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Supporting Information

Palladium-Catalyzed Decarbonylative Dehydration for the Synthesis of α-Vinyl Carbonyl Compounds and Total Synthesis of (−)-Aspewentins A, B, and C**

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Materials and Methods

Unless otherwise stated, reactions were performed in flame-dried glassware under a nitrogen atmosphere using dry, deoxygenated solvents, or under vacuum without the use of solvents. Solvents were dried by passage through an activated alumina column under argon.[1] Reaction progress was monitored by thin-layer chromatography (TLC) or ^{1}H NMR analysis of the crude reaction mixture. TLC was performed using E. Merck silica gel 60 F254 precoated glass plates (0.25 mm) and visualized by UV fluorescence quenching, *p*-anisaldehyde, phosphomolybdic acid, or $KMnO_4$ staining. Silicycle Silia*Flash*® P60 Academic Silica gel (particle size 40−63 nm) was used for flash chromatography. ^{1}H NMR and ^{13}C NMR spectra were recorded on a Varian Inova 500 (500 MHz and 126 MHz, respectively) or a Bruker CryoProbe Prodigy 400 spectrometer (400 MHz and 101 MHz, respectively) and are reported relative to residual $CHCl_3$ (δ 7.26 ppm and δ 77.16 ppm, respectively). Data for ^{1}H 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, p = pentet, sept = septuplet, m = multiplet, br s = broad singlet, br d = broad doublet, app = apparent. 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 chiral GC was performed with an Agilent 6850 GC utilizing a G-TA (30 m x 0.25 mm) column (1.0 mL/min carrier gas flow). Analytical chiral HPLC was performed with an Agilent 1100 Series HPLC utilizing a Chiralpak (AD-H or AS) or Chiralcel (OD-H, OJ-H, or OB-H) columns (4.6 mm x 25 cm) obtained from Daicel Chemical

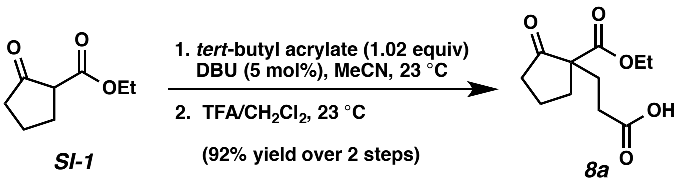
Industries, Ltd. Analytical chiral SFC was performed with a Mettler SFC supercritical CO_2 analytical chromatography system utilizing Chiralpak (AD-H, AS-H or IC) or Chiralcel (OD-H, OJ-H, or OB-H) columns (4.6 mm x 25 cm) obtained from Daicel Chemical Industries, Ltd. High resolution mass spectra (HRMS) were provided by the California Institute of Technology Mass Spectrometry Facility using a JEOL JMS-600H High Resolution Mass Spectrometer (EI+ or FAB+), or obtained with an Agilent 6200 Series TOF using Agilent G1978A Multimode source in electrospray ionization (ESI), atmospheric pressure chemical ionization (APCI), or mixed ionization mode (MM: ESI-APCI).

Reagents were purchased from Sigma-Aldrich, Acros Organics, Strem, or Alfa Aesar and used as received unless otherwise stated. *i*-Pr_2NH was distilled from calcium hydride prior to use. (*S*)-*t*-BuPHOX was prepared by a known method.[2]

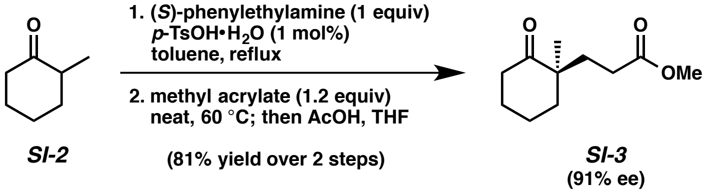
List of Abbreviations:

9-BBN – 9-borabicyclo(3.3.1)nonane, Ac – acetyl, Cy – cyclohexyl, Bz – benzoyl, DBU – 1,8-Diazabicycloundec-7-ene, DIBAL – diisobutylaluminium hydride, ee – enantiomeric excess, HPLC – high-performance liquid chromatography, LDA – lithium diisopropylamide, MTBE – methyl *tert*-butyl ether, LiHMDS – lithium hexamethyldisilazide, NMP – *N*-methylpyrrolidone, SFC – supercritical fluid chromatography, TLC – thin-layer chromatography, TEMPO – 2,2,6,6-Tetramethylpiperidin-1-yloxy, TFA – trifluoroacetic acid, THF – tetrahydrofuran, Ts – *p*-toluenesulfonyl

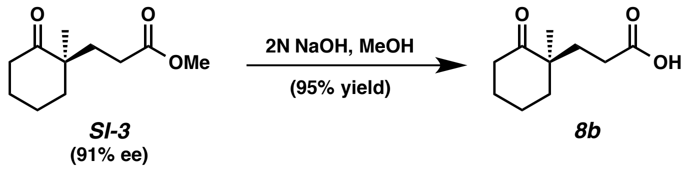
Preparation of Carboxylic Acid Substrates



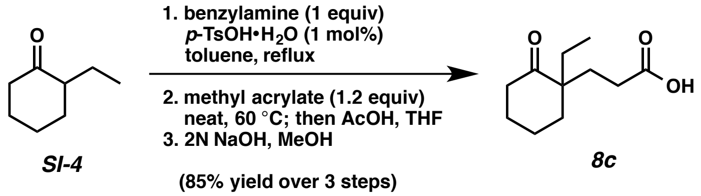
3-(1-(Ethoxycarbonyl)-2-oxocyclopentyl)propanoic acid (8a). A flame-dried 100 mL round-bottom flask was charged with a magnetic stir bar, anhydrous MeCN (30 mL), β-keto ester **SI-1** (2.9 mL, 20 mmol, 1 equiv), *tert*-butyl acrylate (3.0 mL, 20.6 mmol, 1.02 equiv), and DBU (0.15 mL, 1 mmol, 0.05 equiv). The light yellow reaction mixture was stirred at 23 °C. After 12 h, TLC analysis indicated complete consumption of starting material. Solvents were evaporated, and the crude residue was purified by flash column chromatography on silica gel (10→16→25% EtOAc in hexanes) to afford a colorless oil (5.22 g). To a solution of this oil (1.42 g) in CH_2Cl_2 (4 mL) was added trifluoroacetic acid (4 mL). The reaction mixture was stirred at 23 °C for 30 min and concentrated under reduced pressure. Removal of remaining trifluoroacetic acid by azeotropic evaporation from toluene (5 mL x 5) afforded carboxylic acid **8a** (1.14 g, 92% yield over 2 steps) as a viscous colorless oil. $R_f = 0.1$ (25% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 7.86 (br s, 1H), 4.17 (q, $J = 7.1$ Hz, 2H), 2.59 (ddd, $J = 16.3, 10.2, 5.7$ Hz, 1H), 2.53–2.36 (m, 3H), 2.30 (dt, $J = 19.0, 8.0$ Hz, 1H), 2.19 (ddd, $J = 14.2, 10.2, 5.7$ Hz, 1H), 2.09–1.92 (m, 3H), 1.89 (dt, $J = 13.1, 7.4$ Hz, 1H), 1.25 (t, $J = 7.1$ Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 214.7, 178.6, 171.1, 61.8, 59.2, 38.0, 34.0, 29.6, 28.2, 19.7, 14.2; IR (Neat Film, NaCl) 2979, 1713, 1408, 1158, 1028 cm^{-1}; HRMS (MM: ESI-APCI–) *m/z* calc'd for $C_{11}H_{15}O_5$ $[M–H]^-$: 227.0925, found 227.0925.



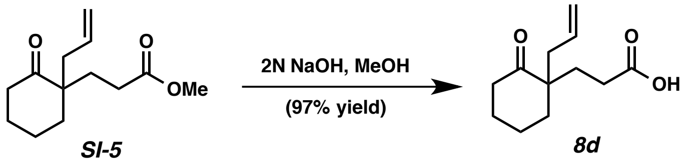
Methyl (*R*)-3-(1-methyl-2-oxocyclohexyl)propanoate (SI-3). Synthesis of **SI-3** was based on a literature procedure.[3] A 100 mL round-bottom flask was charged with a magnetic stir bar, 2-methylcyclohexanone (**SI-2**, 3.7 mL, 30.6 mmol, 1 equiv), (*S*)-phenylethylamine (3.71 g, 30.6 mmol, 1 equiv), *p*-toluenesulfonic acid hydrate (58 mg, 0.306 mmol, 0.01 equiv), and toluene (30 mL). The flask was equipped with a Dean-Stark trap filled with toluene and a reflux condenser. The reaction mixture was heated at reflux for 3.5 h. The Dean-Stark trap was replaced with a distillation head, and the toluene was distilled off under reduced pressure. The residue was cooled to 60 °C under nitrogen and methyl acrylate (3.4 mL, 36.7 mmol, 1.2 equiv) was added. The reaction mixture was stirred at 60 °C for 12 h. After cooling to ambient temperature, the reaction mixture was quantitatively transferred to a 250 mL round-bottom flask by rinsing with THF (50 mL total). Aqueous 20% acetic acid (30 mL) was added and the solution was stirred at 23 °C for 5 h. THF was evaporated under reduced pressure and 1N HCl (11 mL) was added. The biphasic mixture was extracted with Et_2O (25 mL x 3). The combined organic layers were washed with H_2O and brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (5→6→10→12% EtOAc in hexanes) to afford δ-keto ester **SI-3** (4.96 g, 81% yield over 2 steps) as a light brown oil. $R_f = 0.4$ (16% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.66 (s, 3H), 2.46–2.26 (m, 3H), 2.22–2.10 (m, 1H), 2.11–1.98 (m, 1H), 1.93–1.67 (m, 6H), 1.67–1.54 (m, 1H), 1.07 (d, *J* = 2.7 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 215.4, 174.2, 51.8, 48.0, 39.4, 38.8, 32.6, 29.1, 27.6, 22.5, 21.1; IR (Neat Film, NaCl) 2936, 2865, 1740, 1705, 1437, 1378, 1304, 1197, 1172, 1123, 988 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{11}H_{19}O_3$ $[M+H]^+$: 199.1329, found 199.1325; $[\alpha]_D^{25}$ +31.5 (*c* 3.00, EtOH, 91% ee).



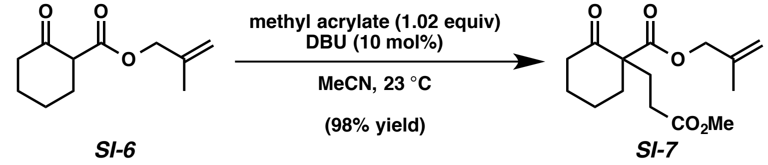
(*R*)-3-(1-Methyl-2-oxocyclohexyl)propanoic acid (8b). To a solution of **SI-3** (2.37 g, 11.9 mmol, 1.0 equiv) in MeOH (11 mL) was added aqueous 2N NaOH (7.8 mL, 15.5 mmol, 1.3 equiv). The reaction mixture was stirred at 23 °C for 2 h, then MeOH was evaporated under reduced pressure. The aqueous layer was washed with Et_2O (10 mL x 1), acidified with 1N HCl (25 mL), and extracted with Et_2O (25 mL x 3). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure to a wet residue. The residue was redissolved in CH_2Cl_2, dried over Na_2SO_4, filtered, and concentrated under reduced pressure to afford carboxylic acid **8b** (2.14 g, 95% yield) as a light yellow viscous oil. $R_f = 0.1$ (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.43–2.31 (m, 3H), 2.22 (ddd, $J = 16.8, 13.2, 5.2$ Hz, 1H), 2.06–1.96 (m, 1H), 1.89–1.68 (m, 6H), 1.66–1.56 (m, 1H), 1.08 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 215.5, 179.7, 48.0, 39.3, 38.8, 32.4, 29.1, 27.5, 22.6, 21.1; IR (Neat Film, NaCl) 2936, 1706, 1455, 1312, 1224, 1124, 1097, 902, 856 cm^{-1}; HRMS (ESI-APCI–) *m/z* calc'd for $C_{10}H_{15}O_3$ $[M-H]^-$: 183.1027, found 183.1034; $[\alpha]_D^{25}$ +36.0 (*c* 4.77, EtOH).



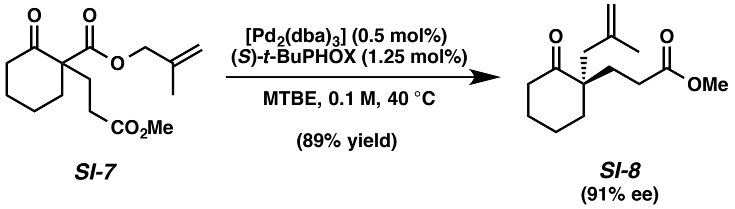
3-(1-Ethyl-2-oxocyclohexyl)propanoic acid (8c). Using 2-ethylcyclohexanone (**SI-4**) as staring material, the procedure for the synthesis of **8b** was followed to provide carboxylic acid **8c** (3.85 g, 85% yield over 3 steps) as a white solid. m.p. 60–62 °C; R$_f$ = 0.1 (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, CDCl$_3$) δ 2.45–2.26 (m, 3H), 2.23–2.12 (m, 1H), 1.93–1.58 (m, 9H), 1.54–1.43 (m, 1H), 0.77 (t, *J* = 7.8 Hz, 3H); ^{13}C NMR (126 MHz, CDCl$_3$) δ 215.1, 179.9, 51.1, 39.2, 35.8, 28.9, 28.8, 27.3, 27.2, 20.8, 7.8; IR (Neat Film, NaCl) 2939, 2868, 1704, 1455, 1423, 1312, 1229, 1127, 1091 cm^{-1}; HRMS (ESI-APCI–) *m/z* calc'd for $C_{11}H_{17}O_3$ [M–H]$^-$: 197.1183, found 197.1187.



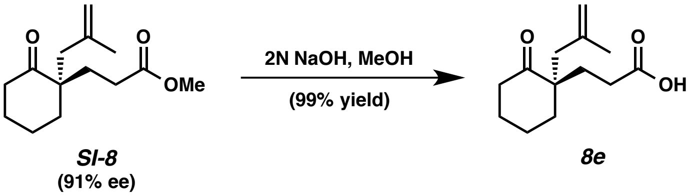
3-(1-Allyl-2-oxocyclohexyl)propanoic acid (8d). Basic hydrolysis of known δ-keto ester **SI-5**[4] (2.24 g, 10.0 mmol, 1.0 equiv) afforded carboxylic acid **8d** (2.04 g, 97% yield) as a viscous colorless oil. R$_f$ = 0.1 (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, CDCl$_3$) δ 10.52 (br s, 1H), 5.64 (dq, *J* = 17.0, 7.7 Hz, 1H), 5.11–5.02 (m, 2H), 2.44–2.28 (m, 4H), 2.28–2.20 (m, 1H), 2.16 (ddd, *J* = 16.4, 11.2, 5.1 Hz, 1H), 1.96 (ddd, *J* = 15.8, 11.2, 5.0 Hz, 1H), 1.88–1.65 (m, 7H); ^{13}C NMR (126 MHz, CDCl$_3$) δ 214.4, 179.7, 133.1, 118.7, 50.9, 39.2, 39.1, 36.2, 29.5, 28.7, 27.1, 20.8; IR (Neat Film, NaCl) 2937, 2866, 1704, 1419, 1312, 1221, 1126, 995, 917 cm^{-1}; HRMS (ESI-APCI–) *m/z* calc'd for $C_{12}H_{17}O_3$ [M–H]$^-$: 209.1183, found 209.1190.



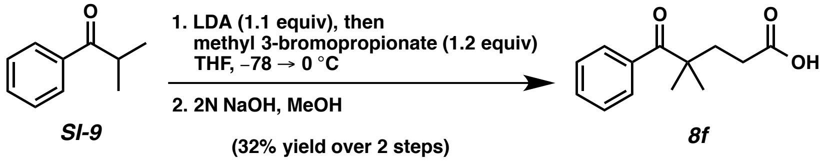
2-Methylallyl 1-(3-methoxy-3-oxopropyl)-2-oxocyclohexane-1-carboxylate (SI-7). A flame-dried 100 mL round-bottom flask was charged with a magnetic stir bar, MeCN (30 mL), β-keto ester **SI-6** (3.32 g, 16.9 mmol, 1.0 equiv), methyl acrylate (1.6 mL, 17.3 mmol, 1.02 equiv), and DBU (0.25 mL, 1.69 mmol, 0.1 equiv). The light yellow reaction mixture was stirred at 23 °C. After 14 h, TLC analysis indicated complete consumption of starting material. Solvents were evaporated, and the crude residue was purified by flash column chromatography on silica gel (8→16% EtOAc in hexanes) to afford ester **SI-7** (4.69 g, 98% yield) as a colorless oil. $R_f = 0.4$ (16% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 4.96 (d, J = 16.1 Hz, 2H), 4.54 (s, 2H), 3.65 (s, 3H), 2.54–2.34 (m, 4H), 2.30–2.15 (m, 2H), 2.06–1.89 (m, 2H), 1.82–1.74 (m, 1H), 1.73 (s, 3H), 1.71–1.57 (m, 2H), 1.54–1.43 (m, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 207.4, 173.6, 171.5, 139.2, 114.2, 68.8, 60.2, 51.8, 41.1, 36.4, 29.8, 29.5, 27.6, 22.6, 19.7; IR (Neat Film, NaCl) 2948, 2867, 1738, 1715, 1436, 1307, 1176, 1135, 990, 907 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{15}H_{23}O_5$ $[M+H]^+$: 283.1540, found 283.1533.



Methyl (*R*)-3-(1-(2-methylallyl)-2-oxocyclohexyl)propanoate (SI-8). In a nitrogen-filled glove box, a 250 mL Schlenk flask was charged with a magnetic stir bar, $Pd_2(dba)_3$ (32 mg, 0.035 mmol, 0.005 equiv), (*S*)-*t*-BuPHOX (34 mg, 0.0875 mmol, 0.0125 equiv), and MTBE (40 mL). The solution was stirred at ambient temperature for 30 min. Then additional MTBE (21 mL) and **SI-7** (1.98 g, 7.0 mmol, 1.0 equiv) were added via syringe. The syringe was rinsed with MTBE (3 mL x 3) to ensure complete transfer of **SI-7**. The Schlenk flask was sealed and taken out of the glove box. The reaction mixture was stirred at 40 °C for 28 h, then concentrated under reduced pressure. The crude residue was purified by flash column chromatography on silica gel (6→10% EtOAc in hexanes) to afford δ-keto ester **SI-8** (1.49 g, 89% yield) as a colorless oil. R_f = 0.5 (16% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 4.83 (s, 1H), 4.65 (s, 1H), 3.64 (s, 3H), 2.47 (dt, *J* = 14.0, 6.5 Hz, 1H), 2.42–2.27 (m, 4H), 2.15–2.06 (m, 1H), 2.02–1.92 (m, 1H), 1.91–1.65 (m, 7H), 1.64 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 214.4, 174.2, 141.9, 115.4, 51.8, 51.0, 42.9, 39.4, 36.7, 30.5, 28.9, 27.2, 24.5, 20.9; IR (Neat Film, NaCl) 2943, 2865, 1738, 1699, 1436, 1374, 1173, 1128, 1080, 895 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{14}H_{23}O_3$ $[M+H]^+$: 239.1642, found 239.1633; $[\alpha]_D^{25}$ +9.0 (*c* 1.00, $CHCl_3$, 91% ee).

