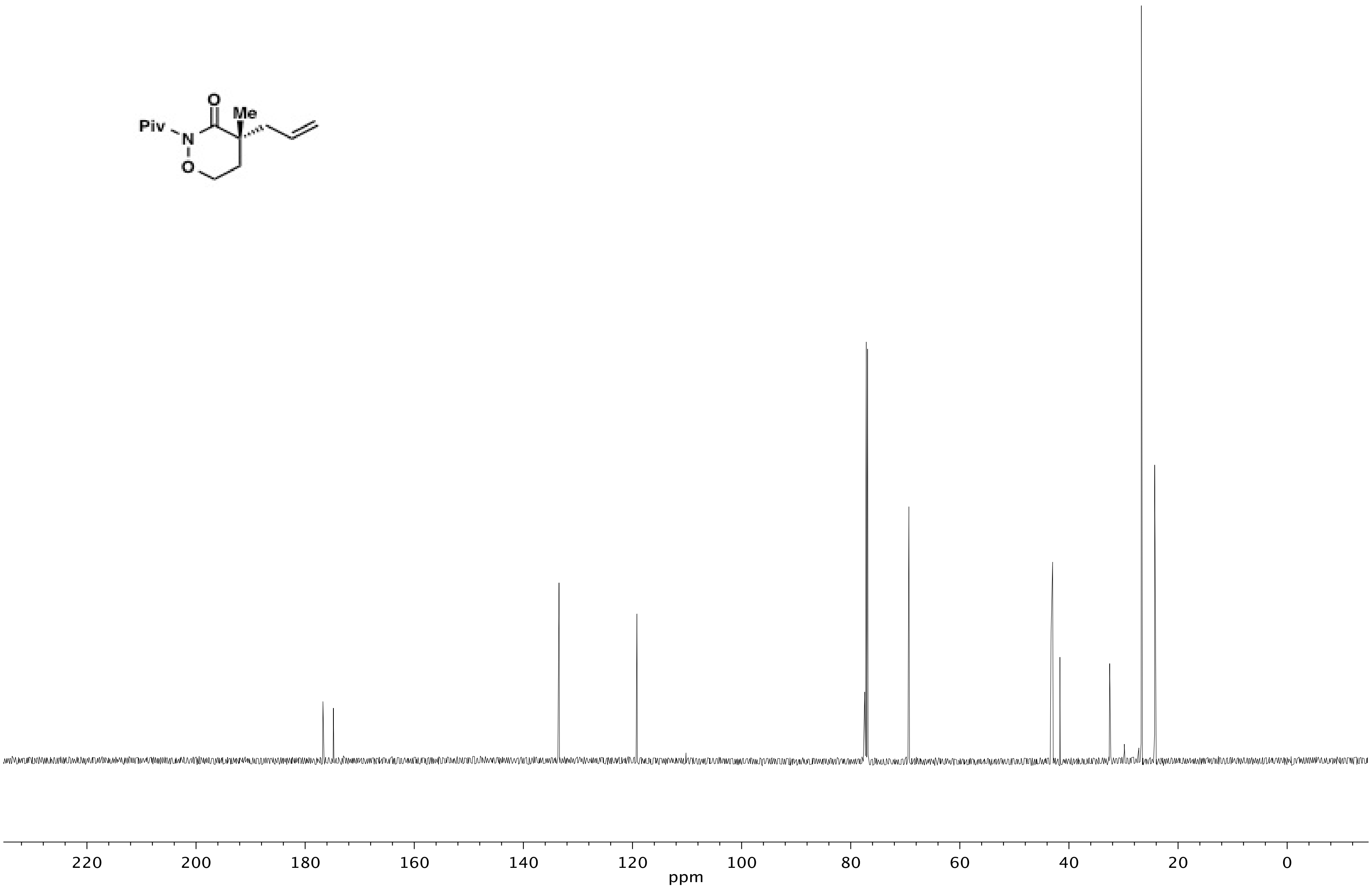
^{1}H NMR (500 MHz, $CDCl_3$) of compound **10**.



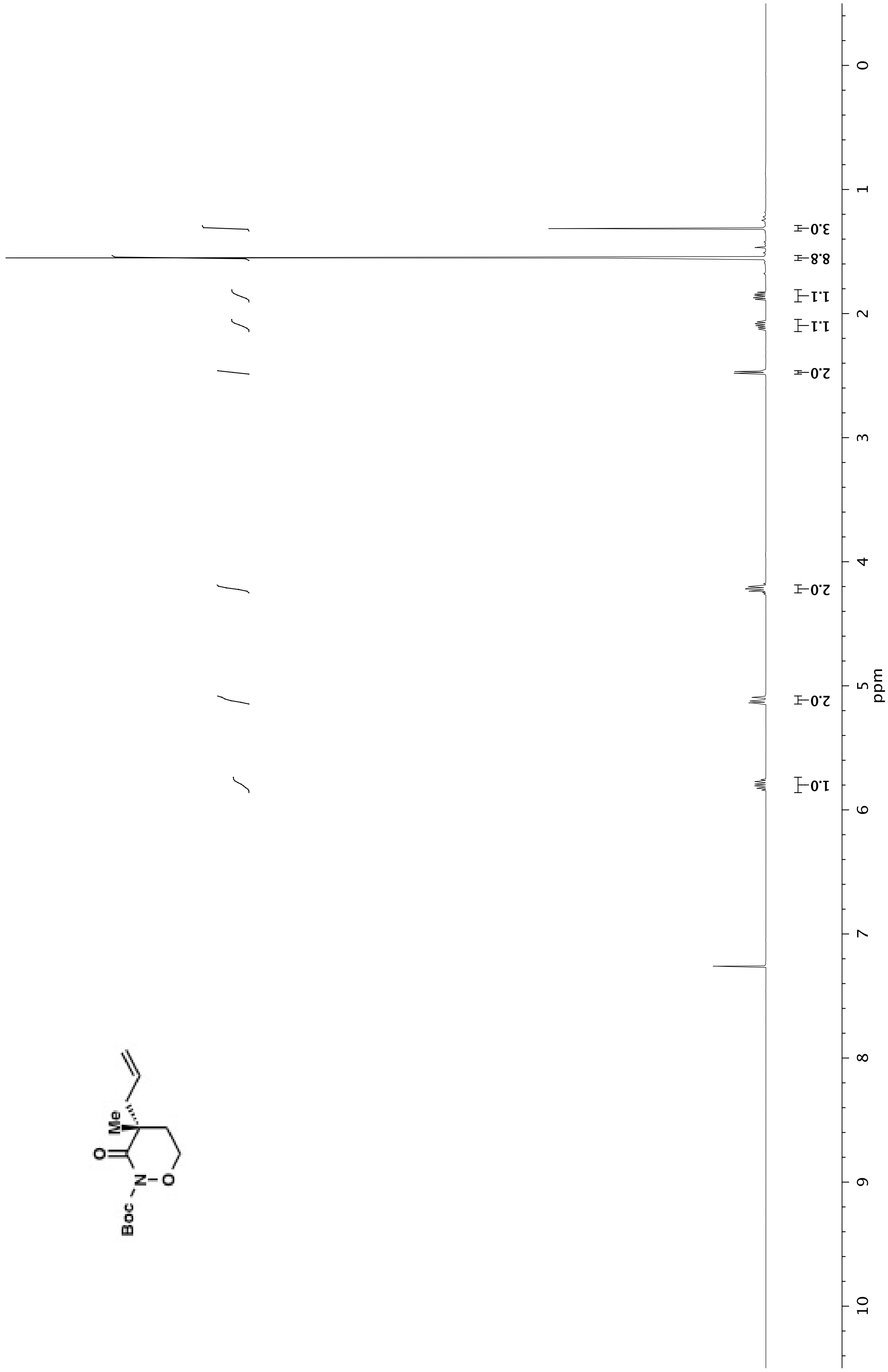
^{13}C NMR (126 MHz, CDCl$_3$) of compound **10**.