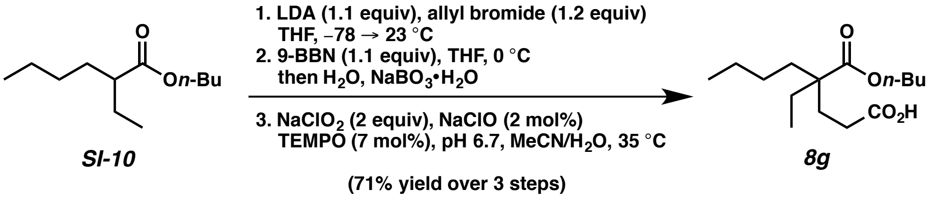


(*R*)-3-(1-(2-Methylallyl)-2-oxocyclohexyl)propanoic acid (8e). Basic hydrolysis of δ-keto ester **SI-8** (1.49 g, 6.25 mmol, 1 equiv) afforded carboxylic acid **8e** (1.39 g, 99% yield) as a white solid. m.p. 81–82 °C; R_f = 0.1 (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 4.82 (s, 1H), 4.64 (s, 1H), 2.54–2.43 (m, 1H), 2.43–2.27 (m, 4H), 2.15 (ddd, *J* = 16.4, 10.8, 5.5 Hz, 1H), 1.96–1.69 (m, 7H), 1.69–1.63 (m, 1H), 1.62 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 214.7, 179.9, 141.7, 115.5, 51.0, 43.0, 39.3, 36.7, 30.1, 28.9, 27.1, 24.4, 20.9; IR (Neat Film, NaCl) 3074, 2940, 2866, 1704, 1455, 1312, 1219, 1128, 896 cm^{-1}; HRMS (ESI-APCI–) *m/z* calc'd for $C_{13}H_{19}O_3$ [M–H]$^-$: 223.1340, found 223.1345; $[\alpha]_D^{25}$ +5.4 (*c* 1.00, $CHCl_3$).



4,4-Dimethyl-5-oxo-5-phenylpentanoic acid (8f). A flame-dried 100 mL round-bottom flask was charged with a magnetic stir bar, THF (26 mL), and cooled to 0 °C. A solution of *n*-butyllithium in hexanes (2.5 M, 5.7 mL, 14.3 mmol, 1.1 equiv) was added, followed by dropwise addition of diisopropylamine (2.0 mL, 14.3 mmol, 1.1 equiv). The light yellow solution was stirred at 0 °C for 10 min, then cooled to –78 °C in a dry ice-acetone bath. Isobutyrophenone (**SI-9**, 2.0 mL, 13 mmol, 1.0 equiv) was added dropwise. The orange-red solution was stirred at the same temperature for 30 min, and methyl 3-bromopropionate (1.7 mL, 15.6 mmol, 1.2 equiv) was added dropwise. The dry ice-acetone bath was removed, and the yellow reaction mixture was warmed to 0 °C and stirred for an additional 2 h. The reaction was quenched with half saturated aqueous NH_4Cl solution (30 mL) and extracted with Et_2O (30 mL x 2). The combined organic layers were washed with H_2O and brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude residue was purified by flash column chromatography on silica gel (5% EtOAc in hexanes) to afford a colorless oil (1.20 g), which was subjected to basic hydrolysis to provide carboxylic acid **8f** (0.93 g, 32% yield over 2 steps) as a viscous colorless oil. R_f = 0.1 (25% EtOAc in hexanes); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69–7.65 (m, 2H), 7.50–7.45 (m, 1H), 7.43–7.37 (m, 2H), 2.36–2.29 (m, 2H), 2.13–2.07 (m, 2H), 1.34 (s, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 208.2, 179.7, 138.6, 131.3, 128.4, 127.8, 47.2, 35.3, 29.9, 26.0; IR (Neat

Film, NaCl) 2972, 1709, 1597, 1444, 1303, 1200, 962, 719, 700 cm^{-1}; HRMS (ESI-APCI–) *m/z* calc'd for $C_{13}H_{15}O_3$ $[M–H]^-$: 219.1027, found 219.1035.

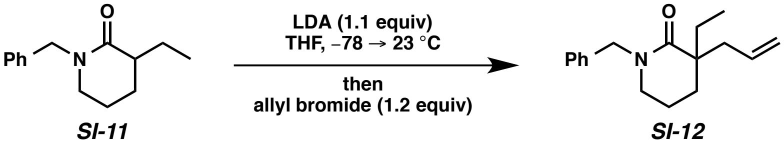


4-(Butoxycarbonyl)-4-ethyloctanoic acid (8g). A flame-dried 50 mL round-bottom flask was charged with a magnetic stir bar, THF (10 mL), and cooled to 0 °C. A solution of *n*-butyllithium in hexanes (2.5 M, 2.4 mL, 6.09 mmol, 1.1 equiv) was added, followed by dropwise addition of diisopropylamine (0.93 mL, 6.65 mmol, 1.2 equiv). The light yellow solution was stirred at 0 °C for 10 min, then cooled to –78 °C in a dry ice-acetone bath. Butyl ester **SI-10** (1.11 g, 5.54 mmol, 1.0 equiv) was added dropwise. The solution was stirred at the same temperature for 40 min, and allyl bromide (0.58 mL, 6.65 mmol, 1.2 equiv) was added dropwise. After stirring at –78 °C for 1 h, the dry ice-acetone bath was removed, and the yellow reaction mixture was warmed to 23 °C and stirred for an additional 1 h. The reaction was quenched with half saturated aqueous NH_4Cl solution (10 mL) and extracted with hexanes (30 mL x 2). The combined organic layers were washed with H_2O, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude residue was purified by flash column chromatography on silica gel (3% Et_2O in hexanes) to afford the allylated ester as a colorless oil (1.24 g, $R_f = 0.8$ (10% Et_2O in hexanes)), which was used directly in the next reaction.

A solution of 9-BBN in THF (0.5 M, 10 mL, 5.0 mmol, 1.1 equiv) was added to a 50 mL round-bottom flask containing the allylated ester (1.24 g, 4.5 mmol, 1.0 equiv) at 0 °C. After 10 min, the ice bath was removed, and the reaction mixture was stirred for another 3 h. Water (10 mL) was added to the reaction mixture, followed by careful portionwise addition of sodium perborate hydrate (1.78 g, 17.8 mmol, 4.0 equiv) to oxidize the organoborane intermediate to the corresponding alcohol. The biphasic mixture was stirred for 40 min, and extracted with EtOAc (25 mL x 3). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude residue was purified by flash column chromatography on silica gel (16→25% EtOAc in hexanes) to afford the desired primary alcohol as a colorless oil (1.14 g, $R_f = 0.4$ (25% EtOAc in hexanes)), which was used directly in the next reaction.

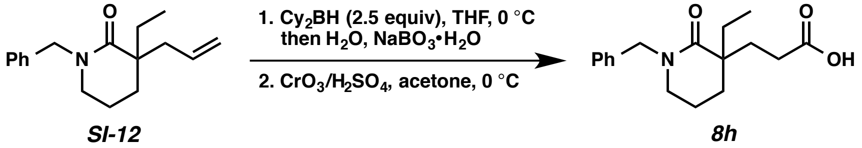
Oxidation of the primary alcohol to the corresponding carboxylic acid was carried out following a literature procedure.[5] A 100 mL round-bottom flask was charged with a magnetic stir bar, the primary alcohol (517 mg, 2.0 mmol, 1.0 equiv), TEMPO (22 mg, 0.14 mmol, 0.07 equiv), MeCN (10 mL), H_2O (2 mL), and aqueous phosphate buffer (0.33 M in NaH_2PO_4 and 0.33 M in Na_2HPO_4, 7.5 mL), and stirred at 20 °C for 5 min. Solid $NaClO_2$ (452 mg, 4.0 mmol, 2.0 equiv) was added to the flask and the reaction mixture was stirred for 2 min when the solid dissolved. A solution of NaClO (0.26 wt%, 1.1 mL, 0.04 mmol, 0.02 equiv) was added, and the reaction mixture immediately turned dark red. The flask was placed in a pre-heated 35 °C oil bath and stirred for 14 h. TLC analysis showed complete consumption of the alcohol. To the reaction mixture was added H_2O (15 mL) and 2N NaOH (4 mL) to bring the solution's pH to 10. The biphasic mixture was poured into an ice-cold solution of Na_2SO_3 (610 mg) in H_2O (10 mL), stirred for 30 min, and extracted with Et_2O (30 mL x 1). The ethereal layer was back-extracted with 0.7N NaOH (8 mL x 2). The alkaline aqueous layers were combined and acidified with 6N HCl (12 mL), and extracted with EtOAc (25 mL x 3). The combined EtOAc extracts were washed with H_2O, dried over Na_2SO_4, filtered, and concentrated under reduced pressure to a liquid/solid mixture. The mixture was dissolved in Et_2O and solid impurities were filtered off.

The filtrate was concentrated and purified by flash column chromatography on silica gel (5% MeOH in CH_2Cl_2) to afford carboxylic acid **8g** (485 mg, 71% yield over 3 steps) as a viscous colorless oil. $R_f = 0.3$ (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 10.27 (br s, 1H), 4.07 (t, *J* = 6.6 Hz, 2H), 2.29–2.19 (m, 2H), 1.95–1.85 (m, 2H), 1.64–1.55 (m, 4H), 1.55–1.49 (m, 2H), 1.43–1.33 (m, 2H), 1.33–1.23 (m, 2H), 1.20–1.05 (m, 2H), 0.93 (t, *J* = 7.4 Hz, 3H), 0.89 (t, *J* = 7.4 Hz, 3H), 0.79 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 179.9, 176.7, 64.4, 48.8, 34.0, 30.8, 29.3, 28.6, 27.2, 26.2, 23.3, 19.3, 14.1, 13.8, 8.4; IR (Neat Film, NaCl) 2961, 2875, 1716, 1458, 1207, 1133, 947 cm^{-1}; HRMS (ESI-APCI–) *m/z* calc'd for $C_{15}H_{27}O_4$ $[M–H]^-$: 271.1915, found 271.1923.



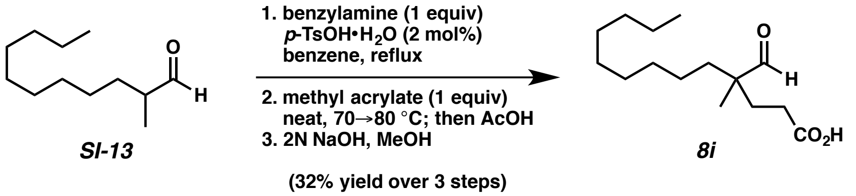
3-Allyl-1-benzyl-3-ethylpiperidin-2-one (SI-12). A flame-dried 100 mL round-bottom flask was charged with a magnetic stir bar, THF (15 mL), diisopropylamine (1.0 mL, 7.08 mmol, 1.1 equiv), and cooled to 0 °C. A solution of *n*-butyllithium in hexanes (2.5 M, 2.8 mL, 7.08 mmol, 1.1 equiv) was added dropwise. The light yellow solution was stirred at 0 °C for 10 min, then cooled to –78 °C in a dry ice-acetone bath. A solution of benzyl lactam **SI-11** (1.40 g, 6.44 mmol, 1.0 equiv) in THF (5 mL) was added dropwise. The dark greenish yellow solution was stirred at –78 °C for 20 min, and allyl bromide (0.67 mL, 7.73 mmol, 1.2 equiv) was added dropwise. The color of the reaction mixture immediately turned into light yellow. The dry ice-acetone bath was removed, and the yellow reaction mixture was warmed to 23 °C and stirred for an additional 1 h. The reaction was quenched with half saturated aqueous NH_4Cl solution (20 mL) and extracted with EtOAc (25 mL x 3). The combined organic layers were washed with

H_2O, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude residue was purified by flash column chromatography on silica gel (hexanes:EtOAc:CH_2Cl_2 = 30:3:2) to afford allyl lactam **SI-12** (1.41 g, 85% yield) as a colorless oil. R_f = 0.5 (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.37–7.31 (m, 2H), 7.31–7.24 (m, 3H), 5.88–5.76 (m, 1H), 5.15–5.07 (m, 2H), 4.68–4.56 (m, 2H), 3.24–3.16 (m, 2H), 2.59 (ddt, *J* = 13.5, 6.7, 1.4 Hz, 1H), 2.25 (ddt, *J* = 13.5, 8.1, 1.1 Hz, 1H), 1.87 (dq, *J* = 13.5, 7.5 Hz, 1H), 1.82–1.70 (m, 4H), 1.57 (dq, *J* = 13.5, 7.4 Hz, 1H), 0.93 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.5, 137.8, 135.0, 128.6, 128.2, 127.3, 117.9, 50.6, 47.8, 45.4, 43.4, 31.6, 28.9, 19.8, 8.9; IR (Neat Film, NaCl) 2938, 2876, 1635, 1490, 1453, 1352, 1196, 913, 737, 701 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{17}H_{24}NO$ [M+H]$^+$: 258.1852, found 258.1862.

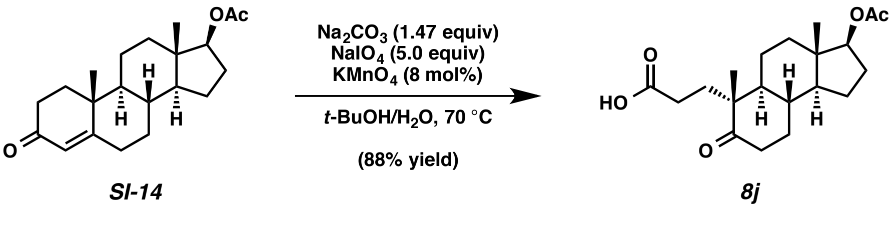


3-(1-Benzyl-3-ethyl-2-oxopiperidin-3-yl)propanoic acid (8h). A flame-dried 50 mL round-bottom flask was charged with a magnetic stir bar, $BH_3 \cdot SMe_2$ (3.8 mL, 2.0 M in THF, 7.5 mmol, 2.5 equiv), and THF (4.0 mL). The solution was cooled to 0 °C in an ice bath, and cyclohexene (1.52 mL, 15.0 mmol, 5.0 equiv) was added. After stirring at 0 °C for 1 h, a solution of allyl lactam **SI-12** (772 mg, 3.0 mmol, 1.0 equiv) in THF (1.0 mL) was added. The vial containing **SI-12** was washed with THF (1.2 mL x 3) and the washings were also added. The ice bath was removed, and the white slurry was stirred at 20 °C for 17 h. TLC analysis then indicated complete consumption of starting material. The reaction was quenched by careful addition of H_2O (10 mL) and $NaBO_3 \cdot H_2O$ (2.25 g). The aqueous phase was extracted with EtOAc (25 mL x 3). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (hexanes:EtOAc:MeOH 20:10:1 → 15:10:1) to afford the desired primary alcohol (591 mg, R_f = 0.2 (hexanes:EtOAc:MeOH = 10:10:1)) as a colorless oil, which was used directly in the next reaction.

The primary alcohol (591 mg, 2.15 mmol, 1.0 equiv) was dissolved in acetone (20 mL) and cooled to 0 °C. Jones' reagent (1.2 mL, 3.1 M in CrO_3, 1.7 equiv) was added dropwise until the reaction mixture became persistently orange. Excess Jones' reagent was quenched with *i*PrOH (5 mL), and green solids precipitated out of the solution. The solids were filtered and washed with additional acetone (10 mL x 2). The filtrate was concentrated and partitioned between EtOAc and H_2O to remove residual chromium salts. The aqueous layer was extracted with EtOAc (20 mL x 3). The organic extracts were combined, concentrated, redissolved in Et_2O (20 mL), and extracted with aqueous 2N NaOH (20 mL x 1). The organic layer was washed with H_2O (10 mL x 1). The combined aqueous layers were acidified with 6N HCl to pH 1 and extracted with CH_2Cl_2 (10 mL x 3). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. The residue was purified by flash column chromatography on silica gel (hexanes:EtOAc:MeOH 100:50:7.5 → 60:30:6) to afford carboxylic acid **8h** (425 mg, 49% yield over 2 steps) as a viscous colorless oil that slowly solidified during storage in a freezer. R_f = 0.3 (67% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.38–7.33 (m, 2H), 7.33–7.24 (m, 3H), 4.72 (d, *J* = 14.5 Hz, 1H), 4.52 (d, *J* = 14.5 Hz, 1H), 3.24 (td, *J* = 5.5, 1.8 Hz, 2H), 2.54 (ddd, *J* = 16.2, 10.4, 5.8 Hz, 1H), 2.42 (ddd, *J* = 16.0, 10.3, 5.5 Hz, 1H), 2.07 (ddd, *J* = 13.9, 10.4, 5.5 Hz, 1H), 1.97–1.77 (m, 5H), 1.74–1.58 (m, 2H), 0.94 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 178.2, 174.6, 137.5, 128.8, 128.2, 127.5, 50.8, 47.8, 44.7, 32.8, 31.0, 30.0, 29.6, 19.5, 8.6; IR (Neat Film, NaCl) 2943, 1732, 1599, 1495, 1454, 1354, 1261, 1196, 910, 735, 701 cm^{-1}; HRMS (ESI-APCI+) *m/z* calc'd for $C_{17}H_{24}NO_3$ $[M+H]^+$: 290.1751, found 290.1754.



4-Formyl-4-methyltridecanoic acid (8i). Using 2-methylundecanal (**SI-13**) as staring material, the procedure for the synthesis of **8b** was followed (Note: the conjugate addition reaction was allowed to proceed for 20 h at 70 °C and then 28 h at 80 °C) to provide carboxylic acid **8i** (481 mg, 32% yield over 3 steps) as a colorless oil. R_f = 0.2 (25% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 11.35 (br s, 1H), 9.41 (s, 1H), 2.34–2.19 (m, 2H), 1.93–1.83 (m, 1H), 1.82–1.72 (m, 1H), 1.53–1.37 (m, 2H), 1.33–1.09 (m, 14H), 1.02 (s, 3H), 0.86 (t, *J* = 6.5 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 205.9, 179.7, 48.5, 35.6, 32.0, 30.3, 29.6, 29.5, 29.4, 29.4, 29.1, 23.9, 22.8, 18.2, 14.2; IR (Neat Film, NaCl) 2924, 2853, 1711, 1458, 1300, 1225, 913 cm^{-1}; HRMS (ESI-APCI–) *m/z* calc'd for $C_{15}H_{27}O_3$ $[M-H]^-$: 255.1966, found 255.1976.

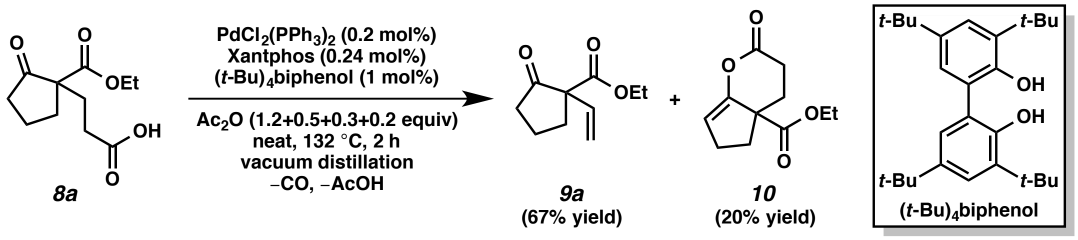


3-((3*S*,3a*S*,5a*S*,6*R*,9a*S*,9b*S*)-3-Acetoxy-3a,6-dimethyl-7-oxododecahydro-1*H*-cyclopenta[*a*]naphthalen-6-yl)propanoic acid (8j). Carboxylic acid **8j** was prepared based on a literature procedure.[6] A 250 mL round-bottom flask was charged with a magnetic stir bar, testosterone acetate **SI-14** (661 mg, 2.0 mmol, 1.0 equiv), Na_2CO_3 (312 mg, 2.94 mmol, 1.47

equiv), *t*-BuOH (21 mL) and H_2O (1 mL). The flask was placed in a pre-heated 70 °C oil bath, and a hot solution of $NaIO_4$ (2.14 g, 10.0 mmol, 5.0 equiv) and $KMnO_4$ (25 mg, 0.16 mmol, 0.08 equiv) in H_2O (21 mL) was added. The reaction mixture was stirred at 70 °C for 20 min when TLC analysis indicated complete consumption of starting material. The flask was cooled to ambient temperature, and 1N HCl (100 mL) was added. After stirring 2 min, the reaction mixture was extracted with EtOAc (30 mL x 3). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (50% EtOAc in hexanes) to afford carboxylic acid **8j** (664 mg, 88% yield) as a solid/liquid mixture, which was recrystallized from hexanes:EtOAc 2:1 to give a white solid. m.p. 135–136 °C; R_f = 0.4 (50% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 4.58 (t, *J* = 8.5 Hz, 1H), 2.63–2.44 (m, 1H), 2.40–2.14 (m, 4H), 2.14–2.06 (m, 1H), 2.04 (s, 3H), 1.99–1.89 (m, 1H), 1.85–1.30 (m, 8H), 1.29–1.14 (m, 3H), 1.12 (s, 3H), 1.10–1.02 (m, 1H), 0.84 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 214.6, 179.6, 171.3, 82.5, 50.5, 50.2, 48.0, 42.7, 38.0, 36.4, 34.8, 30.9, 29.3, 29.2, 27.5, 23.7, 21.3, 21.1, 20.5, 12.2; IR (Neat Film, NaCl) 2941, 1732, 1705, 1448, 1375, 1248, 1043, 952, 735 cm^{-1}; HRMS (ESI-APCI–) *m/z* calc'd for $C_{20}H_{29}O_5$ [M–H]$^-$: 349.2020, found 349.2037; $[\alpha]_D^{25}$ +26.1 (*c* 0.50, $CHCl_3$).

Palladium-Catalyzed Decarbonylative Dehydration of Carboxylic Acids

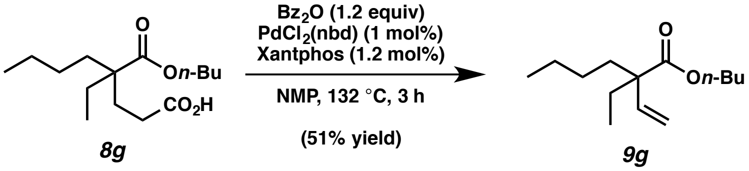
General Procedure A: Large Scale Distillation Process



Ethyl 2-oxo-1-vinylcyclopentane-1-carboxylate (9a). A flame-dried 15 mL round-bottom flask was charged with a magnetic stir bar, $PdCl_2(PPh_3)_2$ (7.0 mg, 0.01 mmol, 0.002 equiv), Xantphos (6.9 mg, 0.012 mmol, 0.0024 equiv), (*t*-Bu)$_4$biphenol[7] (20.5 mg, 0.05 mmol, 0.01 equiv), and carboxylic acid **8a** (1.14 g, 5.0 mmol, 1.0 equiv). The flask was equipped with a distillation head and a 25 mL round-bottom receiving flask. The closed system was connected to a vacuum manifold and equipped with a needle valve. The system was evacuated and backfilled with N_2 (x 3), and the first portion of acetic anhydride (6.0 mmol, 1.2 equiv) was added via syringe through the septum that seals the top of the distillation head. The flask was lowered into a pre-heated 60 °C oil bath and gradually heated to 132 °C in 18 min. When the oil bath temperature reached 122 °C, the needle valve was closed, switched to vacuum, and the needle valve carefully and slowly opened to allow distillation of acetic acid into a receiving flask, which was cooled to −78 °C. When the oil bath temperature reached 130 °C, time was recorded as t = 0. After distillation ceased (about t = 3 min), the needle valve was opened fully and a vacuum of 1–5 mmHg was drawn. At t = 30 min, the system was backfilled with N_2, and the second portion of acetic anhydride (2.5 mmol, 0.5 equiv) was added via syringe. The system was then gradually (t = 35 min) resubjected to a vacuum of 1–5 mmHg. Acetic anhydride was added as follows (0.3, 0.2 equiv) in the same manner every 30 min. The reaction was stopped at t = 2 h and allowed to cool under N_2 to ambient temperature. The distillate was added to a saturated aqueous solution of $NaHCO_3$, stirred for 20 min, and the biphasic mixture was extracted with CH_2Cl_2 (20 mL x 3). The combined extracts were dried over Na_2SO_4 and filtered into a 250 round-bottom flask. To this filtrate were added the residual dark red reaction mixture and the washings of the distillation head's inside (with ~5 mL CH_2Cl_2). The solvents were evaporated and the residue was purified by flash column chromatography on silica gel (5→8% EtOAc in hexanes for **9a** and then 16% EtOAc in hexanes for **10**) to afford vinyl ketone **9a** (613 mg, 67% yield) as a colorless, fragrant oil. R_f = 0.5 (16% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 6.04 (dd, *J* = 17.6, 10.7 Hz, 1H), 5.28 (d, *J* = 10.7 Hz, 1H), 5.19 (d, *J* = 17.6 Hz, 1H), 4.18 (q, *J* = 7.2 Hz, 2H), 2.63–2.55 (m, 1H), 2.45–2.27 (m, 2H), 2.23–2.15 (m, 1H), 2.07–1.87 (m, 2H), 1.25 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 212.5, 170.4, 134.5, 117.0, 63.5, 61.9, 37.7, 32.9, 19.6, 14.2; IR (Neat Film, NaCl) 2980, 1753, 1729, 1635, 1456, 1406, 1255, 1142, 1034, 927 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{10}H_{14}O_3$ $[M]^+$: 182.0943, found 182.0939.

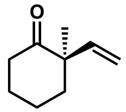
Ethyl 2-oxo-3,4,5,6-tetrahydrocyclopenta[*b*]pyran-4a(2*H*)-carboxylate (10). The above reaction also furnished enol lactone **10** (206 mg, 20% yield) as a colorless oil. R_f = 0.2 (16% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 5.30 (app. s, 1H), 4.20 (q, *J* = 7.1 Hz, 2H), 2.76–2.62 (m, 2H), 2.55–2.42 (m, 3H), 2.35–2.26 (m, 1H), 1.96–1.84 (m, 1H), 1.84–1.73 (m, 1H), 1.26 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.3, 167.4, 151.6, 108.0, 61.8, 50.8, 35.9, 29.5, 28.1, 26.7, 14.2; IR (Neat Film, NaCl) 2940, 2862, 1768, 1726, 1668, 1456, 1248, 1159, 1124, 1020, 891, 805 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{11}H_{14}O_4$ $[M]^+$: 210.0892, found 210.0910.

General Procedure B: Small Scale Nondistillation Process



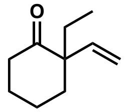
Butyl 2-ethyl-2-vinylhexanoate (9g). A flame-dried 20 x 150 mm Kimax culture tube was charged with a magnetic stir bar, $PdCl_2$(nbd) (1.3 mg, 0.005 mmol, 0.01 equiv), Xantphos (3.5 mg, 0.006 mmol, 0.012 equiv), carboxylic acid **8g** (136 mg, 0.5 mmol, 1.0 equiv), and benzoic anhydride (136 mg, 0.6 mmol, 1.2 equiv). The tube was sealed with a rubber septum, and the system was evacuated and backfilled with N_2 (x 3). NMP (0.25 mL) was added via syringe. The reaction mixture was stirred at 20 °C for 2 min, then placed in a pre-heated 132 °C oil bath and stirred for 3 h. After cooling to ambient temperature, Et_3N (0.3 mL) was added, and the mixture was purified by flash column chromatography on silica gel (2% Et_2O in hexanes) to afford vinyl ester **9g** (58 mg, 51% yield) as a colorless oil. $R_f = 0.5$ (10% Et_2O in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.98 (dd, J = 17.8, 10.9 Hz, 1H), 5.17 (d, J = 11.0 Hz, 1H), 5.07 (d, J = 17.8 Hz, 1H), 4.08 (t, J = 6.6 Hz, 2H), 1.77–1.69 (m, 2H), 1.69–1.63 (m, 2H), 1.63–1.55 (m, 2H), 1.45–1.23 (m, 4H), 1.23–1.08 (m, 2H), 0.93 (t, J = 7.4 Hz, 3H), 0.88 (t, J = 7.4 Hz, 3H), 0.80 (t, J = 7.4 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 175.7, 140.3, 114.3, 64.5, 52.9, 35.7, 30.9, 29.0, 26.7, 23.4, 19.4, 14.1, 13.8, 8.9; IR (Neat Film, NaCl) 2960, 2874, 1731, 1459, 1380, 1240, 1206, 1136, 1001, 915 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{14}H_{26}O_2$ $[M]^+$: 226.1933, found 226.1933.

Spectroscopic Data for Pd-Catalyzed Decarbonylative Dehydration Products



ent-7

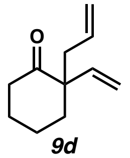
(*R*)-2-Methyl-2-vinylcyclohexan-1-one (*ent*-7). Ketone *ent*-**7** was prepared according to General Procedure A and isolated by silica gel chromatography (3% Et_2O in hexanes) as a colorless, fragrant oil. 60% yield. $R_f = 0.6$ (20% Et_2O in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 5.97 (dd, *J* = 17.8, 10.8 Hz, 1H), 5.13 (d, *J* = 10.8 Hz, 1H), 4.98 (d, *J* = 17.7 Hz, 1H), 2.56–2.45 (m, 1H), 2.37–2.28 (m, 1H), 2.01–1.90 (m, 2H), 1.84–1.65 (m, 3H), 1.65–1.56 (m, 1H), 1.15 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 213.6, 142.7, 114.9, 52.2, 39.9, 39.3, 27.8, 24.0, 21.8; IR (Neat Film, NaCl) 2932, 2864, 1709, 1635, 1450, 1371, 1313, 1123, 1093, 986, 918 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_9H_{14}O$ $[M]^+$: 138.1045, found 138.1026; $[\alpha]_D^{25}$ +113.2 (*c* 1.03, $CHCl_3$, 92% ee).



9c

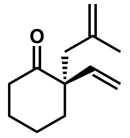
2-Ethyl-2-vinylcyclohexan-1-one (9c). Ketone **9c** was prepared according to General Procedure A and isolated by silica gel chromatography (2% Et_2O in hexanes) as a colorless, fragrant oil. 66% yield. $R_f = 0.4$ (10% Et_2O in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 5.90 (dd, *J* = 17.8, 10.9 Hz, 1H), 5.19 (d, *J* = 10.9 Hz, 1H), 4.96 (d, *J* = 17.7 Hz, 1H), 2.52–2.41 (m, 1H), 2.36–2.27 (m, 1H), 1.98–1.83 (m, 2H), 1.80–1.53 (m, 6H), 0.79 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 213.3, 141.5, 115.5, 55.5, 39.6, 35.6, 29.8, 27.4, 21.6, 8.2; IR (Neat

Film, NaCl) 2938, 2863, 1707, 1448, 1313, 1230, 1124, 993, 918 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{10}H_{16}O$ $[M]^+$: 152.1201, found 152.1176.



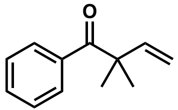
9d

2-Allyl-2-vinylcyclohexan-1-one (9d). Ketone **9d** was prepared according to General Procedure A and isolated by silica gel chromatography (3% Et_2O in hexanes) as a colorless, fragrant oil. 54% yield. R_f = 0.4 (10% Et_2O in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.86 (dd, *J* = 17.7, 10.8 Hz, 1H), 5.68 (ddt, *J* = 18.0, 11.1, 7.3 Hz, 1H), 5.22 (d, *J* = 10.8 Hz, 1H), 5.05–4.95 (m, 3H), 2.54–2.45 (m, 1H), 2.42–2.27 (m, 3H), 1.99–1.88 (m, 2H), 1.81–1.60 (m, 4H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 212.7, 141.4, 134.3, 117.9, 116.2, 54.9, 42.0, 39.6, 36.0, 27.3, 21.6; IR (Neat Film, NaCl) 3077, 2936, 2864, 1708, 1636, 1448, 1314, 1222, 1124, 998, 916 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{11}H_{16}O$ $[M]^+$: 164.1201, found 164.1173.



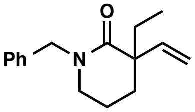
9e

(*S*)-2-(2-Methylallyl)-2-vinylcyclohexan-1-one (9e). Ketone **9e** was prepared according to General Procedure A and isolated by silica gel chromatography (2→3% Et_2O in hexanes) as a colorless, fragrant oil. 69% yield. R_f = 0.4 (10% Et_2O in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.94 (dd, *J* = 18.1, 11.1 Hz, 1H), 5.19 (d, *J* = 10.8 Hz, 1H), 4.98 (d, *J* = 17.8 Hz, 1H), 4.80 (s, 1H), 4.65 (s, 1H), 2.55–2.43 (m, 2H), 2.43–2.32 (m, 2H), 2.01–1.87 (m, 2H), 1.79–1.66 (m, 4H), 1.65 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 212.3, 142.5, 142.4, 115.8, 115.0, 54.8, 45.5, 39.5, 36.0, 27.1, 25.0, 21.7; IR (Neat Film, NaCl) 3075, 2938, 2863, 1707, 1641, 1448, 1125, 919, 892 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{12}H_{18}O$ $[M]^+$: 178.1358, found 178.1350; $[\alpha]_D^{25}$ +129.5 (*c* 1.00, $CHCl_3$, 92% ee).



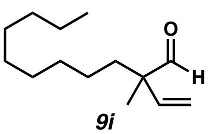
9f

2,2-Dimethyl-1-phenylbut-3-en-1-one (9f). Ketone **9f** was prepared according to General Procedure A and isolated by silica gel chromatography (2.5% Et_2O in hexanes) as a colorless oil. 75% yield. R_f = 0.4 (10% Et_2O in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 7.89–7.85 (m, 2H), 7.49–7.43 (m, 1H), 7.40–7.35 (m, 2H), 6.19 (dd, *J* = 17.6, 10.6 Hz, 1H), 5.26–5.18 (m, 2H), 1.40 (s, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 204.8, 144.0, 137.2, 131.8, 129.4, 128.1, 114.2, 50.3, 26.2; IR (Neat Film, NaCl) 3084, 2975, 2933, 1679, 1634, 1446, 1258, 971, 918, 719, 694 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{12}H_{14}O$ $[M]^+$: 174.1045, found 174.1069.



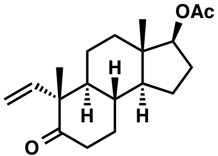
9h

1-Benzyl-3-ethyl-3-vinylpiperidin-2-one (9h). Lactam **9h** was prepared according to General Procedure B and isolated by silica gel chromatography (9% EtOAc in hexanes) as a colorless oil. 57% yield. R_f = 0.4 (25% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 7.36–7.31 (m, 2H), 7.31–7.24 (m, 3H), 5.96 (dd, *J* = 17.6, 10.8 Hz, 1H), 5.19 (dd, *J* = 10.8, 1.0 Hz, 1H), 5.11 (dd, *J* = 17.6, 1.0 Hz, 1H), 4.68–4.57 (m, 2H), 3.29–3.16 (m, 2H), 1.98–1.80 (m, 4H), 1.80–1.66 (m, 2H), 0.90 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.0, 142.6, 137.7, 128.6, 128.1, 127.3, 114.1, 50.6, 49.4, 47.8, 31.8, 28.8, 19.3, 8.6; IR (Neat Film, NaCl) 2938, 2876, 1634, 1494, 1453, 1353, 1261, 1196, 915, 742, 700 cm^{-1}; HRMS (MM: ESI-APCI+) *m/z* calc'd for $C_{16}H_{22}NO$ $[M+H]^+$: 244.1696, found 244.1702.



9i

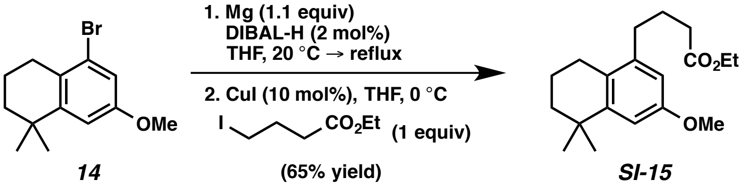
2-Methyl-2-vinylundecanal (9i). Aldehyde **9i** was prepared according to General Procedure B and isolated by silica gel chromatography (2% Et_2O in hexanes) as a colorless, fragrant oil. 77% yield. R_f = 0.5 (10% Et_2O in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 9.38 (s, 1H), 5.79 (dd, *J* = 17.6, 10.8 Hz, 1H), 5.25 (d, *J* = 10.8 Hz, 1H), 5.11 (d, *J* = 17.5 Hz, 1H), 1.57 (td, *J* = 9.6, 5.9 Hz, 2H), 1.25 (br s, 14H), 1.15 (s, 3H), 0.87 (t, *J* = 6.7 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 203.2, 139.1, 116.6, 52.9, 35.7, 32.0, 30.3, 29.7, 29.6, 29.4, 24.0, 22.8, 17.8, 14.3; IR (Neat Film, NaCl) 2927, 2854, 1732, 1463, 998, 920 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{14}H_{26}O$ $[M]^+$: 210.1984, found 210.2009.