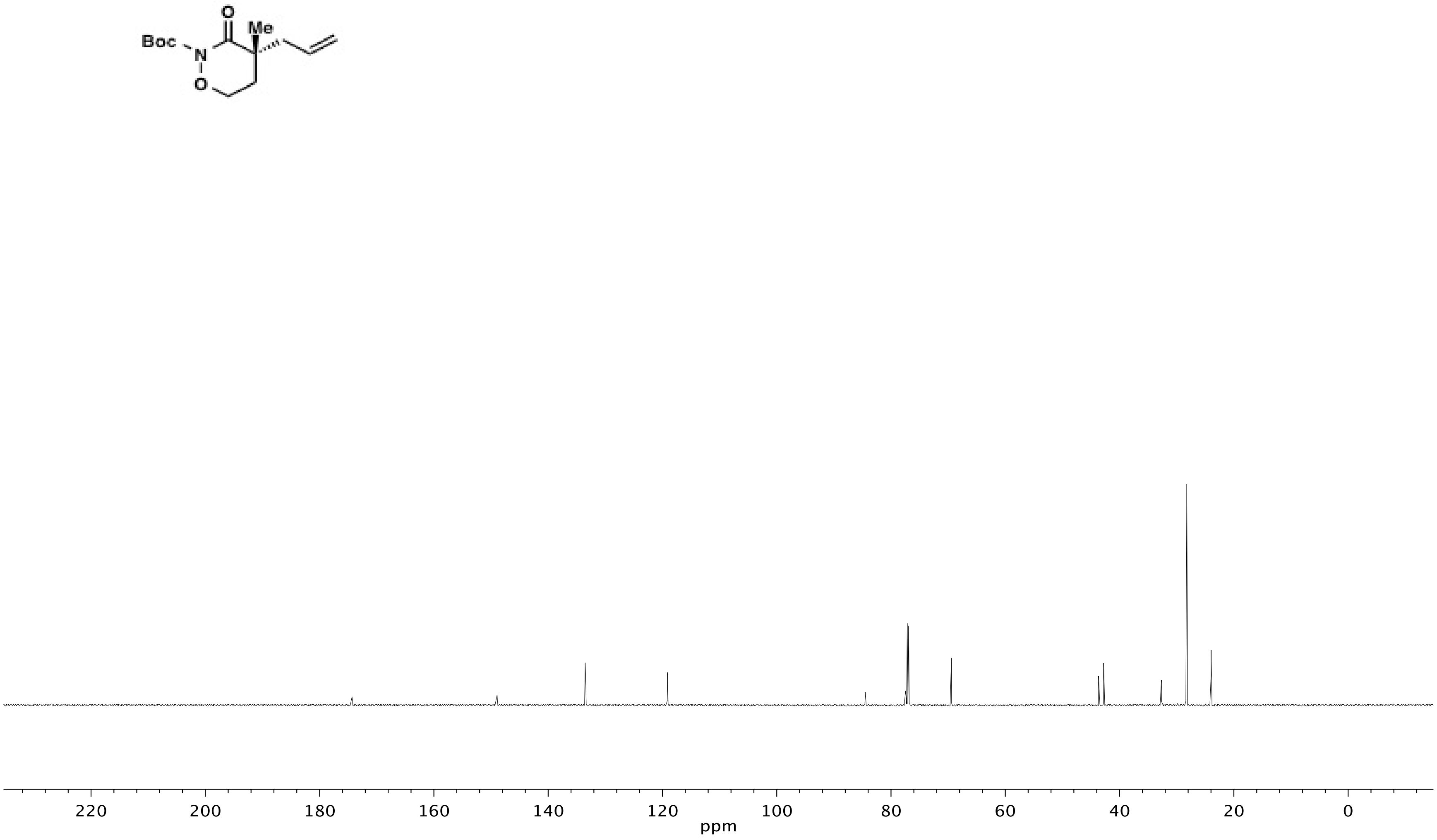
^{1}H NMR (500 MHz, $CDCl_3$) of compound **4e**.



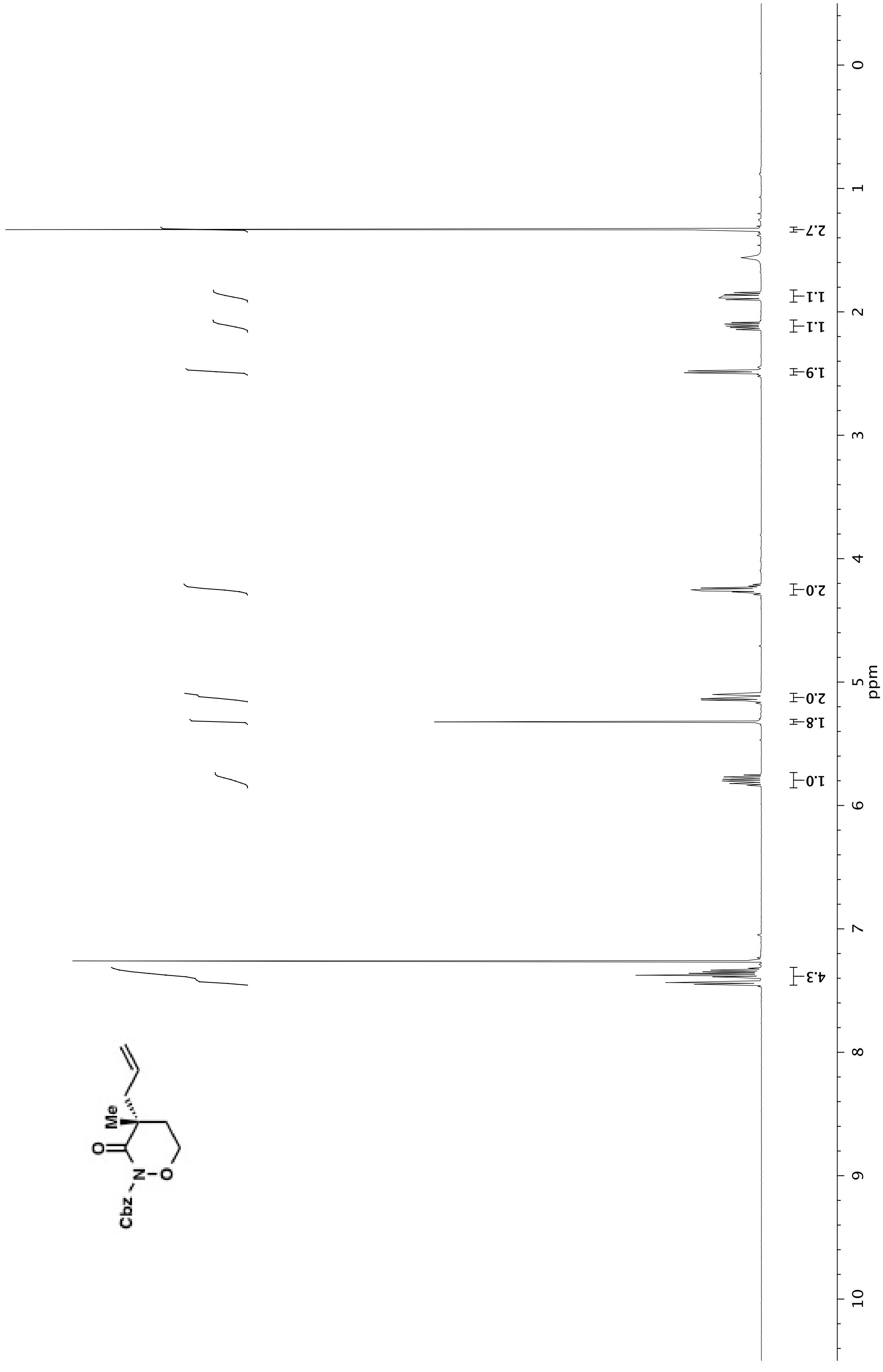
^{13}C NMR (126 MHz, CDCl$_3$) of compound **4e**.