9j

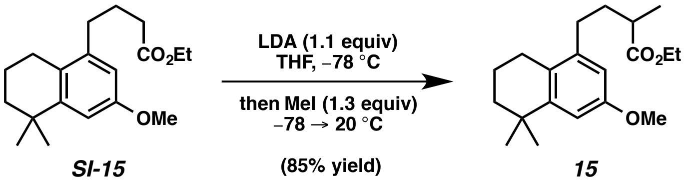
(3*S*,3a*S*,5a*S*,6*R*,9a*S*,9b*S*)-3a,6-dimethyl-7-oxo-6-vinyldodecahydro-1*H*-cyclopenta[*a*]naphthalen-3-yl acetate (9j). Ketone **9j** was prepared according to General Procedure B and isolated by silica gel chromatography (10→14% EtOAc in hexanes) as a white solid. 41% yield. m.p. 138–139 °C; R_f = 0.3 (16% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 5.78 (dd, *J* = 17.6, 10.9 Hz, 1H), 5.24 (d, *J* = 10.9 Hz, 1H), 5.02 (d, *J* = 17.6 Hz, 1H), 4.59 (t, *J* = 8.5 Hz, 1H), 2.61 (td, *J* = 14.3, 6.3 Hz, 1H), 2.37–2.30 (m, 1H), 2.24–2.14 (m, 1H), 2.03 (s, 3H), 2.02–1.95 (m, 1H), 1.83–1.62 (m, 3H), 1.58–1.47 (m, 1H), 1.45–1.33 (m, 3H), 1.32–1.25 (m, 2H), 1.24 (s, 3H), 1.18–1.05 (m, 2H), 0.85 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 214.3, 171.2, 141.7, 114.7, 82.4, 54.6, 51.0, 50.4, 43.0, 38.0, 36.4, 34.8, 31.2, 27.6, 23.6, 21.9, 21.3, 15.2, 12.3; IR (Neat Film, NaCl) 2946, 2845, 1735, 1696, 1373, 1250, 1041, 922 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{19}H_{28}O_3$ [M]$^+$: 304.2039, found 304.2044; $[\alpha]_D^{25}$ +9.0 (*c* 0.50, $CHCl_3$).

Total Synthesis of (–)-Aspewentin A, B, C, and Related Compounds



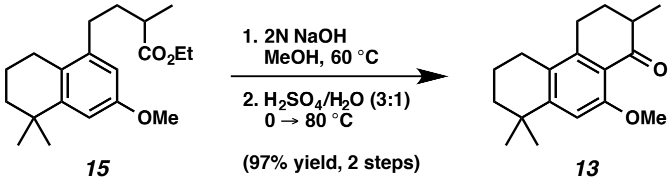
Ester SI-15. A 100 mL 2-necked round-bottom flask was charged with a magnetic stir bar and magnesium turnings (560 mg, 23.0 mmol, 1.1 equiv). The flask was equipped with a reflux condenser, flame-dried under vacuum, and allowed to cool to ambient temperature under N_2. THF (3 mL) was added, followed by a small portion (2 mL) of a solution of bromoarene **14**[8] (5.63 g, 20.9 mmol, 1.0 equiv) in THF (8.5 mL). DIBAL-H (0.4 mL, 1.0 M in hexanes, 0.4 mmol, 0.02 equiv) was added, and the reaction mixture was gently heated to reflux using a heat gun. Grignard reagent formation initiated as the reaction mixture turned dark with a strong exotherm. The remainder of the bromoarene solution in THF (ca. 6.5 mL) was added dropwise to maintain a gentle reflux. After addition was finished, the reaction mixture was further refluxed for 1 h, and allowed to cool to ambient temperature under N_2. The dark gray solution of Grignard reagent was taken up in a syringe and added dropwise to a separate 100 mL round-bottom flask containing a stirred suspension of CuI (400 mg, 2.09 mmol, 0.1 equiv) and ethyl 4-iodobutyrate (5.06 g, 20.9 mmol, 1.0 equiv) in THF (20 mL) at 0 °C. After 15 min, the reaction mixture was warmed to 20 °C and quenched with aqueous NH_4Cl and $NaHSO_4$ solution. The layers were separated, and the aqueous layer was extracted with EtOAc (30 mL x 3). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Flash column chromatography on silica gel (3→4→10% EtOAc in hexanes) furnished ester **SI-15** (4.16 g, 65% yield) as a colorless oil. $R_f = 0.5$ (10% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 6.78 (s, 1H), 6.56 (s, 1H), 4.15 (q, $J = 7.2$ Hz, 2H), 3.79 (s, 3H), 2.62 (t, $J =$

6.4 Hz, 2H), 2.60–2.55 (m, 2H), 2.39 (t, *J* = 7.4 Hz, 2H), 1.95–1.85 (m, 2H), 1.84–1.76 (m, 2H), 1.66–1.60 (m, 2H), 1.30–1.25 (m, 9H); ^{13}C NMR (126 MHz, CDCl$_3$) δ 173.7, 157.3, 147.6, 140.7, 126.6, 112.1, 110.2, 60.4, 55.3, 39.0, 34.5, 34.3, 32.9, 32.2, 26.6, 25.3, 19.8, 14.4; IR (Neat Film, NaCl) 2930, 1734, 1603, 1465, 1304, 1254, 1188, 1116, 1065, 847 cm^{-1}; HRMS (MM: ESI-APCI+) *m/z* calc'd for $C_{19}H_{29}O_3$ [M+H]$^+$: 305.2111, found 305.2105.



Ester 15. To a stirred solution of *n*-BuLi (3.2 mL, 2.5 M in hexanes, 8.10 mmol, 1.1 equiv) in THF (12 mL) was added *i*-Pr$_2$NH (1.2 mL, 8.83 mmol, 1.2 equiv) dropwise at 0 °C. The light yellow solution was stirred for 5 min, then cooled to –78 °C in a dry ice-acetone bath. A solution of ester **SI-15** (2.24 g, 7.36 mmol, 1.0 equiv) in THF (6 mL) was added dropwise, followed by washings of the syringe (THF, 1 mL x 2). The reaction mixture was stirred at –78 °C for 15 min, and iodomethane (0.60 mL, 9.57 mmol, 1.3 equiv) was added dropwise. After stirring at –78 °C for another 45 min, the reaction mixture was allowed to warm to 20 °C, and quenched with aqueous 1N HCl (ca. 30 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (30 mL x 3). The combined organic layers were dried over Na$_2$SO$_4$, filtered, and concentrated under reduced pressure. Flash column chromatography on silica gel (2.5→3% EtOAc in hexanes) furnished ester **15** (1.99 g, 85% yield) as a colorless oil. R_f = 0.6 (10% EtOAc in hexanes); ^{1}H NMR (500 MHz, CDCl$_3$) δ 6.77 (s, 1H), 6.56 (s, 1H), 4.16 (q, *J* = 7.1 Hz, 2H), 3.79 (s, 3H), 2.61 (t, *J* = 6.5 Hz, 2H), 2.58–2.48 (m, 3H), 1.98–1.88 (m, 1H), 1.84–1.75 (m, 2H), 1.71–1.58 (m, 3H), 1.30–1.26 (m, 9H), 1.22 (d, *J* = 7.0 Hz, 3H); ^{13}C NMR (126

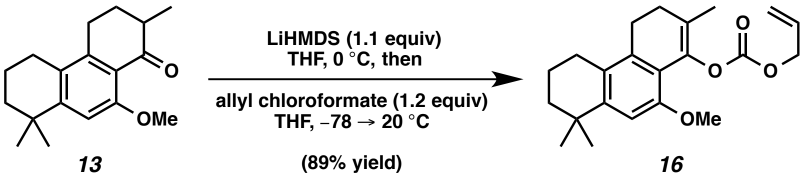
MHz, $CDCl_3$) δ 176.7, 157.4, 147.6, 141.0, 126.5, 112.0, 110.2, 60.4, 55.3, 39.8, 39.0, 34.6, 34.3, 32.2, 32.2, 31.3, 26.6, 19.8, 17.4, 14.5; IR (Neat Film, NaCl) 2935, 1732, 1605, 1467, 1304, 1255, 1156, 1126, 1053, 864 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{20}H_{30}O_3$ $[M]^+$: 318.2195, found 318.2202.



Ketone 13. To a 50 mL round-bottom flask containing ester **15** (1.96 g, 6.16 mmol, 1.0 equiv) was added a magnetic stir bar, MeOH (9 mL), and aqueous 2N NaOH (4.6 mL, 9.24 mmol, 1.5 equiv). The reaction mixture was stirred at 60 °C for 4 h and cooled to ambient temperature. Most of the MeOH was evaporated under reduced pressure, and the alkaline solution was acidified with 1N NCl (15 mL) and extracted with CH_2Cl_2 (20 mL x 3). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure to the crude carboxylic acid as a colorless oil, which was used immediately for the next reaction.

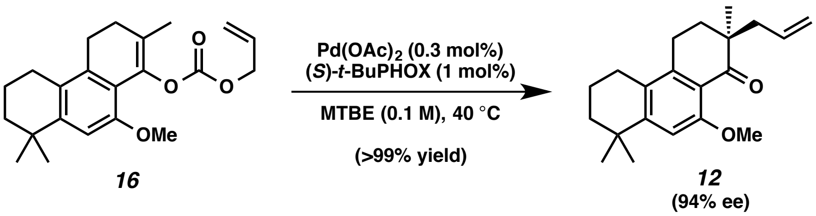
The crude carboxylic acid was added dropwise to a mixture of conc. H_2SO_4 and H_2O (28 mL total, 3:1 v/v) at 0 °C via pipette. Washings of the pipette (Et_2O, 2 mL x 3) were also added. The cooling bath was removed, and the reaction mixture was stirred for 15 min, and then placed in a pre-heated 80 °C oil bath. After 20 min, the reaction mixture was allowed to cool to ambient temperature, diluted with ice water (ca. 90 mL), and extracted with EtOAc (30 mL x 3). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Flash column chromatography on silica gel (2.5→3% Et_2O in CH_2Cl_2) furnished ketone **13** (1.64 g, 97% yield over 2 steps) as a white solid. m.p. 85–86 °C; $R_f = 0.7$ (10% Et_2O

in CH_2Cl_2); ^1H NMR (500 MHz, $CDCl_3$) δ 6.83 (s, 1H), 3.87 (s, 3H), 2.85 (dt, J = 17.6, 4.0 Hz, 1H), 2.72 (ddd, J = 17.0, 11.0, 5.2 Hz, 1H), 2.60–2.47 (m, 3H), 2.20–2.10 (m, 1H), 1.91–1.71 (m, 3H), 1.69–1.57 (m, 2H), 1.30 (s, 6H), 1.19 (d, J = 6.7 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 200.7, 158.0, 152.2, 144.3, 126.3, 120.9, 108.4, 56.1, 56.1, 43.1, 38.4, 31.7, 31.7, 30.7, 27.1, 26.8, 19.4, 15.5; IR (Neat Film, NaCl) 2928, 1685, 1591, 1559, 1457, 1317, 1246, 1102, 1012 cm^{-1}; HRMS (MM: ESI-APCI+) *m/z* calc'd for $C_{18}H_{25}O_2$ $[M+H]^+$: 273.1849, found 273.1855.

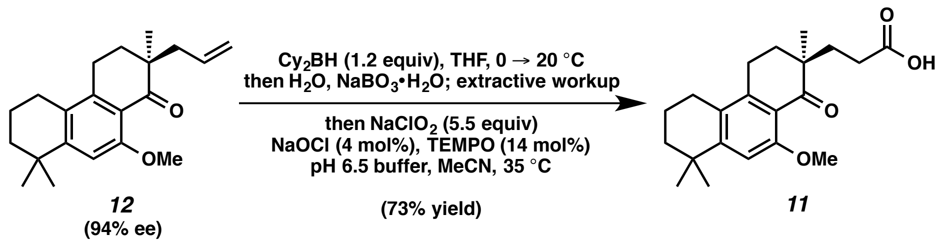


Allyl enol carbonate 16. To a stirred solution of LiHMDS (1.11 g, 6.61 mmol, 1.1 equiv) in THF (10 mL) at 0 °C was added a solution of ketone **13** (1.64 g, 6.01 mmol, 1.0 equiv) in THF (5 mL) via syringe. Washings of the syringe (THF, 1.5 mL x 2) were also added. The deep red solution was stirred at 0 °C for 1 h. In a separate, flame-dried 200 mL round-bottom flask, THF (34 mL) and allyl chloroformate (0.77 mL, 7.21 mmol, 1.2 equiv) were added, and the solution was cooled to –78 °C in a dry ice-acetone bath. To this cooled solution was added the deep red enolate solution dropwise via cannula (ca. 15 min addition time). The reaction mixture was stirred at –78 °C for another 15 min, and the cold bath was removed. After warming to room temperature, the reaction was quenched with half saturated NH_4Cl solution (ca. 50 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (30 mL x 3). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Flash column chromatography on silica gel (3→5% EtOAc in hexanes) furnished allyl enol carbonate **16** (1.91 g, 89% yield) as a white solid. R_f = 0.6 (16% EtOAc in hexanes); ^1H

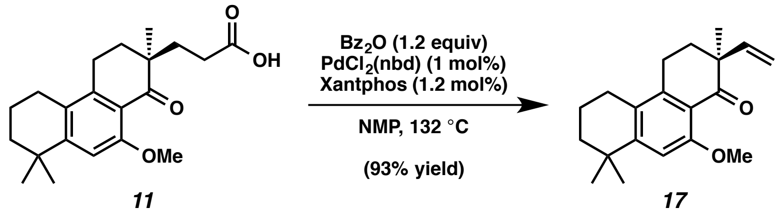
NMR (500 MHz, $CDCl_3$) δ 6.74 (s, 1H), 6.06–5.96 (m, 1H), 5.41 (d, *J* = 17.1 Hz, 1H), 5.29 (d, *J* = 10.4 Hz, 1H), 4.70 (d, *J* = 5.8 Hz, 2H), 3.75 (s, 3H), 2.67 (t, *J* = 8.0 Hz, 2H), 2.56 (t, *J* = 6.5 Hz, 2H), 2.27 (t, *J* = 8.0 Hz, 2H), 1.85 (s, 3H), 1.83–1.76 (m, 2H), 1.64–1.58 (m, 2H), 1.27 (s, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 153.4, 152.8, 146.3, 140.3, 136.1, 132.0, 126.0, 123.5, 118.8, 117.2, 109.1, 68.7, 56.4, 38.7, 34.4, 31.9, 28.7, 27.5, 24.2, 19.7, 16.4; IR (Neat Film, NaCl) 2929, 1762, 1670, 1592, 1465, 1363, 1247, 1107, 1046 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{22}H_{28}O_4$ $[M]^+$: 356.1988, found 356.1979.



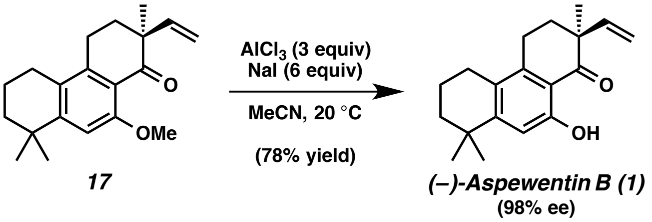
α-Allyl ketone 12. In a nitrogen-filled glove box, a 100 mL Schlenk flask was charged with $Pd(OAc)_2$ (2.7 mg, 0.012 mmol, 0.003 equiv), (*S*)-*t*-BuPHOX (15.5 mg, 0.0399 mmol, 0.01 equiv), and MTBE (15 mL). The solution was stirred at ambient temperature for 30 min. Another portion of MTBE (15 mL) was added, and then allyl enol carbonate **16** (1.42 g, 3.99 mmol, 1.0 equiv) was added as a solid to the reaction mixture. Washings of the vial containing **16** (MTBE, 2.5 mL x 4) were also added. The Schlenk flask was sealed with a Kontes valve, brought out of the glove box, and placed in a pre-heated 40 °C oil bath. The reaction mixture was stirred at this temperature for 17 h, at which time TLC analysis indicated complete conversion of starting material. Evaporation of solvent and flash column chromatography on silica gel (10% EtOAc in hexanes) afforded α-allyl ketone **12** (1.24 g, >99% yield) as a viscous colorless oil. R_f = 0.4 (16% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 6.83 (s, 1H), 5.86–5.75 (m, 1H), 5.08–5.00 (m, 2H), 3.87 (s, 3H), 2.80–2.66 (m, 2H), 2.52 (t, *J* = 6.5 Hz, 2H), 2.37 (dd, *J* = 13.8, 7.5 Hz, 1H), 2.28 (dd, *J* = 13.9, 7.3 Hz, 1H), 1.98 (dt, *J* = 13.2, 6.4 Hz, 1H), 1.88–1.78 (m, 3H), 1.69–1.60 (m, 2H), 1.30 (s, 3H), 1.29 (s, 3H), 1.14 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 202.1, 158.7, 152.2, 143.7, 134.7, 126.1, 119.8, 117.9, 108.6, 56.1, 45.1, 41.4, 38.4, 34.9, 32.9, 31.7, 31.7, 27.0, 23.6, 21.9, 19.5; IR (Neat Film, NaCl) 2928, 1684, 1591, 1559, 1457, 1318, 1245, 1104, 1016, 913 cm^{-1}; HRMS (MM: ESI-APCI+) *m/z* calc'd for $C_{21}H_{29}O_2$ $[M+H]^+$: 313.2162, found 313.2158; $[\alpha]_D^{25}$ –13.1 (*c* 1.00, $CHCl_3$, 94% ee).



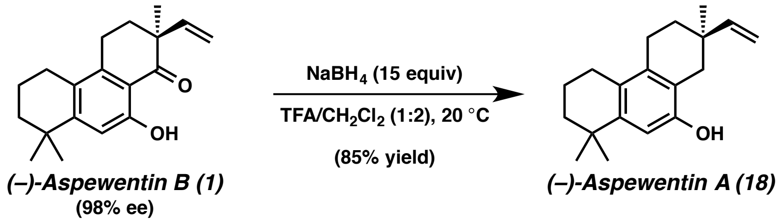
Carboxylic acid 11. A flame-dried 25 mL round-bottom flask was charged with a magnetic stir bar, $BH_3{\cdot}SMe_2$ (0.6 mL, 2.0 M in THF, 1.2 mmol, 1.2 equiv), and THF (0.5 mL). The solution was cooled to 0 °C in an ice bath, and cyclohexene (0.23 mL, 2.3 mmol, 2.3 equiv) was added. After stirring at 0 °C for 1 h, a solution of α-allyl ketone **12** (312 mg, 1.0 mmol, 1.0 equiv) in THF (0.6 mL) was added. The vial containing **12** was washed with THF (0.6 mL x 2) and the washings were also added. The white slurry soon turned into a light yellow and clear solution (ca. 5 min). The ice bath was removed, and the solution was stirred at 20 °C for 12 h. TLC analysis then indicated almost complete consumption of starting material. To the solution was added H_2O (1 mL) and $NaBO_3{\cdot}H_2O$ (350 mg). Additional H_2O (10 mL) was added to break up the white solid formed in the mixture. The aqueous phase was extracted with EtOAc (15 mL x 3). The combined organic layers were dried over Na_2SO_4, filtered, concentrated under reduced pressure, and quantitatively transferred to a 50 mL round-bottom flask. To this flask was added a magnetic stir bar, TEMPO (22 mg, 0.14 mmol, 0.14 equiv), MeCN (5 mL), H_2O (2.6 mL), and aqueous phosphate buffer (0.33 M in NaH_2PO_4 and 0.33 M in Na_2HPO_4, 4 mL), and stirred at 20 °C for 5 min. Solid $NaClO_2$ (622 mg, 5.5 equiv) was added to the flask and the reaction mixture was stirred for 2 min when the solid dissolved. A solution of NaClO (0.26 wt%, 1.2 mL, 0.04 mmol, 0.04 equiv) was added, and the reaction mixture immediately turned dark red. The flask was placed in a pre-heated 35 °C oil bath and stirred for 53 h. TLC analysis showed complete consumption of the alcohol. After cooling to 23 °C, 2N NaOH (5 mL) was added, followed by a solution of Na_2SO_3 (0.88 g) in H_2O (6 mL). The mixture was stirred vigorously for 30 min, and extracted with Et_2O (30 mL x 1). The ethereal layer was discarded. The alkaline aqueous layer was acidified with 8N HCl (ca. 3 mL), and extracted with EtOAc (30 mL x 1). The EtOAc layer was washed with 1N HCl (10 mL) and H_2O (10 mL), dried over Na_2SO_4, filtered, and concentrated under reduced pressure to afford carboxylic acid **11** (252 mg, 73% yield) as a viscous light brown oil. Recrystallization from hexanes/EtOAc gave pure **11** as white crystals. m.p. 125–127 °C; R_f = 0.4 (67% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 6.82 (s, 1H), 3.85 (s, 3H), 2.82–2.68 (m, 2H), 2.51 (t, *J* = 6.5 Hz, 2H), 2.44 (dt, *J* = 16.5, 8.1 Hz, 1H), 2.34 (dt, *J* = 16.5, 8.2 Hz, 1H), 1.98 (dt, *J* = 13.1, 6.3 Hz, 1H), 1.94–1.79 (m, 5H), 1.66–1.60 (m, 2H), 1.30 (s, 3H), 1.29 (s, 3H), 1.15 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 201.8, 179.5, 158.6, 152.5, 143.4, 126.2, 119.5, 108.6, 56.0, 44.5, 38.4, 34.9, 33.5, 31.7, 31.7, 31.6, 29.4, 27.0, 23.6, 21.9, 19.4; IR (Neat Film, NaCl) 2931, 1708, 1674, 1591, 1558, 1460, 1318, 1245, 1227, 1103, 913, 731 cm^{-1}; HRMS (MM: ESI-APCI+) *m/z* calc'd for $C_{21}H_{29}O_4$ $[M+H]^+$: 345.2060, found 345.2047; $[\alpha]_D^{25}$ –1.5 (*c* 1.00, $CHCl_3$).



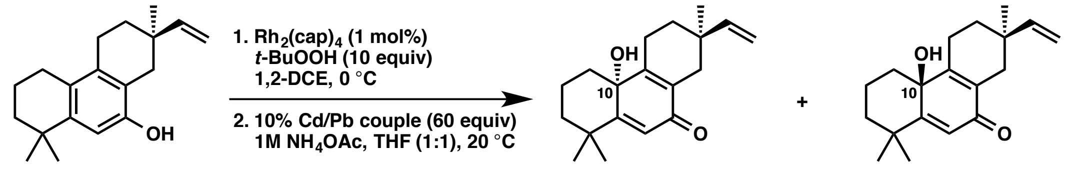
α-Vinyl ketone 17. Following General Procedure B, palladium-catalyzed decarbonylative dehydration of carboxylic acid **11** (172 mg, 0.5 mmol, 1.0 equiv) and flash column chromatography on silica gel (7→10% EtOAc in hexanes) furnished α-vinyl ketone **17** (140 mg, 93% yield) as a colorless oil. $R_f = 0.3$ (16% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.82 (s, 1H), 6.01 (dd, $J = 17.7, 10.9$ Hz, 1H), 5.08–4.98 (m, 2H), 3.86 (s, 3H), 2.81–2.68 (m, 2H), 2.58–2.43 (m, 2H), 2.08 (dt, $J = 13.8, 5.1$ Hz, 1H), 2.00–1.90 (m, 1H), 1.89–1.73 (m, 2H), 1.68–1.55 (m, 2H), 1.28 (s, 6H), 1.27 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 199.9, 158.5, 152.3, 143.7, 141.1, 126.0, 120.2, 114.4, 108.5, 56.1, 49.0, 38.4, 34.9, 34.5, 31.7, 31.6, 27.0, 24.0, 23.4, 19.4; IR (Neat Film, NaCl) 2928, 1684, 1591, 1559, 1458, 1318, 1245, 1105, 1020, 915 cm^{-1}; HRMS (MM: ESI-APCI+) *m/z* calc'd for $C_{20}H_{27}O_2$ $[M+H]^+$: 299.2006, found 299.1992; $[\alpha]_D^{25}$ –43.2 (*c* 1.00, $CHCl_3$).



(–)-Aspewentin B (1). A 50 mL round-bottom flask was charged with a magnetic stir bar, NaI (329 mg, 2.20 mmol, 6.0 equiv), $AlCl_3$ (146 mg, 1.10 mmol, 3.0 equiv), and MeCN (4 mL) in air. To this slurry was added a solution of α-vinyl ketone **17** (109 mg, 0.37 mmol, 1.0 equiv) in MeCN (6 mL). The reaction mixture immediately turned yellow-orange. After stirring for 5 min, the reaction was quenched with 1N HCl (30 mL) and extracted with CH_2Cl_2 (10 mL x 4). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Flash column chromatography on silica gel (2.5% Et_2O in hexanes) furnished (–)-aspewentin B (**1**, 82 mg, 78% yield) as a light yellow oil. $R_f = 0.7$ (16% EtOAc in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 12.40 (s, 1H), 6.84 (s, 1H), 5.98 (dd, *J* = 17.7, 10.8 Hz, 1H), 5.13 (d, *J* = 10.7 Hz, 1H), 5.03 (d, *J* = 17.6 Hz, 1H), 2.81–2.69 (m, 2H), 2.59–2.44 (m, 2H), 2.14–2.06 (m, 1H), 2.04–1.94 (m, 1H), 1.88–1.73 (m, 2H), 1.68–1.55 (m, 2H), 1.33 (s, 3H), 1.27 (s, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 207.2, 160.9, 156.1, 142.3, 140.5, 124.7, 115.1, 114.6, 113.3, 47.9, 38.3, 35.0, 34.4, 31.7, 31.6, 26.9, 23.4, 23.3, 19.4; IR (Neat Film, NaCl) 2929, 1635, 1464, 1358, 1222, 1083, 920, 809 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{19}H_{25}O_2$ $[M+H]^+$: 285.1855, found 285.1842; $[\alpha]_D^{25}$ –90.5 (*c* 0.20, MeOH, 98% ee).[9]



(–)-Aspewentin A (18). A 20 mL scintillation vial was charged with a magnetic stir bar and $NaBH_4$ (38 mg, 1.0 mmol, 10 equiv). Trifluoroacetic acid (1 mL) was added carefully with stirring. Solids soon dissolved, with a slight exotherm. A solution of (–)-aspewentin B (**1**, 29 mg, 0.10 mmol, 1.0 equiv) in CH_2Cl_2 (2 mL) was added, and the reaction mixture immediately turned yellow. After stirring 1 h, additional $NaBH_4$ (7.5 mg, 0.20 mmol, 2.0 equiv) was added. After 45 min, a third portion of $NaBH_4$ (11 mg, 0.30 mmol, 3.0 equiv, 15 equiv total) was added. After stirring another 2 h, the reaction was quenched with saturated aq. $NaHCO_3$ solution (ca. 15 mL). Care should be taken during addition of $NaHCO_3$ due to rapid gas evolution. The biphasic mixture was extracted with EtOAc (15 mL x 2). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Flash column chromatography on silica gel (9% Et_2O in hexanes) furnished (–)-aspewentin A (**18**, 23 mg, 85% yield) as a colorless oil. $R_f = 0.4$ (20% Et_2O in hexanes); ^1H NMR (500 MHz, $CDCl_3$) δ 6.67 (s, 1H), 5.90 (dd, *J* = 17.5, 10.7 Hz, 1H), 4.99 (dd, *J* = 17.5, 1.3 Hz, 1H), 4.96 (dd, *J* = 10.8, 1.2 Hz, 1H), 4.69 (br s, 1H), 2.66 (d, *J* = 16.3 Hz, 1H), 2.57 (t, *J* = 6.7 Hz, 2H), 2.50 (t, *J* = 6.5 Hz, 2H), 2.46 (d, *J* = 16.3 Hz, 1H), 1.86–1.79 (m, 2H), 1.76–1.70 (m, 1H), 1.69–1.64 (m, 1H), 1.64–1.60 (m, 2H), 1.27 (s, 3H), 1.27 (s, 3H), 1.11 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 151.3, 147.2, 143.9, 135.2, 126.5, 119.7, 111.2, 110.0, 38.8, 34.5, 34.5, 34.1, 33.9, 32.1, 32.0, 26.8, 26.0, 24.4, 19.7; IR (Neat Film, NaCl) 3307, 2923, 1606, 1456, 1418, 1324, 1252, 1019, 910, 858 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{19}H_{26}O$ $[M]^+$: 270.1984, found 270.1972; $[\alpha]_D^{25}$ –38.6 (*c* 0.20, MeOH).



(–)-Aspewentin A (18)

(–)-Aspewentin C (19) (13% yield over 2 steps)

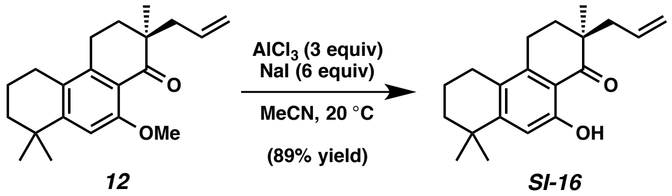
(+)-10-epi-Aspewentin C (20) (7% yield over 2 steps)

(–)-Aspewentin C (19) and (+)-10-*epi*-aspewentin C (20). The reaction was performed according to a literature procedure.[10] To a 20 mL scintillation vial containing (–)-aspewentin A (**18**, 23 mg, 0.085 mmol, 1.0 equiv) was added a magnetic stir bar and $Rh_2(cap)_4$ (0.6 mg, 0.00085 mmol, 0.01 equiv). The vial was sealed with a hollow plastic cap containing a PTFE septum, and evacuated and refilled with N_2 (x 3). 1,2-DCE (2 mL) was added via syringe, and the solution was stirred at 60 °C in an oil bath for 2 min to ensure complete dissolution of the catalyst. The reaction mixture was cooled to 0 °C, and *tert*-butyl hydroperoxide (118 μL, 0.85 mmol, 10 equiv) was added dropwise. The reaction mixture immediately turned red. After stirring at 0 °C for 40 min, the reaction was quenched with H_2O and extracted with CH_2Cl_2 (10 mL x 3). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Flash column chromatography on silica gel (6% Et_2O in hexanes) afforded the peroxide intermediate (12.5 mg, R_f = 0.6 (20% Et_2O in hexanes)), which was used directly in the next reaction.

To a 20 mL scintillation vial containing the peroxide intermediate (11 mg, 0.031 mmol, 1.0 equiv) was added THF (0.65 mL) and aq 1M NH_4OAc (0.65 mL) under N_2. 10% Cd/Pb couple (150 mg, 1.24 mmol, 40 equiv) was added, and the reaction mixture was stirred vigorously at 20 °C. After 4 h, another portion of 10% Cd/Pb couple (37 mg, 0.31 mmol, 10 equiv) was added to increase conversion. After 2 h, a third portion of 10% Cd/Pb couple (37 mg, 0.31 mmol, 10 equiv) was added. After stirring for 4.5 h, the reaction mixture was filtered through a cotton plug and eluted with H_2O and CH_2Cl_2. The biphasic mixture was extracted with CH_2Cl_2 (10 mL x 3). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Flash column chromatography on silica gel (9% EtOAc in hexanes) furnished (–)-aspewentin C (**19**, 2.8 mg, 13% yield over 2 steps) as a white solid. R_f = 0.3 (16% EtOAc in hexanes); ^{1}H NMR (500 MHz, Acetone-d_6) δ 5.98 (s, 1H), 5.75 (dd, J = 17.5, 10.7 Hz, 1H), 4.90 (dd, J = 10.7, 1.4 Hz, 1H), 4.81 (dd, J = 17.5, 1.4 Hz, 1H), 4.23 (d, J = 2.3 Hz, 1H), 2.72–2.60 (m, 1H), 2.44 (br d, J = 17.4 Hz, 1H), 2.27–2.19 (m, 2H), 2.18–2.08 (m, 1H), 1.95 (br d, J = 17.4 Hz, 1H), 1.72–1.60 (m, 2H), 1.56–1.47 (m, 1H), 1.42 (s, 3H), 1.41–1.30 (m, 2H), 1.16 (s, 3H), 1.15–1.07 (m, 1H), 1.03 (s, 3H); ^{13}C NMR (101 MHz, Acetone-d_6) δ 185.1, 167.7, 157.2, 145.6, 128.5, 122.4, 110.8, 70.2, 41.9, 37.9, 37.5, 34.4, 33.4, 32.4, 30.4, 27.4, 26.9, 21.5, 17.6; IR (Neat Film, NaCl) 3419, 2956, 2919, 1659, 1623, 1603, 1398, 1302, 1137, 1073, 1040, 1016, 959, 909, 878, 734 cm^{-1}; HRMS (MM: ESI-APCI+) *m/z* calc'd for $C_{19}H_{27}O_2$

$[M+H]^+$: 287.2006, found 287.2016; $[\alpha]_D^{25}$ –123.2 (*c* 0.10, MeOH). [Note: ^{13}C NMR spectrum also contains smaller peaks at 70.1 ppm and 122.4 ppm. We think that these additional peaks belong to an unknown impurity, which may also be responsible for the large difference in optical rotation of the synthetic compound and the natural product.]

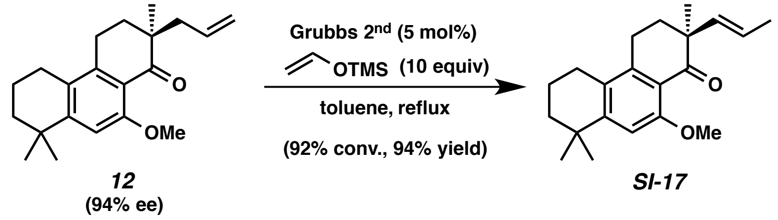
The same reaction also formed (+)-10-*epi*-aspewentin C (**20**, 1.6 mg, 7% yield over 2 steps) as a white solid. R_f = 0.4 (16% EtOAc in hexanes); ^{1}H NMR (500 MHz, Acetone-d_6) δ 5.99 (s, 1H), 5.86 (dd, *J* = 17.5, 10.8 Hz, 1H), 4.95 (dd, *J* = 17.5, 1.4 Hz, 1H), 4.90 (dd, *J* = 10.8, 1.3 Hz, 1H), 4.24 (d, *J* = 2.3 Hz, 1H), 2.75–2.64 (m, 1H), 2.41–2.33 (m, 1H), 2.33–2.27 (m, 1H), 2.21–2.10 (m, 3H), 1.69 (dtd, *J* = 13.1, 3.4, 2.0 Hz, 1H), 1.60–1.50 (m, 2H), 1.50–1.44 (m, 1H), 1.43 (s, 3H), 1.36 (td, *J* = 13.4, 4.1 Hz, 1H), 1.22 (tdd, *J* = 13.2, 4.3, 2.1 Hz, 1H), 1.16 (s, 3H), 0.96 (s, 3H); ^{13}C NMR (126 MHz, Acetone-d_6) δ 185.2, 167.8, 157.0, 148.1, 128.3, 122.4, 109.9, 70.2, 42.0, 38.0, 37.5, 33.9, 33.2, 32.7, 30.5, 26.9, 23.3, 21.1, 17.6; IR (Neat Film, NaCl) 3400, 2958, 2923, 1660, 1626, 1604, 1397, 1302, 1128, 1075, 1039, 1017, 958, 939, 906, 877, 825 cm^{-1}; HRMS (MM: ESI-APCI+) *m/z* calc'd for $C_{19}H_{27}O_2$ $[M+H]^+$: 287.2006, found 287.2016; $[\alpha]_D^{25}$ +39.4 (*c* 0.10, MeOH). [Note: the two big peaks not having integration values (around 2.8 ppm) in the ^{1}H NMR spectra of compounds **19** and **20** belong to water; see spectra on pages 114 and 116, respectively.]



12
(94% ee)

SI-16

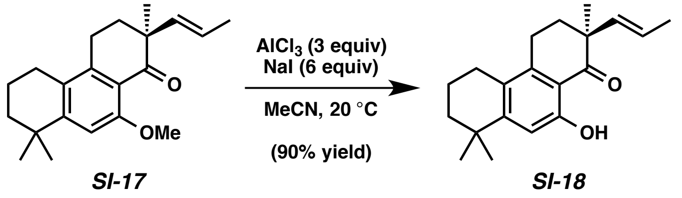
Ketone SI-16. Using α-allyl ketone **12** as starting material (20 mg, 0.064 mmol, 1.0 equiv), and following the same procedure as that for (–)-aspewentin B (**1**), ketone **SI-16** was obtained (17 mg, 89% yield) as a colorless oil. R$_f$ = 0.7 (16% EtOAc in hexanes); ^{1}H NMR (500 MHz, CDCl$_3$) δ 12.47 (s, 1H), 6.84 (s, 1H), 5.83–5.72 (m, 1H), 5.13–5.05 (m, 2H), 2.82–2.66 (m, 2H), 2.52 (t, *J* = 6.5 Hz, 2H), 2.46 (dd, *J* = 13.9, 7.3 Hz, 1H), 2.26 (dd, *J* = 13.8, 7.5 Hz, 1H), 2.08–1.98 (m, 1H), 1.90–1.77 (m, 3H), 1.65–1.59 (m, 2H), 1.28 (s, 6H), 1.19 (s, 3H); ^{13}C NMR (126 MHz, CDCl$_3$) δ 209.1, 161.0, 156.0, 142.2, 133.8, 124.7, 118.6, 114.2, 113.4, 44.1, 41.2, 38.3, 35.0, 32.6, 31.6, 31.6, 26.9, 23.0, 22.2, 19.4; IR (Neat Film, NaCl) 2930, 1634, 1464, 1360, 1220, 1190, 919, 811 cm^{-1}; HRMS (MM: ESI-APCI+) *m/z* calc'd for $C_{20}H_{27}O_2$ [M+H]$^+$: 299.2006, found 299.1999; $[\alpha]_D^{25}$ –23.5 (*c* 0.20, MeOH).