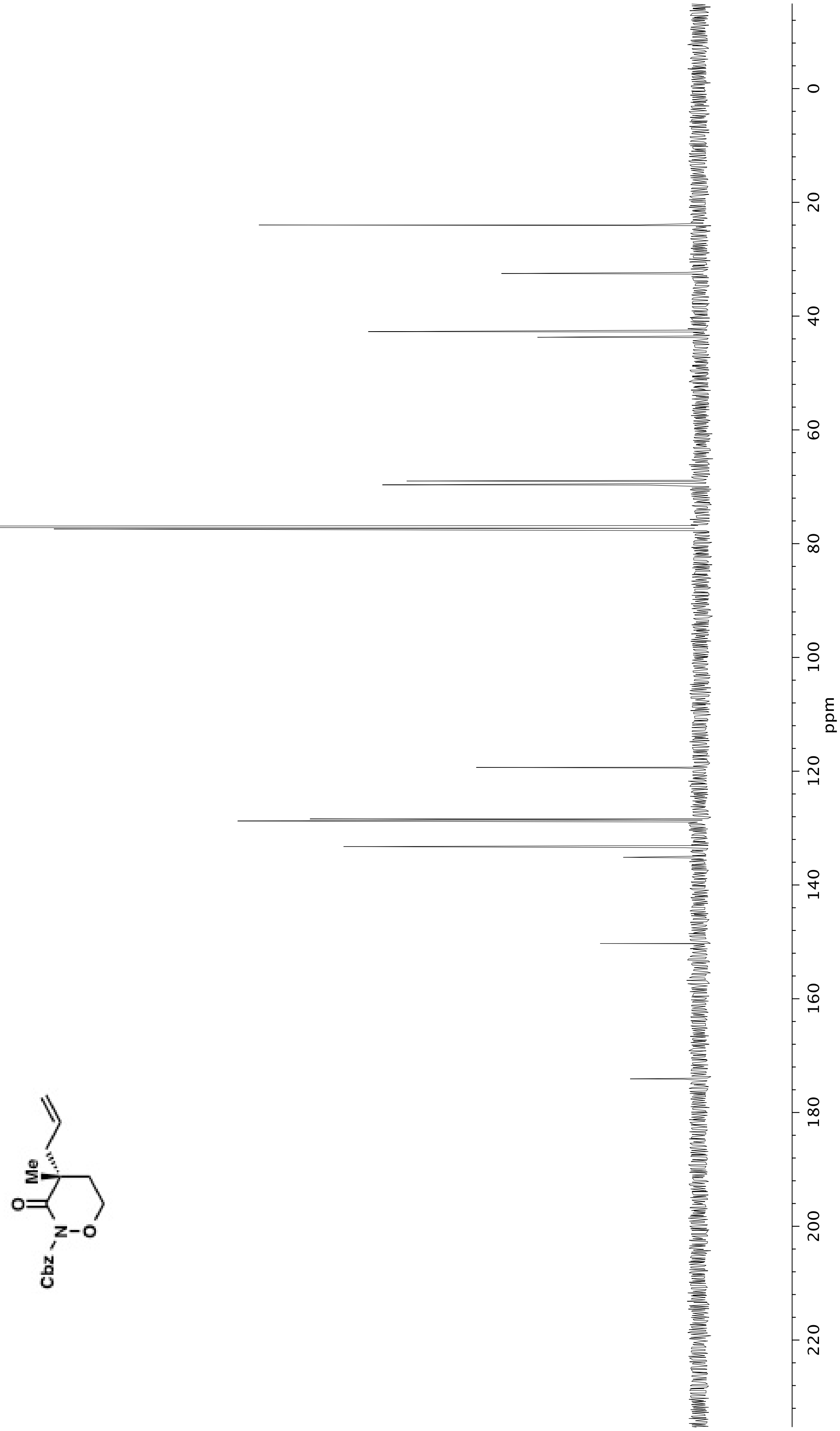
^{1}H NMR (500 MHz, CDCl$_3$) of compound **4g**.



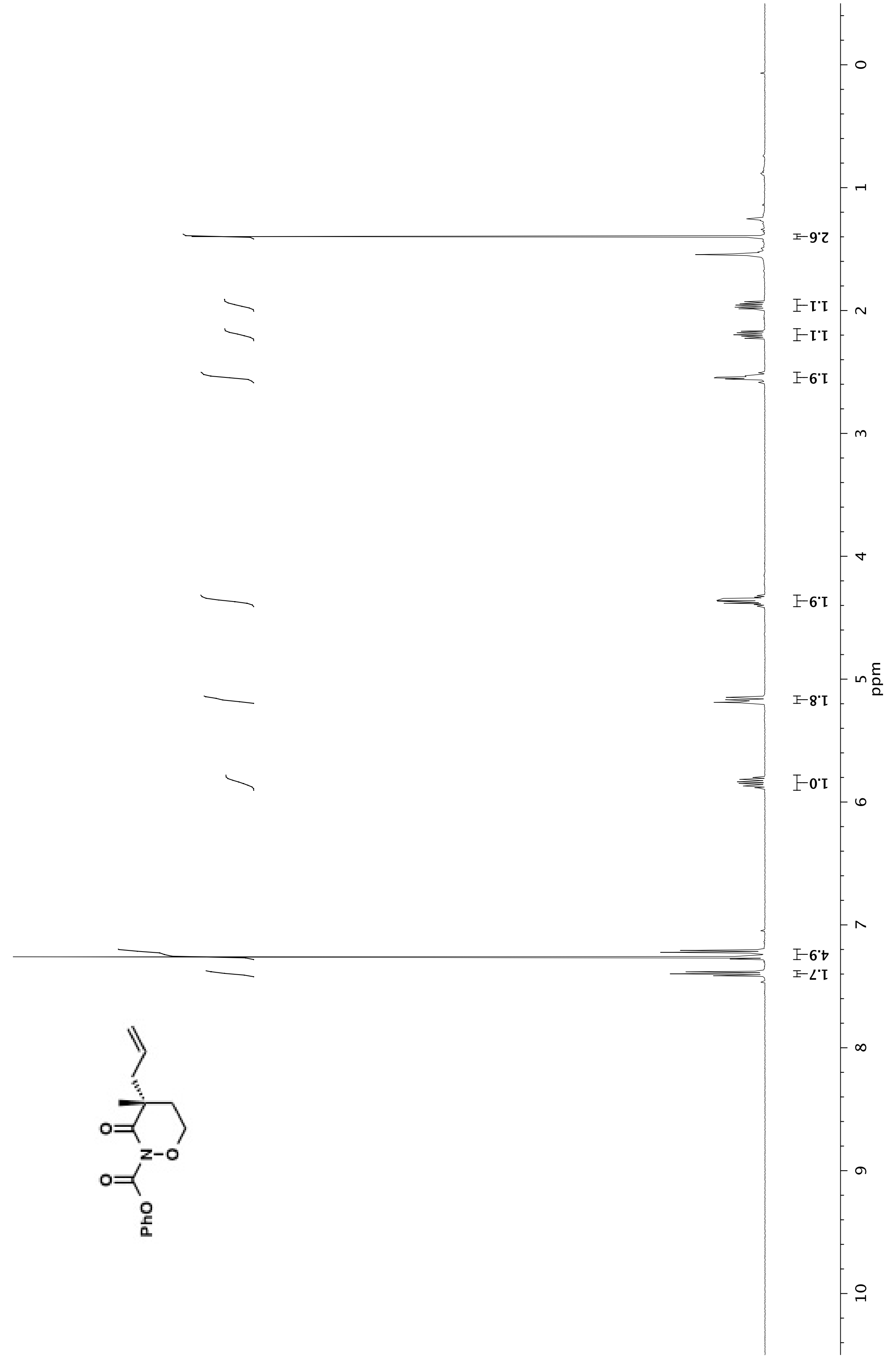
^{13}C NMR (126 MHz, $CDCl_3$) of compound **4g**.