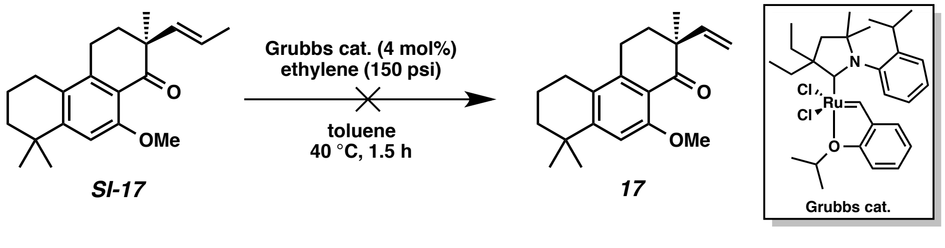
12
(94% ee)

SI-17

Ketone SI-17. To a solution of α-allyl ketone **12** (109 mg, 0.349 mmol, 1.0 equiv) and vinyloxytrimethylsilane (0.52 mL, 3.49 mmol, 10.0 equiv) in toluene (19 mL) was added Grubbs 2nd generation catalyst (14.8 mg, 0.01745 mmol, 0.05 equiv) at 20 °C. The purple reaction mixture was immersed in a pre-heated 128°C oil bath (color changed to yellow) and refluxed for 16 h. The reaction mixture was concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (10% EtOAc in hexanes) to afford ketone **SI-17** (103 mg, 92% conv., 94% yield) as a colorless oil. R$_f$ = 0.4 (16% EtOAc in hexanes); ^{1}H NMR (500 MHz, CDCl$_3$) δ 6.82 (s, 1H), 5.60 (d, *J* = 15.9 Hz, 1H), 5.48–5.38 (m, 1H), 3.86 (s, 3H), 2.79–2.66 (m, 2H), 2.58–2.45 (m, 2H), 2.08–1.99 (m, 1H), 1.96–1.88 (m, 1H), 1.87–1.74 (m, 2H), 1.68–1.56 (m, 5H), 1.30 (s, 3H), 1.28 (s, 3H), 1.24 (s, 3H); ^{13}C NMR (126 MHz, CDCl$_3$) δ 200.4, 158.6, 152.1, 143.9, 133.6, 126.0, 125.0, 120.2, 108.5, 56.1, 48.2, 38.4, 35.1, 34.9, 31.8, 31.6, 27.0, 24.1, 24.0, 19.5, 18.5; IR (Neat Film, NaCl) 2928, 1683, 1591, 1558, 1456, 1318, 1245, 1106, 1020, 966 cm^{-1}; HRMS (MM: ESI-APCI+) *m/z* calc'd for $C_{21}H_{29}O_2$ $[M+H]^+$: 313.2162, found 313.2154; $[\alpha]_D^{25}$ –49.0 (*c* 1.00, $CHCl_3$).



Ketone SI-18. Using ketone **SI-17** as starting material (35 mg, 0.112 mmol, 1.0 equiv), and following the same procedure as that for (–)-aspewentin B (**1**), ketone **SI-18** was obtained (30 mg, 90% yield) as a colorless oil. R_f = 0.7 (16% EtOAc in hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 12.46 (s, 1H), 6.84 (s, 1H), 5.57 (d, *J* = 15.9 Hz, 1H), 5.49–5.39 (m, 1H), 2.79–2.67 (m, 2H), 2.59–2.44 (m, 2H), 2.09–2.00 (m, 1H), 2.00–1.91 (m, 1H), 1.89–1.74 (m, 2H), 1.66 (d, *J* = 5.9 Hz, 3H), 1.64–1.55 (m, 2H), 1.30 (s, 3H), 1.28 (s, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 207.7, 160.9, 155.9, 142.5, 133.1, 125.9, 124.6, 114.6, 113.3, 47.1, 38.3, 35.1, 35.0, 31.7, 31.6, 26.9, 23.9, 23.5, 19.4, 18.4; IR (Neat Film, NaCl) 2929, 1634, 1464, 1359, 1267, 1221, 1191, 964 cm^{-1}; HRMS (MM: ESI-APCI+) *m/z* calc'd for $C_{20}H_{27}O_2$ $[M+H]^+$: 299.2006, found 299.2002; $[\alpha]_D^{25}$ –65.1 (*c* 0.20, MeOH).



Ethenolysis of SI-17. In a nitrogen-filled glove box, a Fisher-Porter bottle was charged with a magnetic stir bar, toluene (10 mL), and Grubbs catalyst (1.7 mg, 0.0028 mmol, 0.04 equiv). A solution of **SI-17** (22 mg, 0.07 mmol, 1.0 equiv) in toluene (0.2 mL) was added. The head of the Fisher-Porter bottle was equipped with a pressure gauge, and a dip-tube was adapted on the bottle. The system was sealed and taken out of the glove box and connected to the ethylene line. The vessel was then purged with ethylene (polymer purity 99.9% from Matheson Tri Gas) for 5 min, pressurized to 150 psi, and placed in an oil bath at 40 °C. After stirring for 1.5 h, the solvent was evaporated, and the residue was diluted in EtOAc and passed through a short plug of silica gel to remove the ruthenium catalyst. The filtrate was concentrated under reduced pressure, and ^{1}H NMR analysis of the residue showed starting material **SI-17** remaining, and no peaks corresponding to the desired product **17**.

Comparison of Synthetic and Natural Aspewentin A (Table S1)

Synthetic (–)-Aspewentin A	**Natural (+)-Aspewentin A**[11]
^{1}H NMR (500 MHz, CDCl$_3$)	*^{1}H NMR (500 MHz, CDCl$_3$)*
6.67 (s, 1H)	6.66 (s, 1H)
5.90 (dd, *J* = 17.5, 10.7 Hz, 1H)	5.89 (dd, *J* = 17.6, 10.8 Hz, 1H)
4.99 (dd, *J* = 17.5, 1.3 Hz, 1H)	4.98 (br d, *J* = 17.6 Hz, 1H)
4.96 (dd, *J* = 10.8, 1.2 Hz, 1H)	4.94 (br d, *J* = 10.8 Hz, 1H)
4.69 (br s, 1H)	4.44 (br s, 1H)
2.66 (d, *J* = 16.3 Hz, 1H)	2.64 (d, 16.4 Hz, 1H)
2.57 (t, *J* = 6.7 Hz, 2H)	2.55 (t, 6.6 Hz, 2H)
2.50 (t, *J* = 6.5 Hz, 2H)	2.48 (t, 6.5 Hz, 2H)
2.46 (d, *J* = 16.3 Hz, 1H)	2.44 (d, 16.4 Hz, 1H)
1.86–1.79 (m, 2H)	1.80 (m, 2H)
1.76–1.70 (m, 1H)	1.71 (m, 1H)
1.69–1.64 (m, 1H)	1.64 (m, 1H)
1.64–1.60 (m, 2H)	1.60 (m, 2H)
1.27 (s, 3H), 1.27 (s, 3H)	1.25 (s, 3H), 1.25 (s, 3H)
1.11 (s, 3H)	1.08 (s, 3H)
^{13}C NMR (101 MHz, CDCl$_3$)	*^{13}C NMR (125 MHz, CDCl$_3$)*
151.3	151.2
147.2	147.1
143.9	143.8
135.2	135.1
126.5	126.4
119.7	119.6
111.2	111.1
110.0	109.9
38.8	38.7
34.5	34.4
34.5	34.4
34.1	34.0
33.9	33.8
32.1	32.0
32.0	31.9
26.8	26.7
26.0	25.8
24.4	24.2
19.7	19.6
Optical Rotation	*Optical Rotation*
$[\alpha]_D^{25}$ –38.6 (*c* 0.20, MeOH)	$[\alpha]_D^{14}$ +41.8 (*c* 0.19, MeOH)

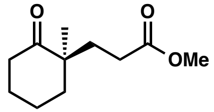
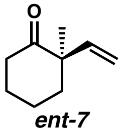
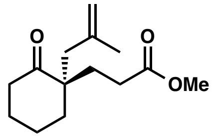
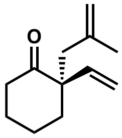
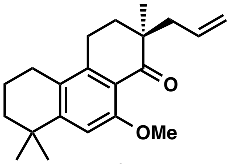
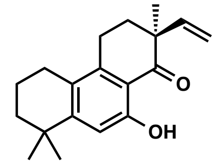
Comparison of Synthetic and Natural Aspewentin B (Table S2)

Synthetic (–)-Aspewentin B	**Natural (+)-Aspewentin B**[11]
^{1}H NMR (500 MHz, $CDCl_3$)	*^{1}H NMR (500 MHz, $CDCl_3$)*
12.40 (s, 1H)	12.40 (s, 1H)
6.84 (s, 1H)	6.84 (s, 1H)
5.98 (dd, *J* = 17.7, 10.8 Hz, 1H)	5.98 (dd, *J* = 17.6, 10.8 Hz, 1H)
5.13 (d, *J* = 10.7 Hz, 1H)	5.14 (d, *J* = 10.8 Hz, 1H)
5.03 (d, *J* = 17.6 Hz, 1H)	5.03 (d, *J* = 17.6 Hz, 1H)
2.81–2.69 (m, 2H)	2.75 (m, 2H)
2.59–2.44 (m, 2H)	2.51 (m, 2H)
2.14–2.06 (m, 1H)	2.10 (m, 1H)
2.04–1.94 (m, 1H)	2.00 (m, 1H)
1.88–1.73 (m, 2H)	1.81 (m, 2H)
1.68–1.55 (m, 2H)	1.61 (m, 2H)
1.33 (s, 3H)	1.33 (s, 3H)
1.27 (s, 6H)	1.28 (s, 3H), 1.27 (s, 3H)
^{13}C NMR (126 MHz, $CDCl_3$)	*^{13}C NMR (125 MHz, $CDCl_3$)*
207.2	207.1
160.9	160.8
156.1	156.2
142.3	142.2
140.5	140.4
124.7	124.6
115.1	115.0
114.6	114.4
113.3	113.3
47.9	47.8
38.3	38.2
35.0	34.9
34.4	34.3
31.7	31.6
31.6	31.5
26.9	26.8
23.4	23.3
23.3	23.2
19.4	19.3
Optical Rotation	*Optical Rotation*
$[\alpha]_D^{25}$ –90.5 (*c* 0.20, MeOH, 98% ee)	$[\alpha]_D^{20}$ +23.3 (*c* 0.20, MeOH)

Comparison of Synthetic and Natural Aspewentin C (Table S3)

Synthetic (–)-Aspewentin C	**Natural (+)-Aspewentin C**[11]
^{1}H NMR (500 MHz, Acetone-d_6)	*^{1}H NMR (500 MHz, Acetone-d_6)*
5.98 (s, 1H)	5.99 (s, 1H)
5.75 (dd, *J* = 17.5, 10.7 Hz, 1H)	5.76 (dd, *J* = 17.5, 10.8 Hz, 1H)
4.90 (dd, *J* = 10.7, 1.4 Hz, 1H)	4.91 (br d, *J* = 10.8 Hz, 1H)
4.81 (dd, *J* = 17.5, 1.4 Hz, 1H)	4.82 (br d, *J* = 17.5 Hz, 1H)
4.23 (d, *J* = 2.3 Hz, 1H)	4.22 (br s, 1H)
2.72–2.60 (m, 1H)	2.68 (m, 1H)
2.44 (br d, *J* = 17.4 Hz, 1H)	2.44 (br d, 17.8 Hz, 1H)
2.27–2.19 (m, 2H)	2.24 (m, 1H), 2.24 (m, 1H)
2.18–2.08 (m, 1H)	2.15 (m, 1H)
1.95 (br d, *J* = 17.4 Hz, 1H)	1.96 (br d, 17.8 Hz, 1H)
1.72–1.60 (m, 2H)	1.69 (m, 1H), 1.65 (m, 1H)
1.56–1.47 (m, 1H)	1.53 (m, 1H)
1.42 (s, 3H)	1.43 (s, 3H)
1.41–1.30 (m, 2H)	1.41 (m, 1H), 1.35 (m, 1H)
1.16 (s, 3H)	1.16 (s, 3H)
1.15–1.07 (m, 1H)	1.13 (m, 1H)
1.03 (s, 3H)	1.03 (s, 3H)
^{13}C NMR (101 MHz, Acetone-d_6)	*^{13}C NMR (125 MHz, Acetone-d_6)*
185.1	185.1
167.7	167.7
157.2	157.2
145.6	145.7
128.5	128.5
122.4	122.4
110.8	110.8
70.2	70.2
41.9	41.9
37.9	37.9
37.5	37.5
34.4	34.4
33.4	33.4
32.4	32.5
30.4	30.4
27.4	27.4
26.9	26.9
21.5	21.5
17.6	17.6
Optical Rotation	*Optical Rotation*
$[\alpha]_D^{25}$ –123.2 (*c* 0.10, MeOH)	$[\alpha]_D^{21}$ +8.3 (*c* 0.10, MeOH)

Methods for the Determination of Enantiomeric Excess (Table S4)

entry	compound	assay conditions	retention time of major isomer (min)	retention time of minor isomer (min)	% ee
1	 ***SI-3***	HPLC Chiralcel OD-H 10% IPA in hexanes isocratic, 1.0 mL/min 220 nm	6.43	5.93	91
2	 ***ent-7***	GC G-TA 60 °C isotherm 5 min then ramp 2 °C/min	24.20	23.92	92
3	 ***SI-8***	HPLC Chiralcel OD-H 5% IPA in hexanes isocratic, 1.0 mL/min 210 nm	8.08	9.99	91
4	 ***9e***	HPLC Chiralpak AS 0.2% IPA in hexanes isocratic, 1.0 mL/min 210 nm	9.50	7.89	92
5	 ***12***	SFC Chiralcel OB-H 3% MeOH in CO_2 isocratic, 3.0 mL/min 254 nm	8.82	6.41	94
6	 ***(–)-Aspewentin B (1)***	HPLC Chiralpak AD 0.5% IPA in hexanes isocratic, 1.0 mL/min 210 nm	7.22	6.56	98

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[9] We believe the increase in enantioenrichment occurs at the recrystallization of carboxylic acid **11**.

[10] Carlsen, P. N.; Mann, T. J.; Hoveyda, A. H.; Frontier, A. J. *Angew. Chem., Int. Ed.* **2014**, *53*, 9334–9338.

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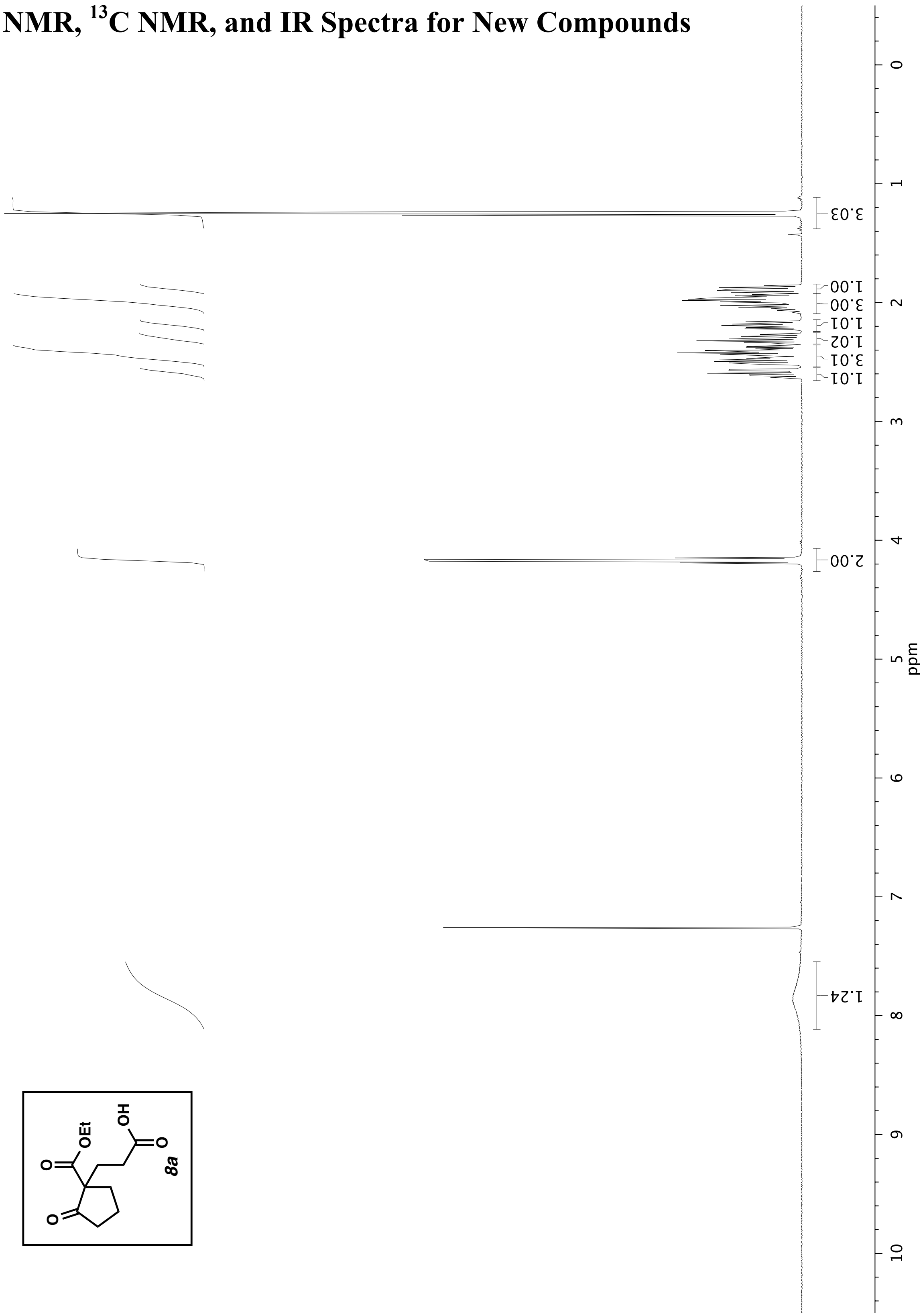
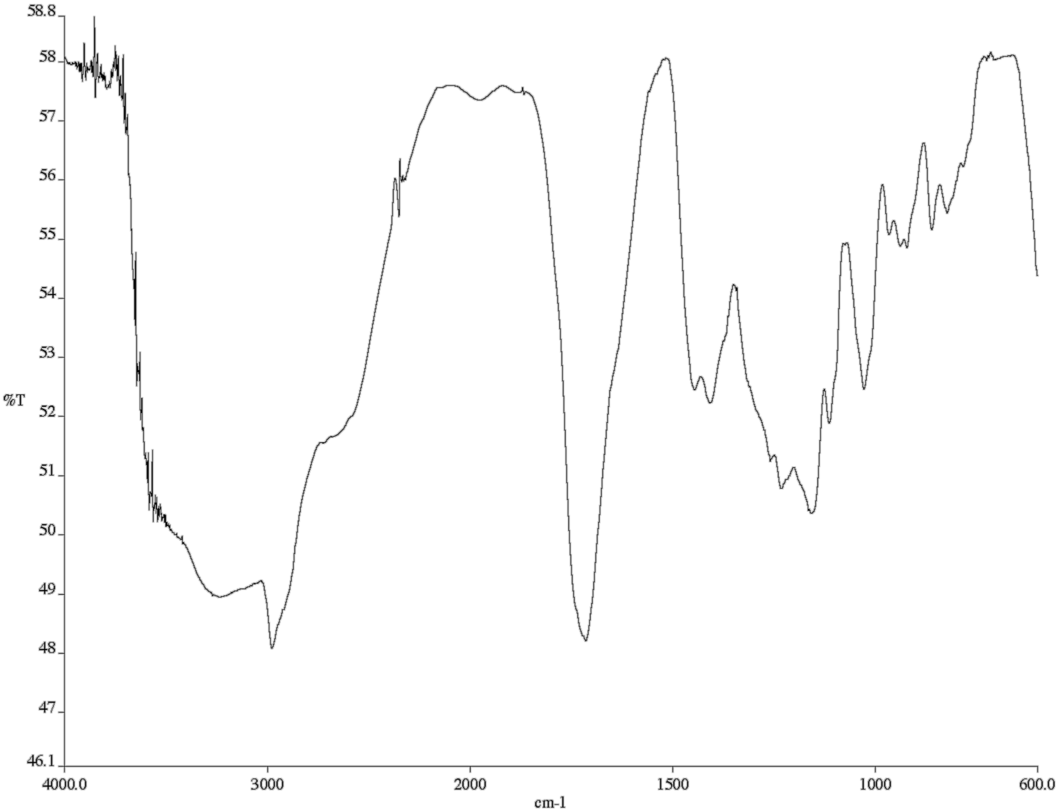
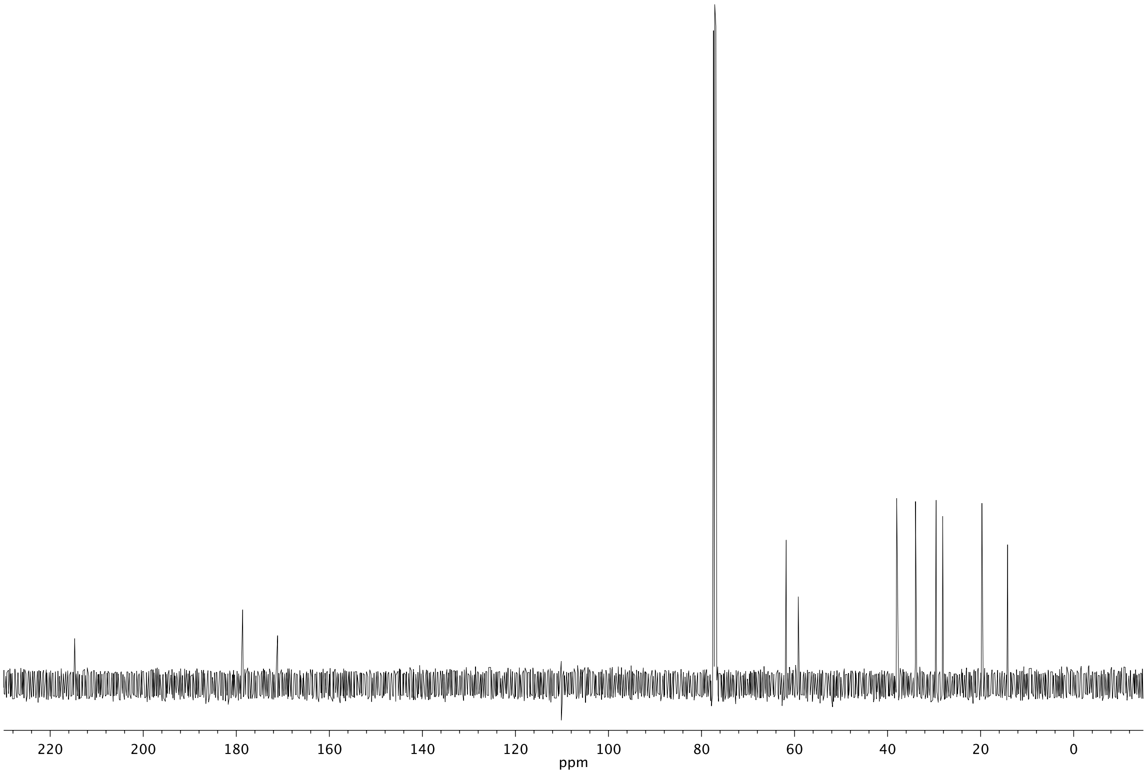
^{1}H NMR, ^{13}C NMR, and IR Spectra for New Compounds