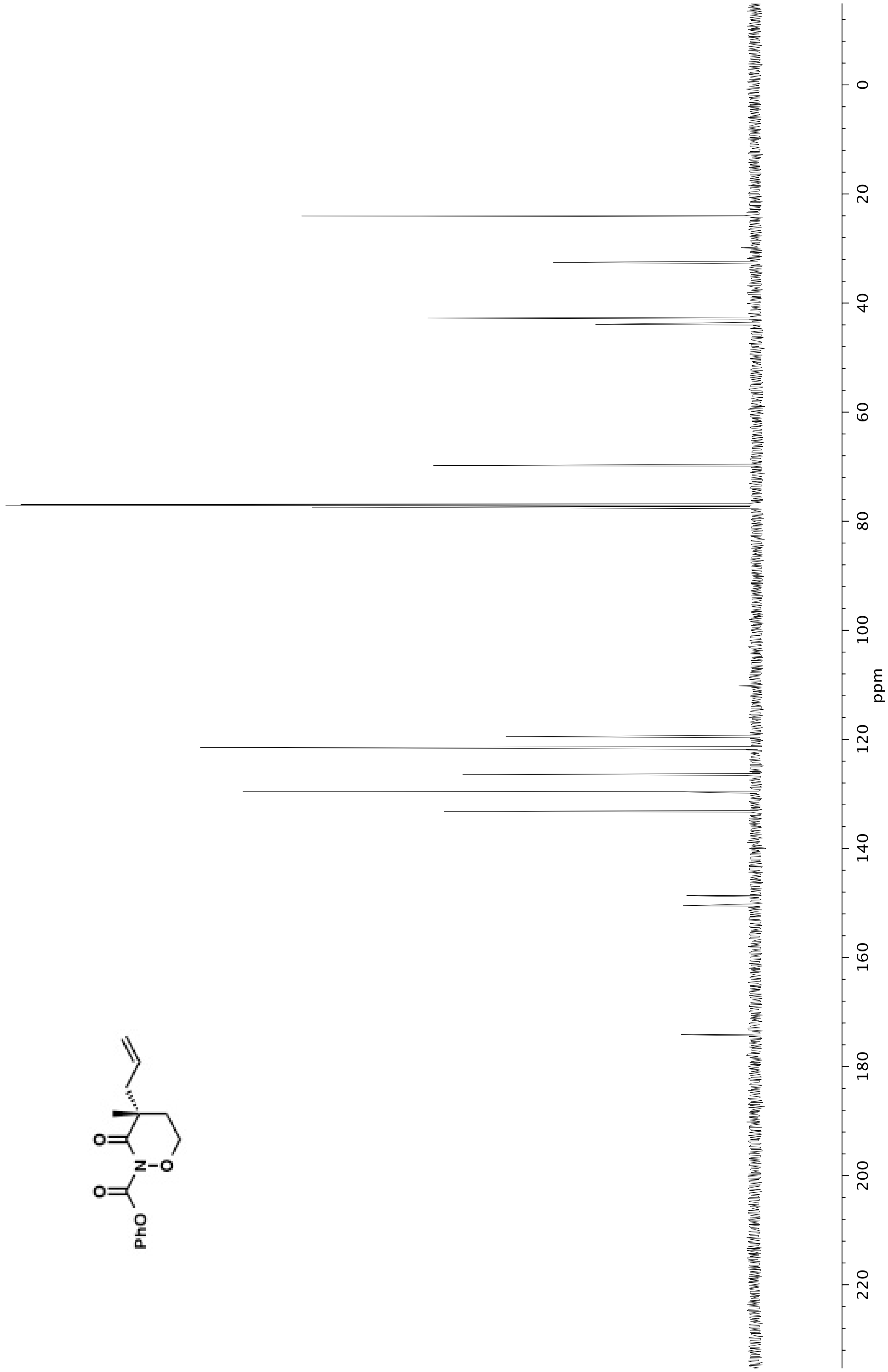
^{1}H NMR (500 MHz, $CDCl_3$) of compound **4h**.



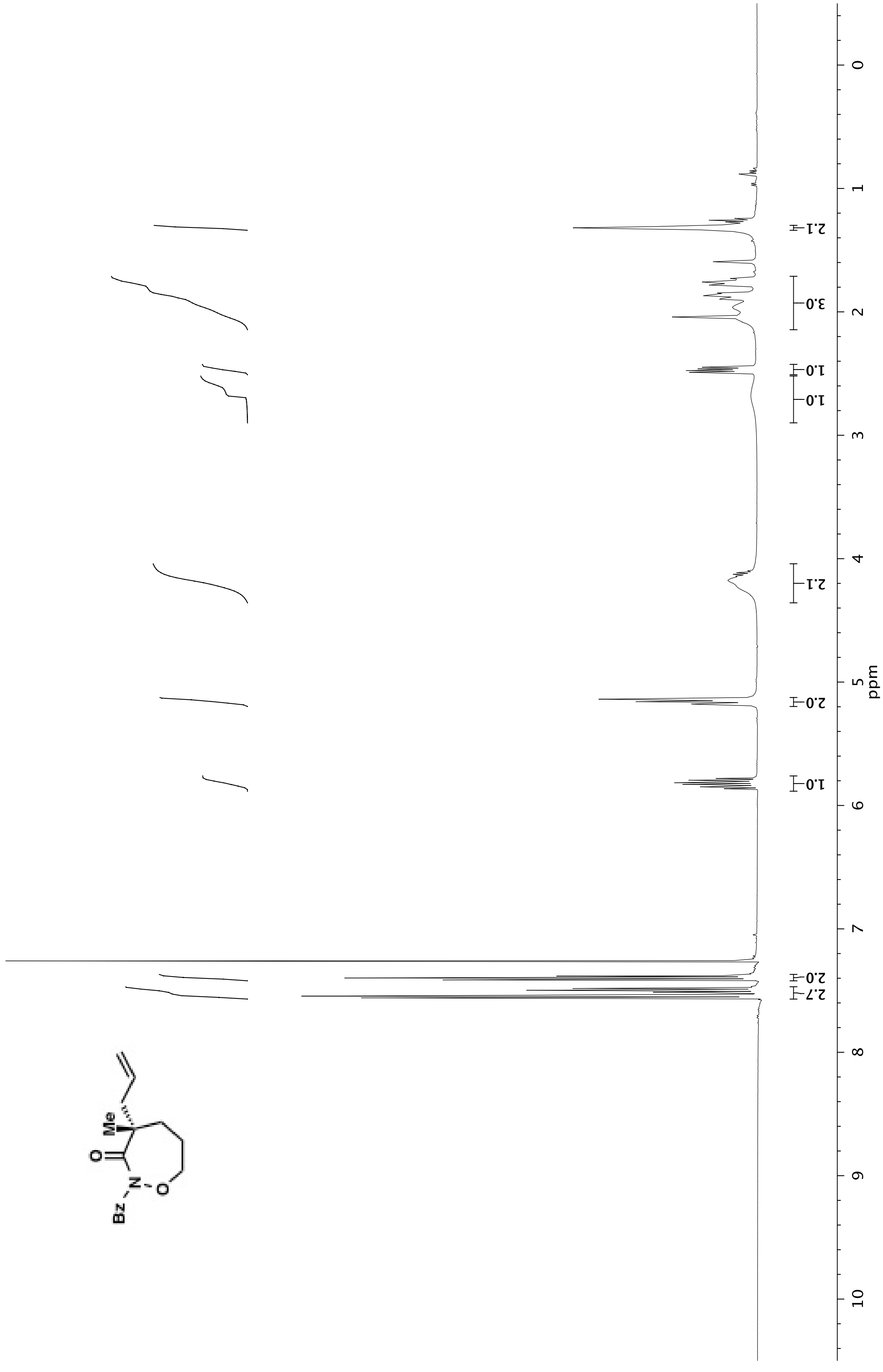
^{13}C NMR (126 MHz, CDCl$_3$) of compound **4h**.



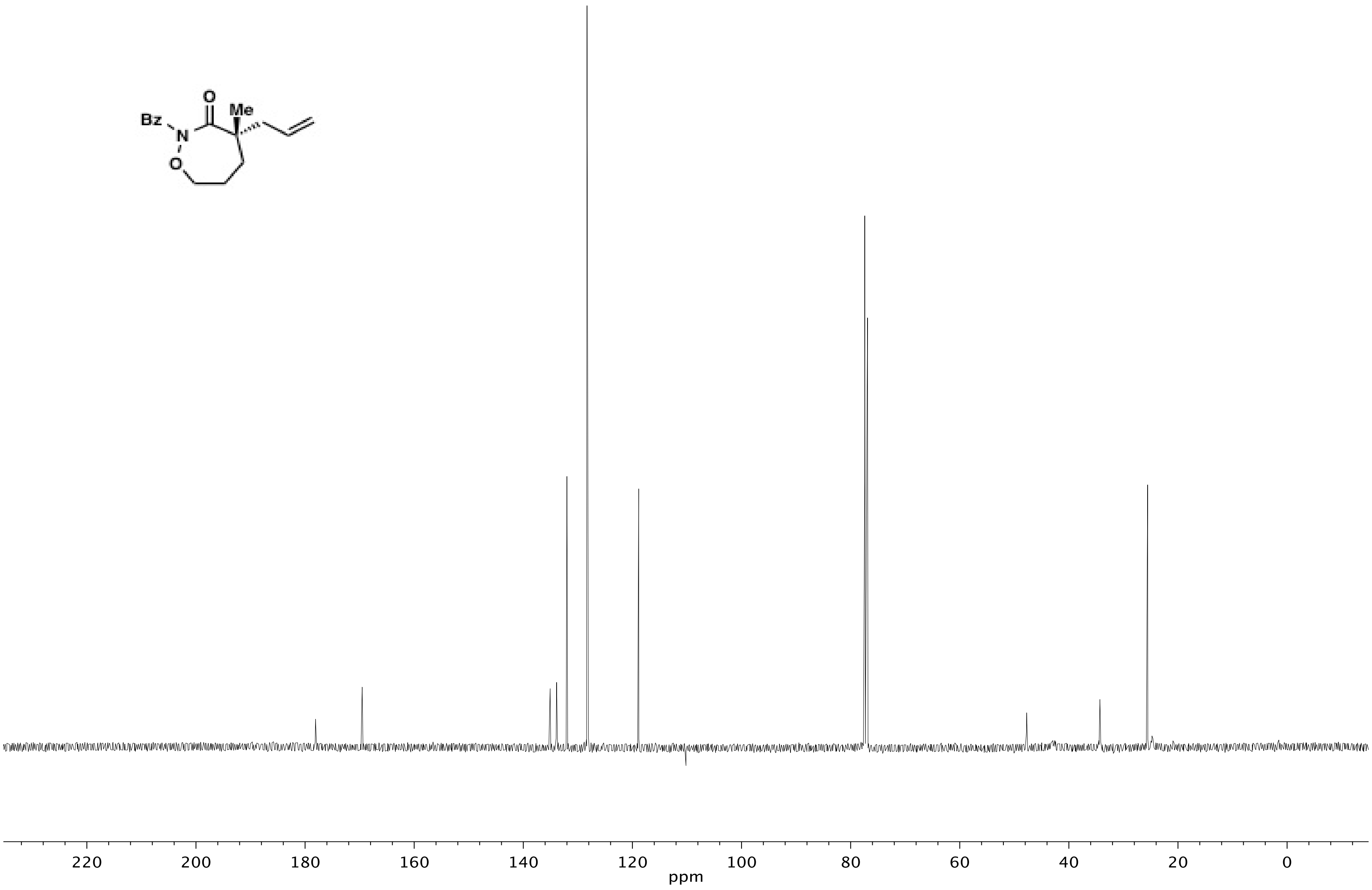
^{1}H NMR (500 MHz, $CDCl_3$) of compound **4i**.



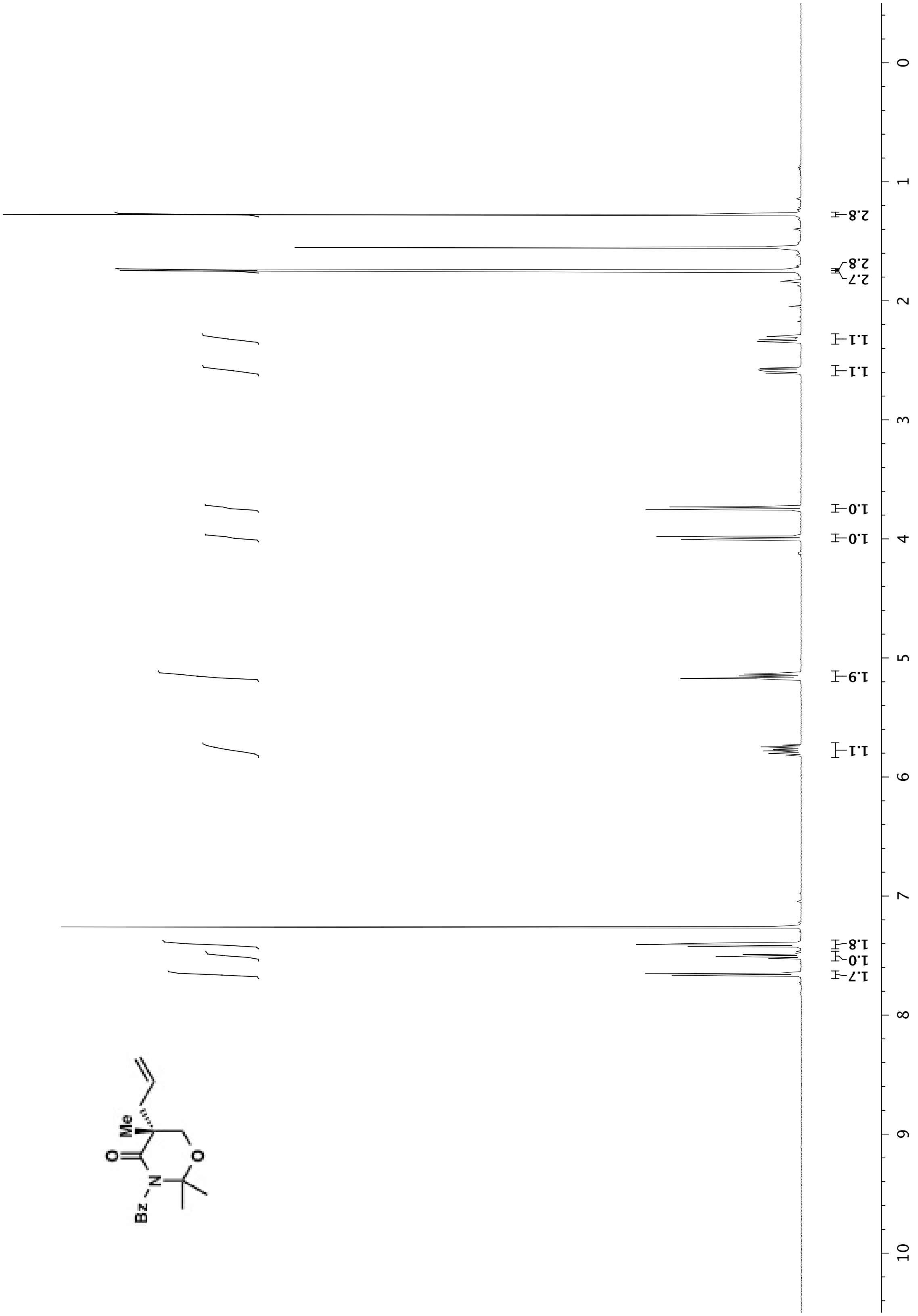
^{13}C NMR (126 MHz, CDCl$_3$) of compound **4i**.



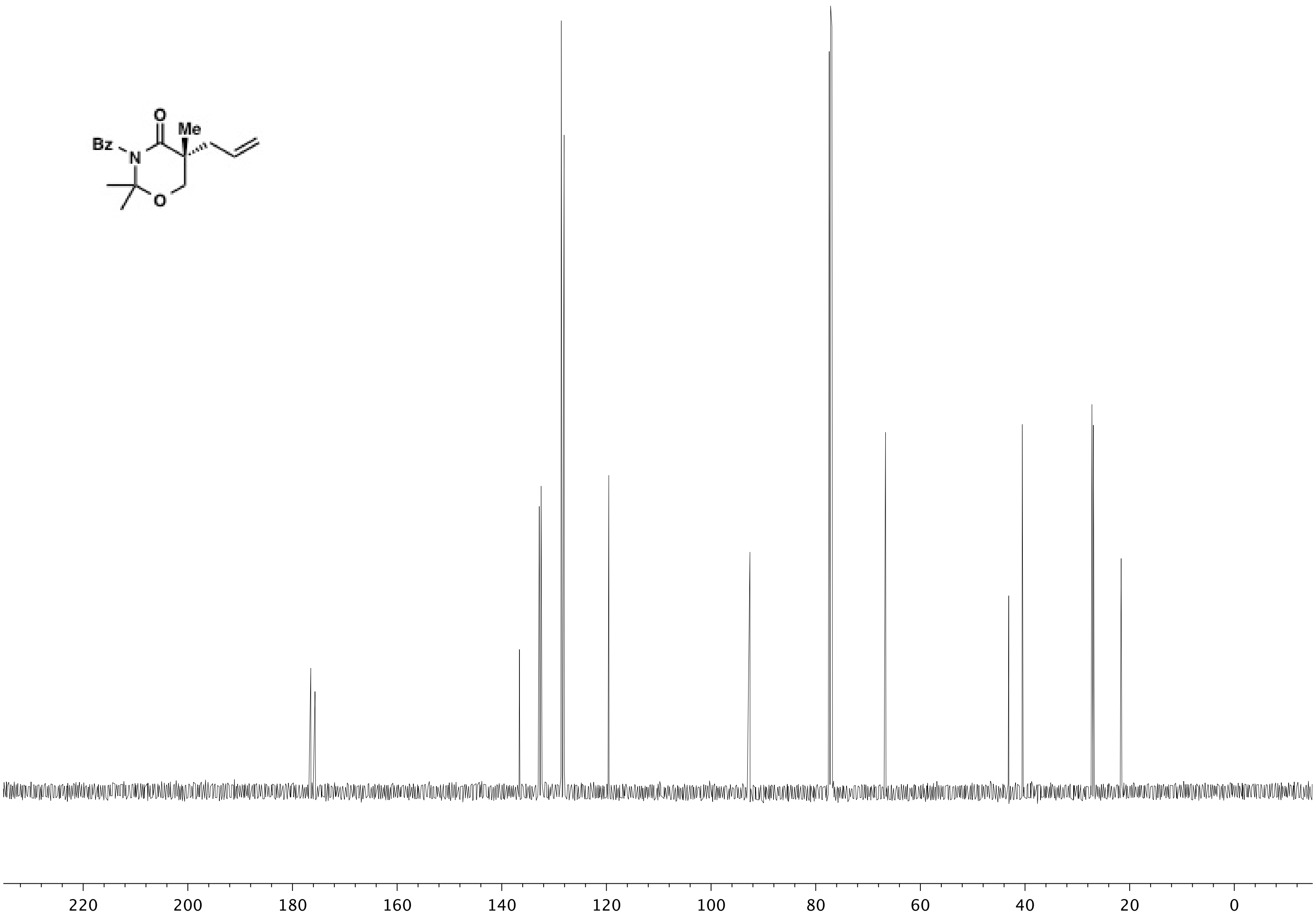
^{1}H NMR (500 MHz, CDCl$_3$) of compound **4j**.