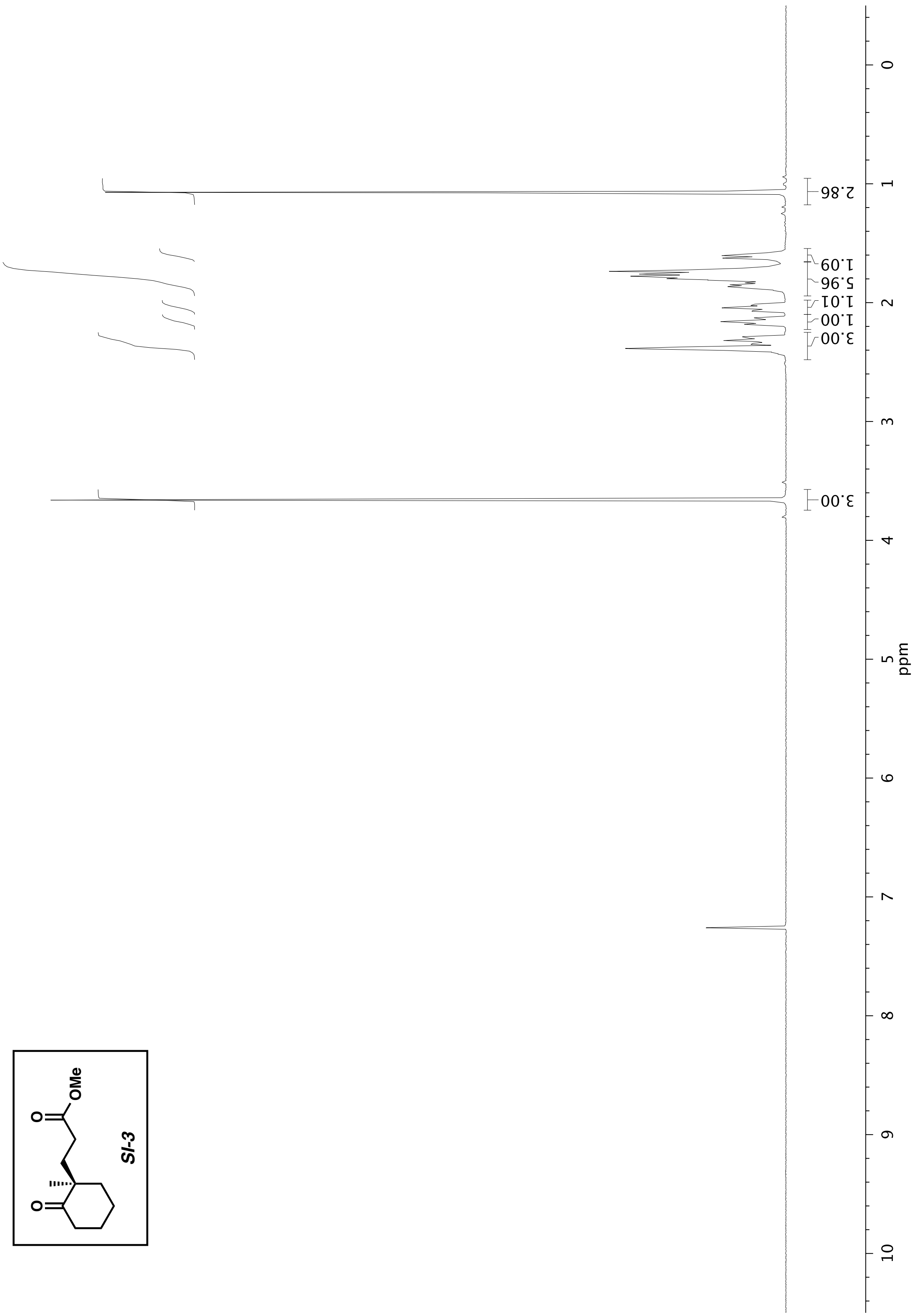
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8a**.



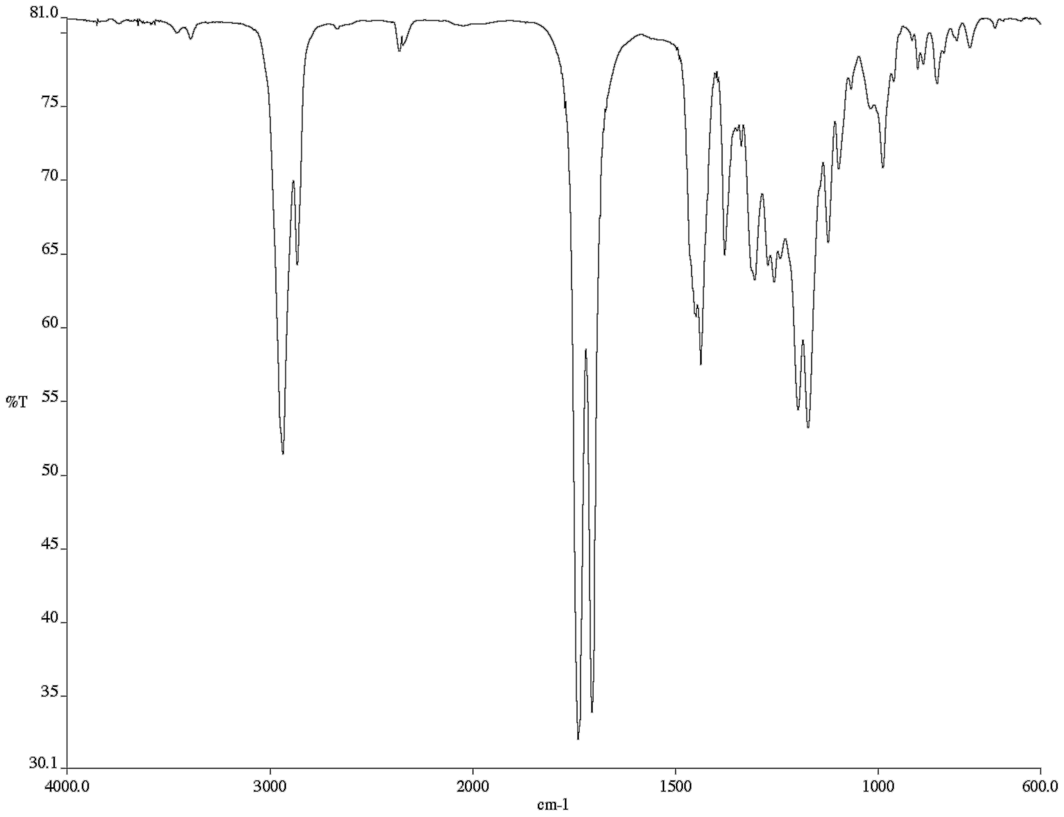
Infrared spectrum (Thin Film, NaCl) of compound **8a**.



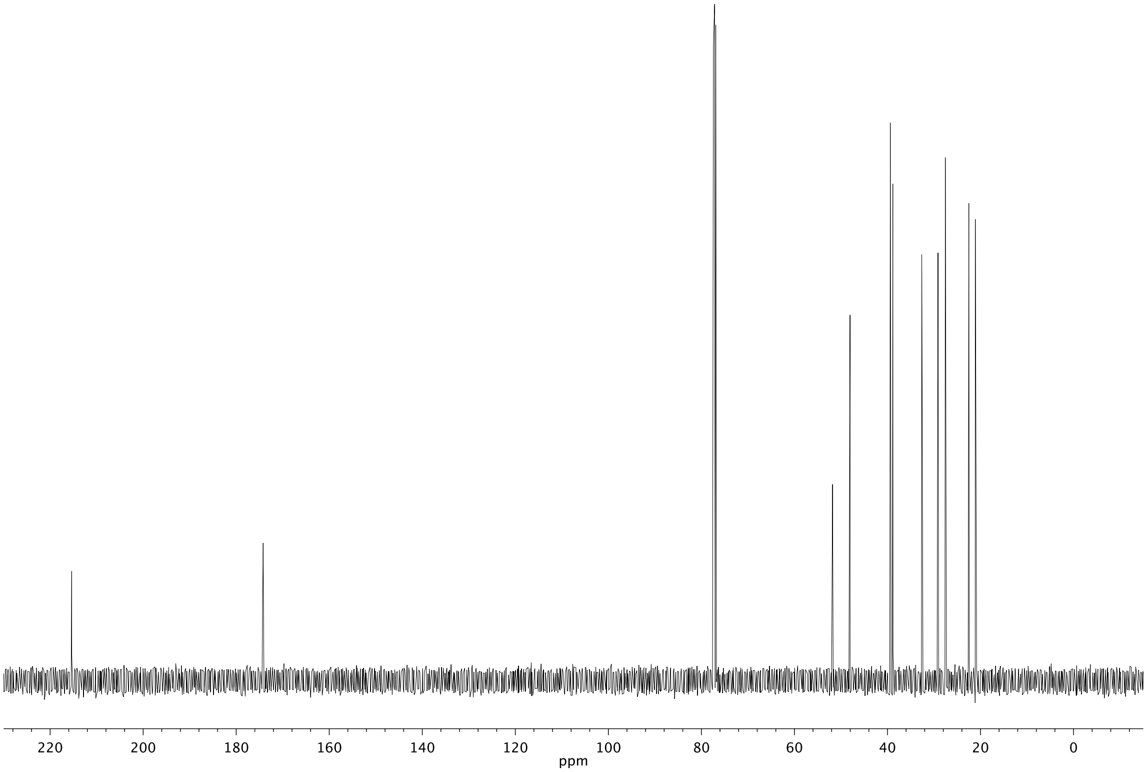
^{13}C NMR (126 MHz, $CDCl_3$) of compound **8a**.



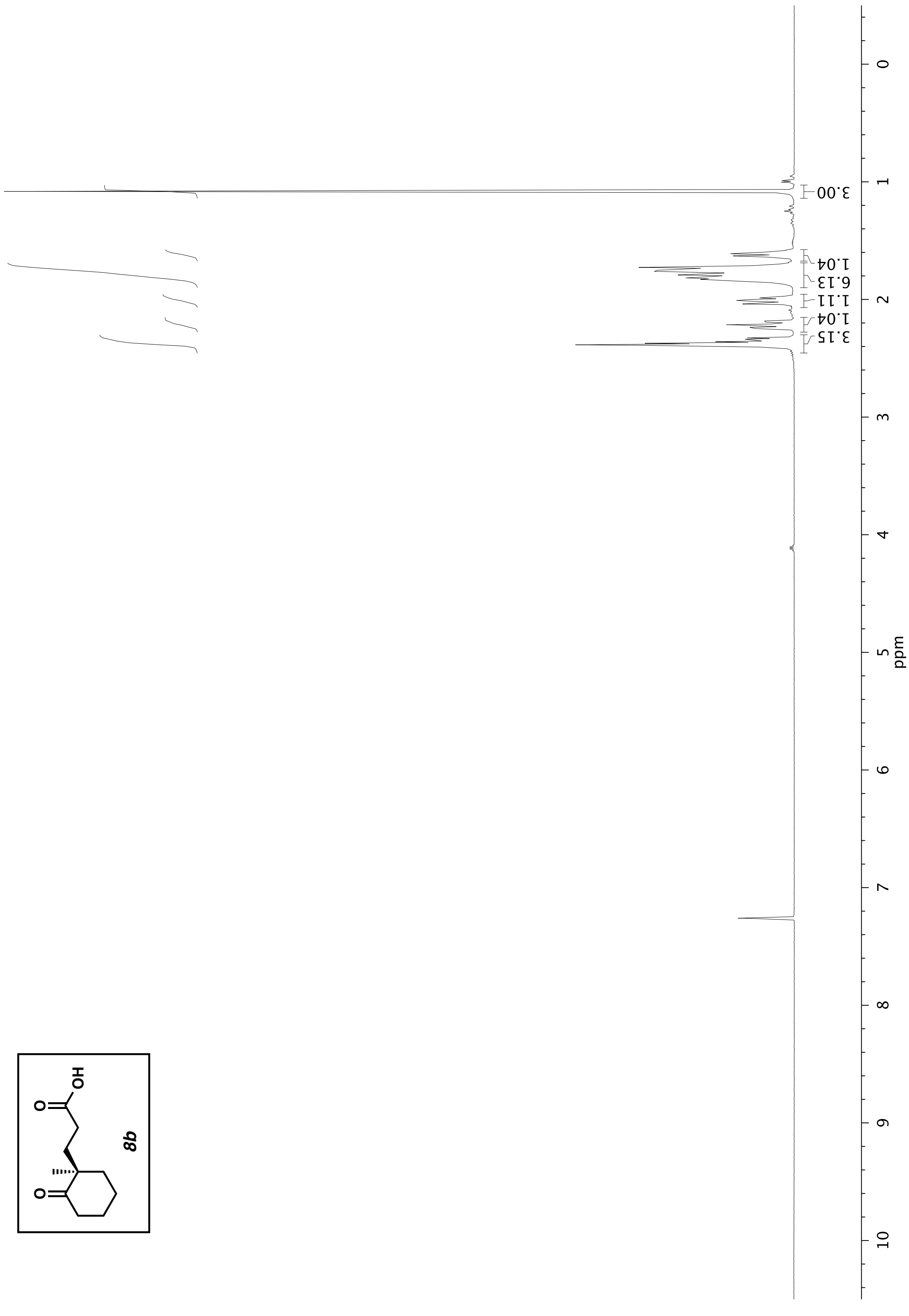
^{1}H NMR (500 MHz, CDCl$_3$) of compound **SI-3**.



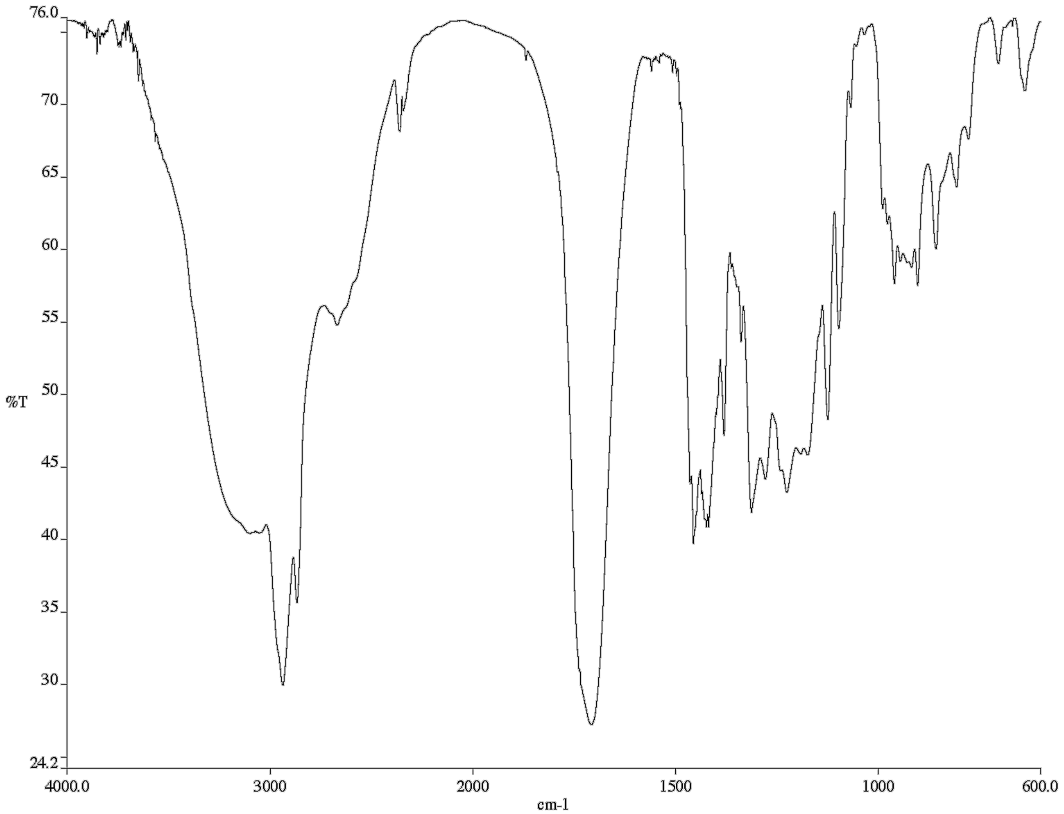
Infrared spectrum (Thin Film, NaCl) of compound **SI-3**.