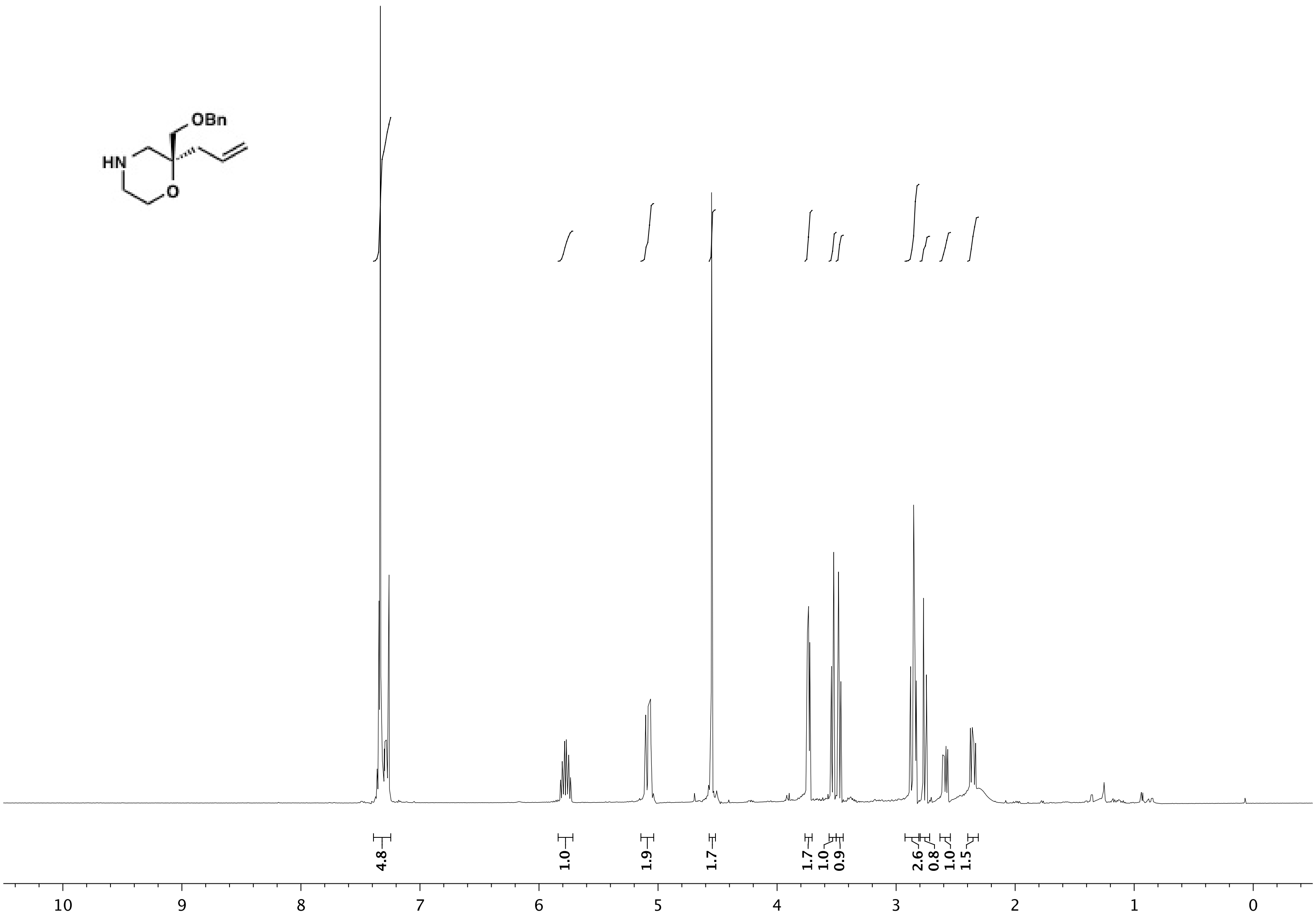
^{13}C NMR (126 MHz, CDCl$_3$) of compound **4j**.



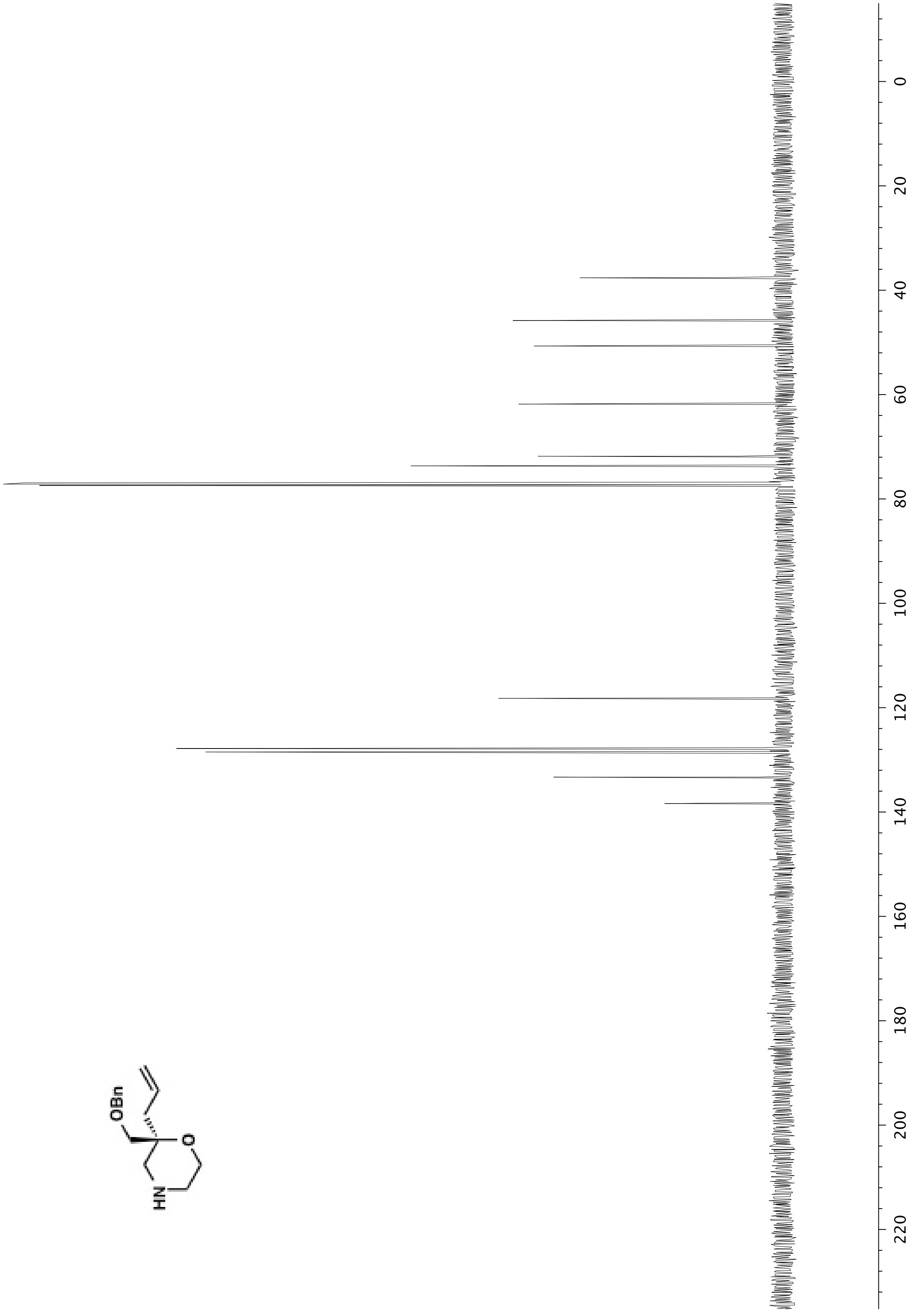
^{1}H NMR (500 MHz, CDCl$_3$) of compound **6**.



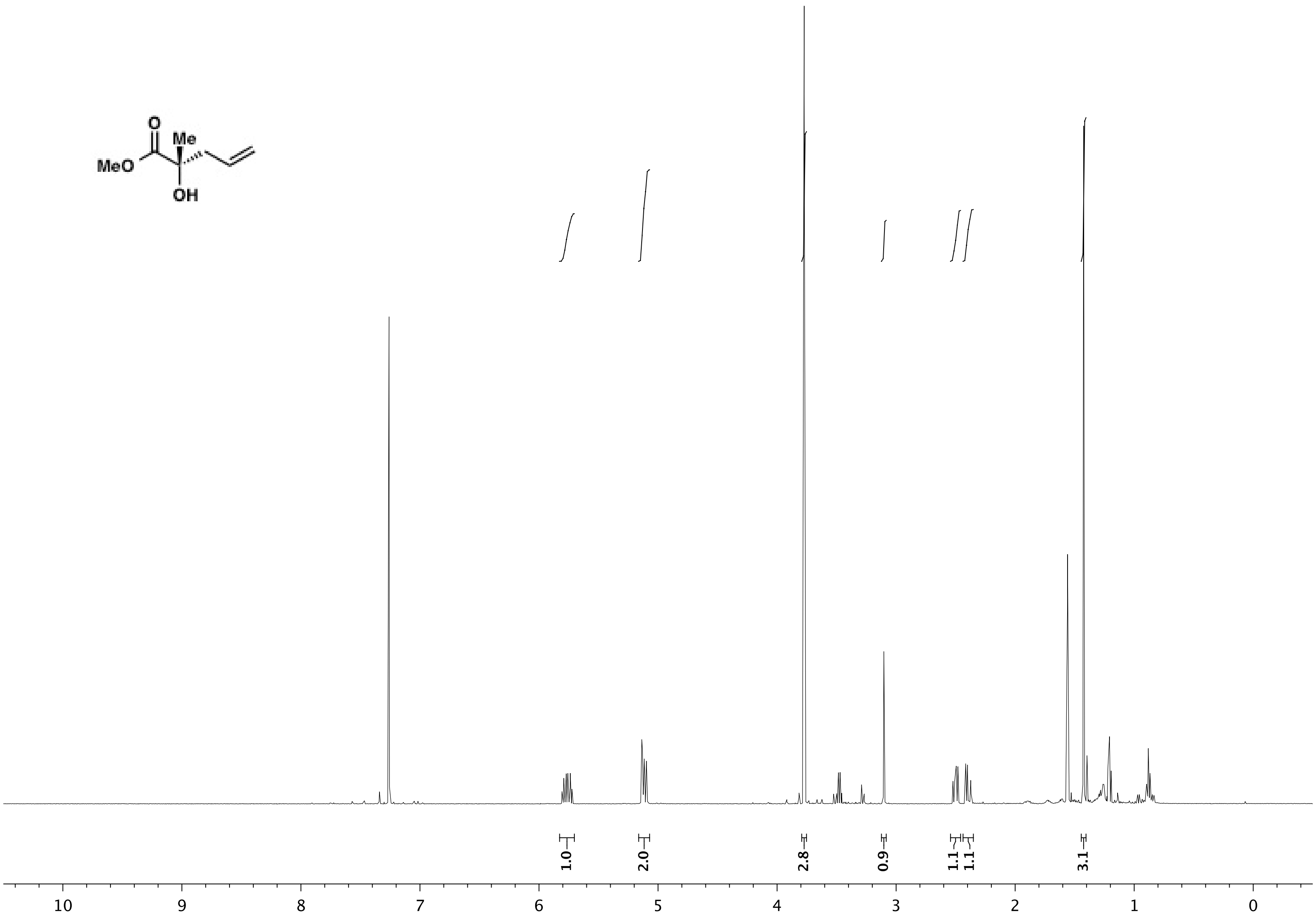
^{13}C NMR (126 MHz, CDCl$_3$) of compound **6**.



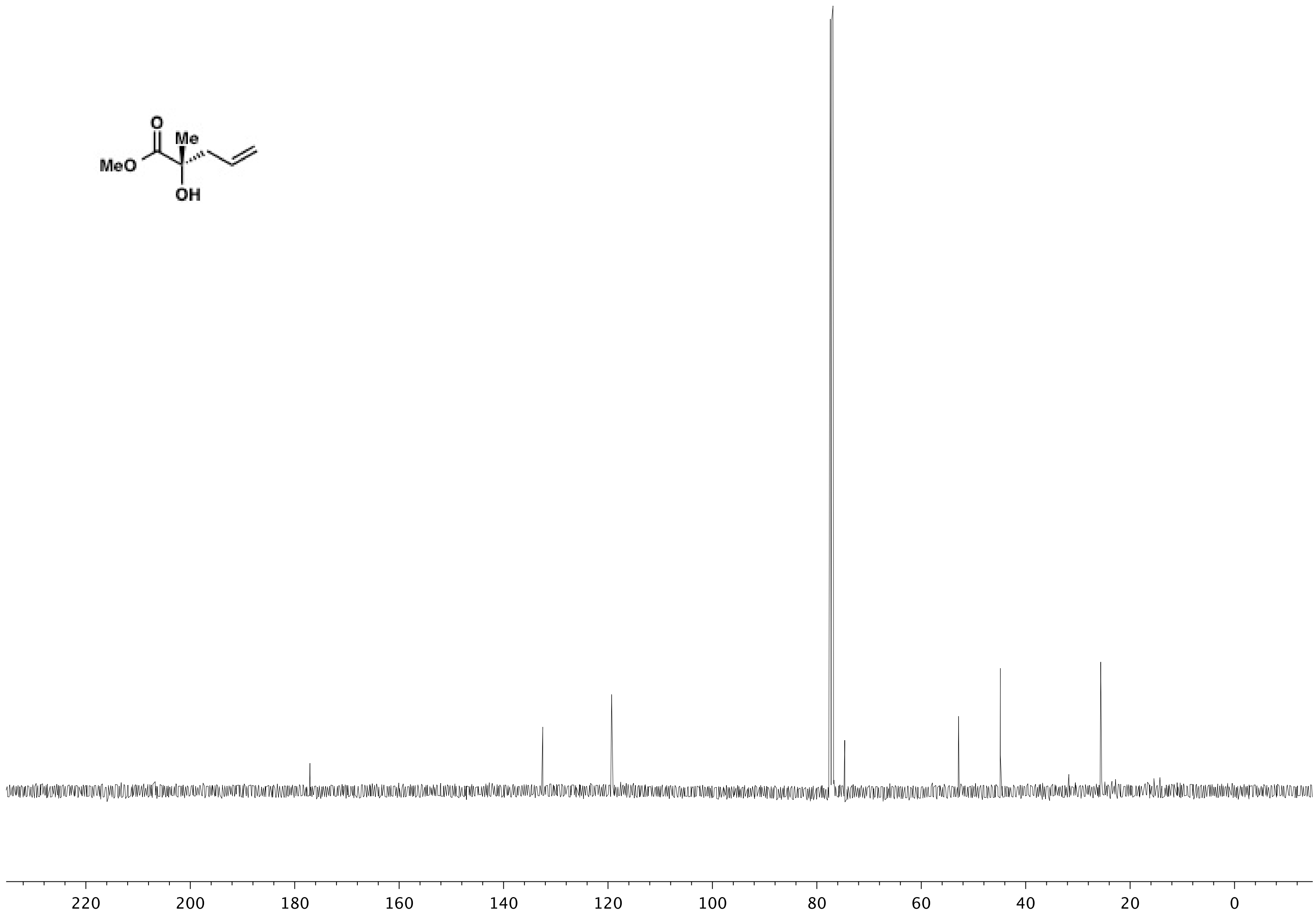
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7**.



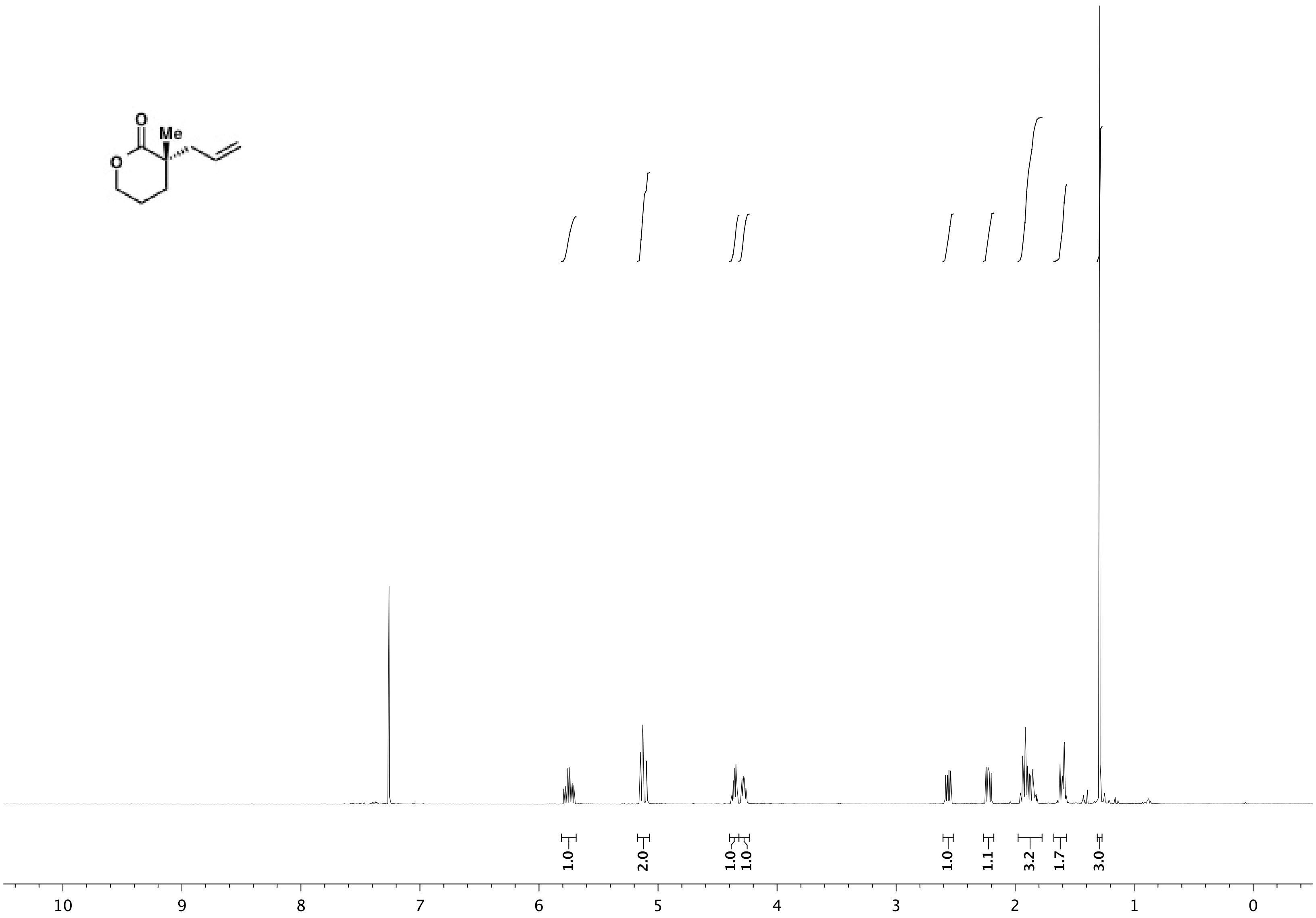
^{13}C NMR (126 MHz, CDCl$_3$) of compound **7**.



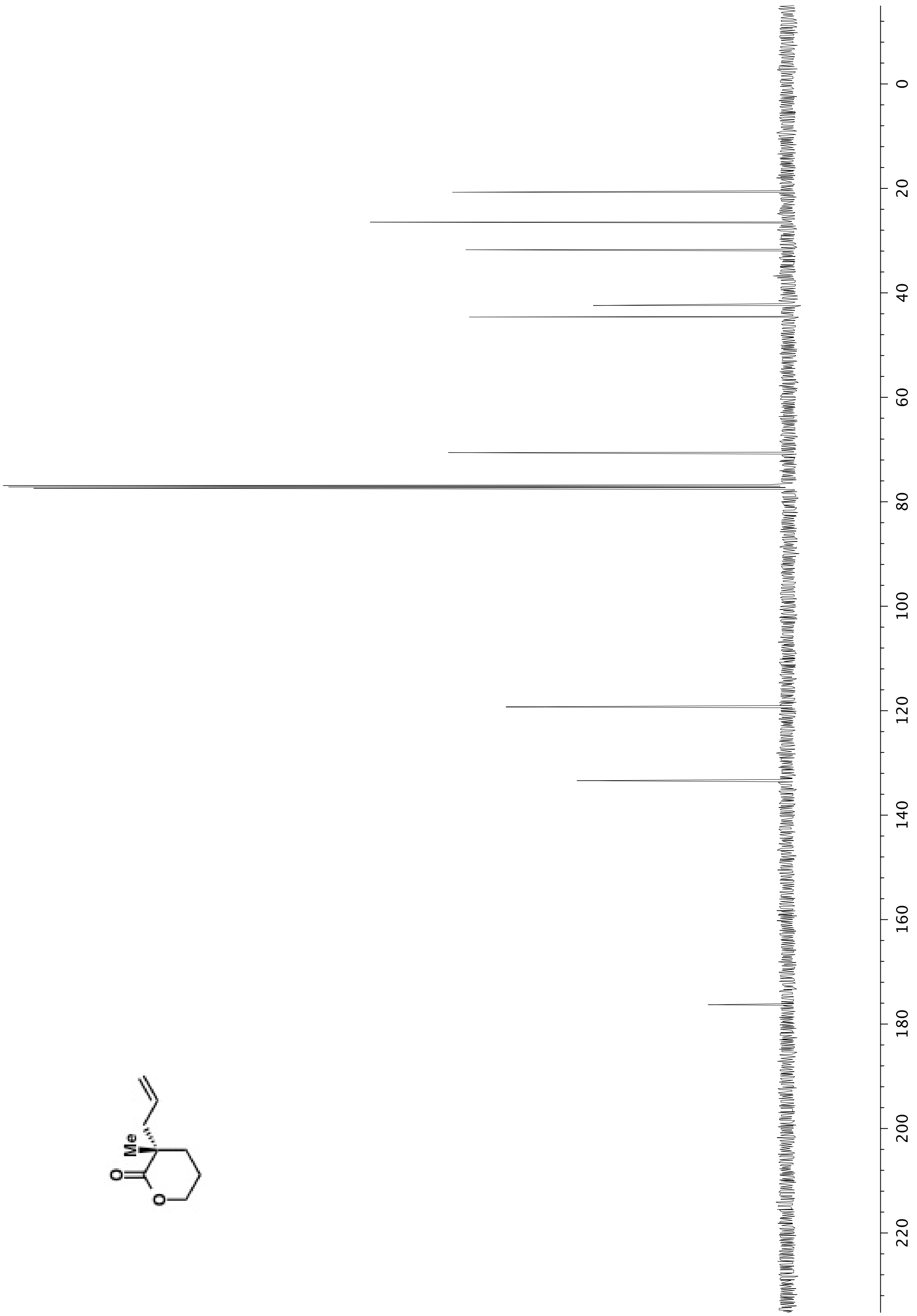
^{1}H NMR (500 MHz, CDCl$_3$) of compound **8**.



^{13}C NMR (126 MHz, CDCl$_3$) of compound **8**.



^{1}H NMR (500 MHz, $CDCl_3$) of compound **9**.



^{13}C NMR (126 MHz, CDCl$_3$) of compound **9**.