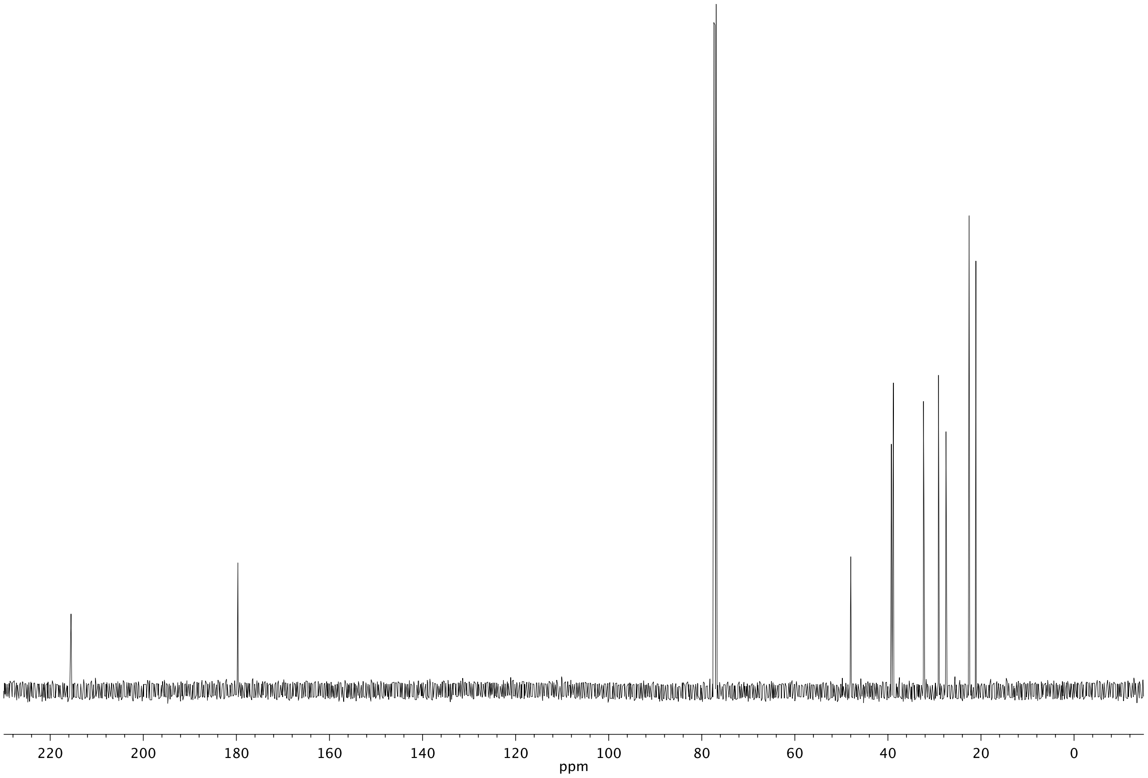
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-3**.



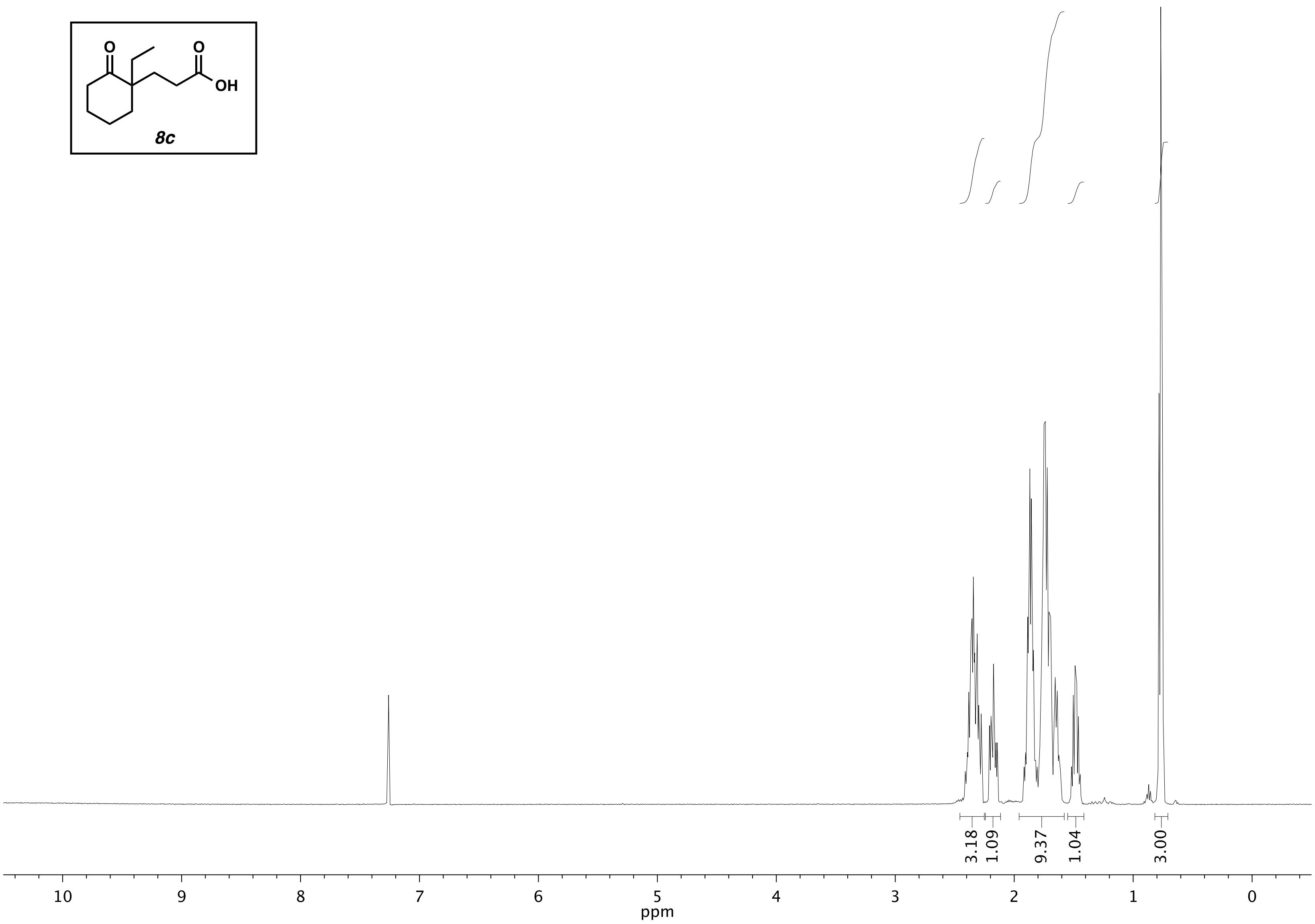
^{1}H NMR (500 MHz, CDCl$_3$) of compound **8b**.



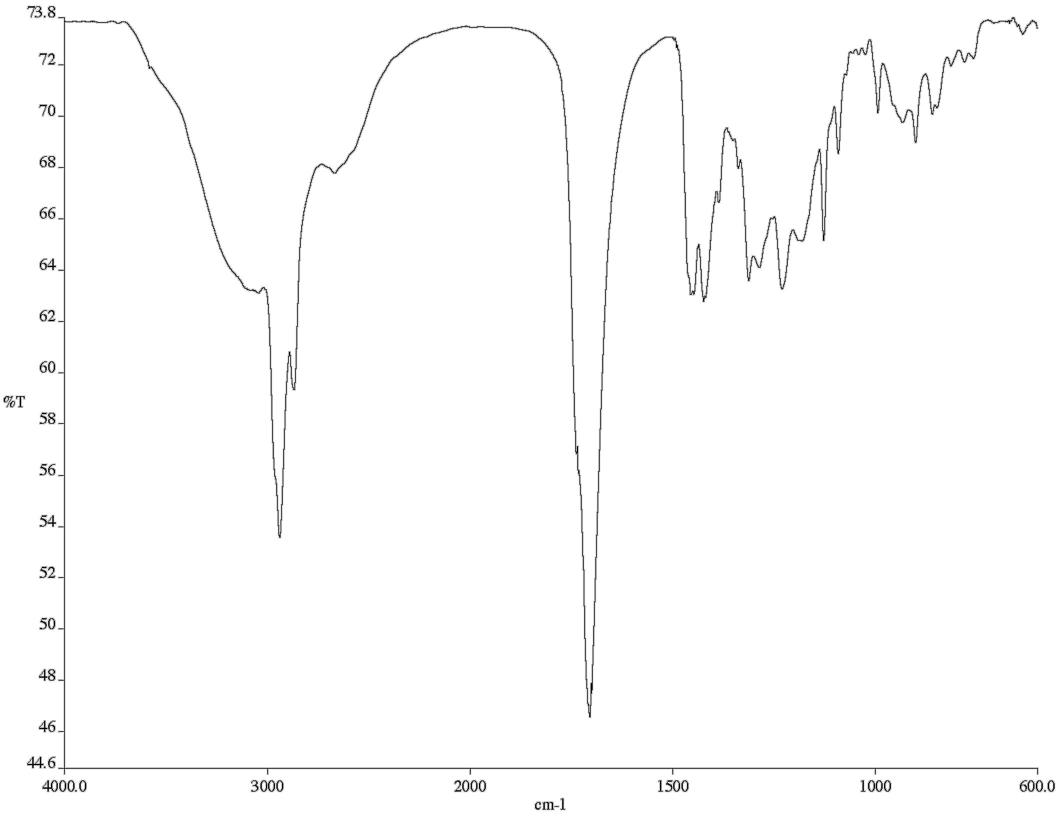
Infrared spectrum (Thin Film, NaCl) of compound **8b**.



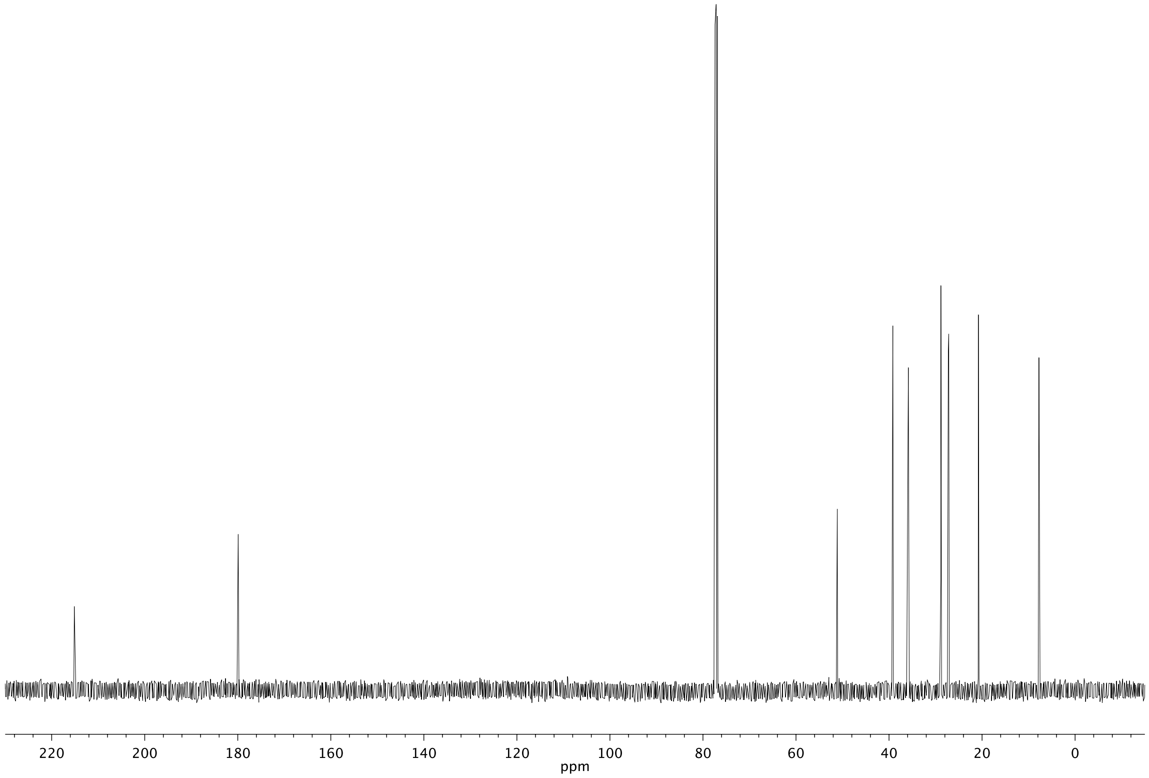
^{13}C NMR (126 MHz, $CDCl_3$) of compound **8b**.



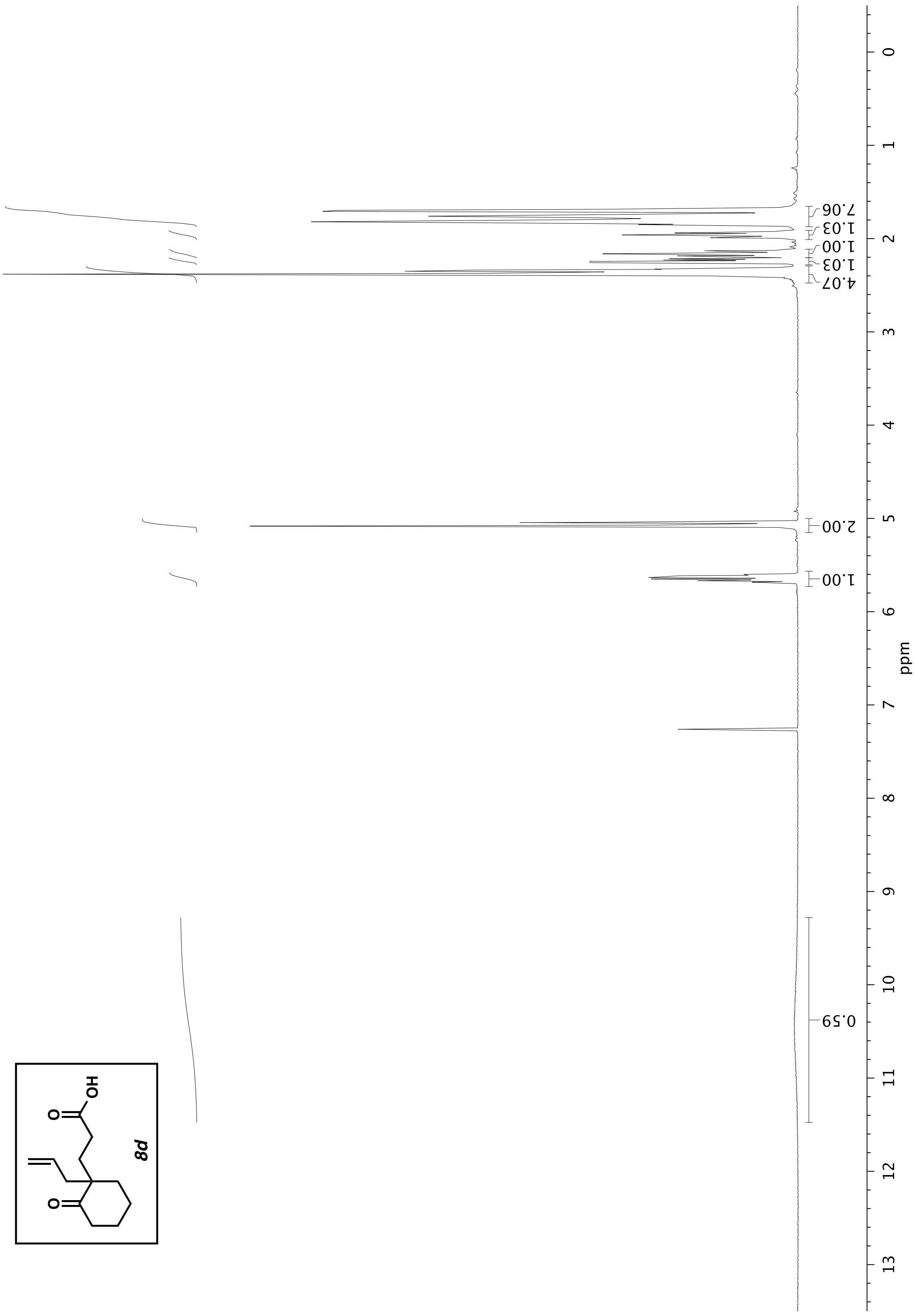
^{1}H NMR (500 MHz, CDCl$_3$) of compound **8c**.



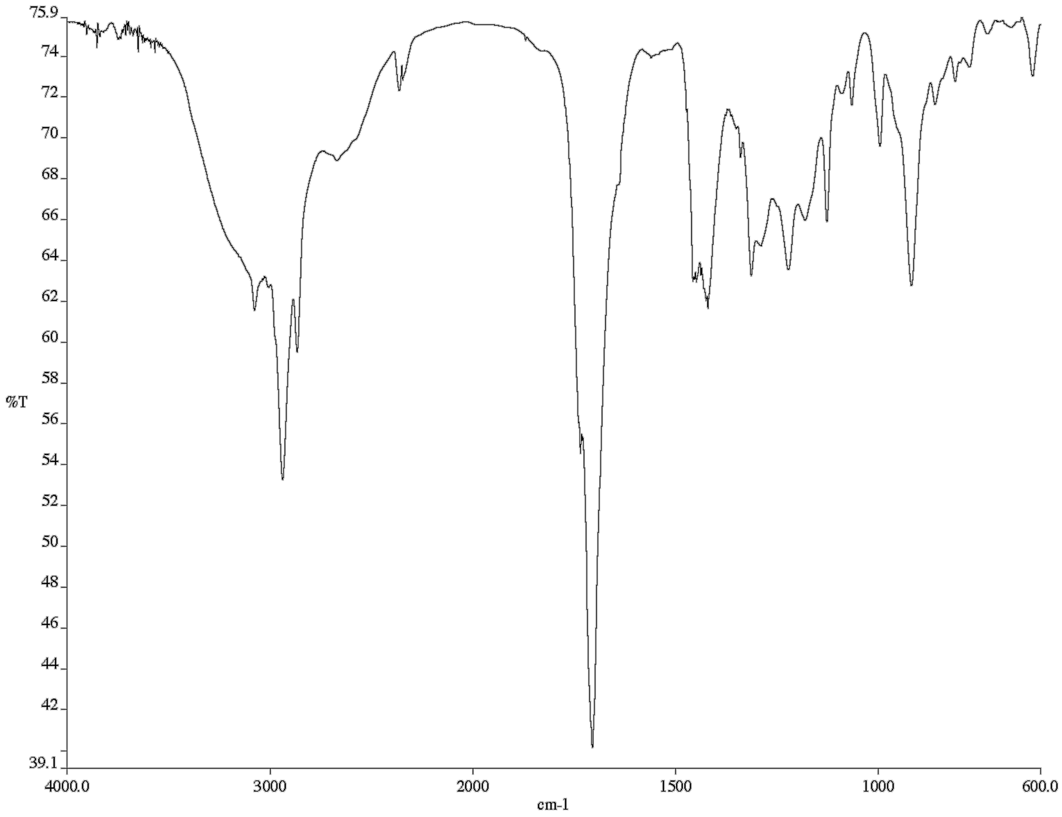
Infrared spectrum (Thin Film, NaCl) of compound **8c**.



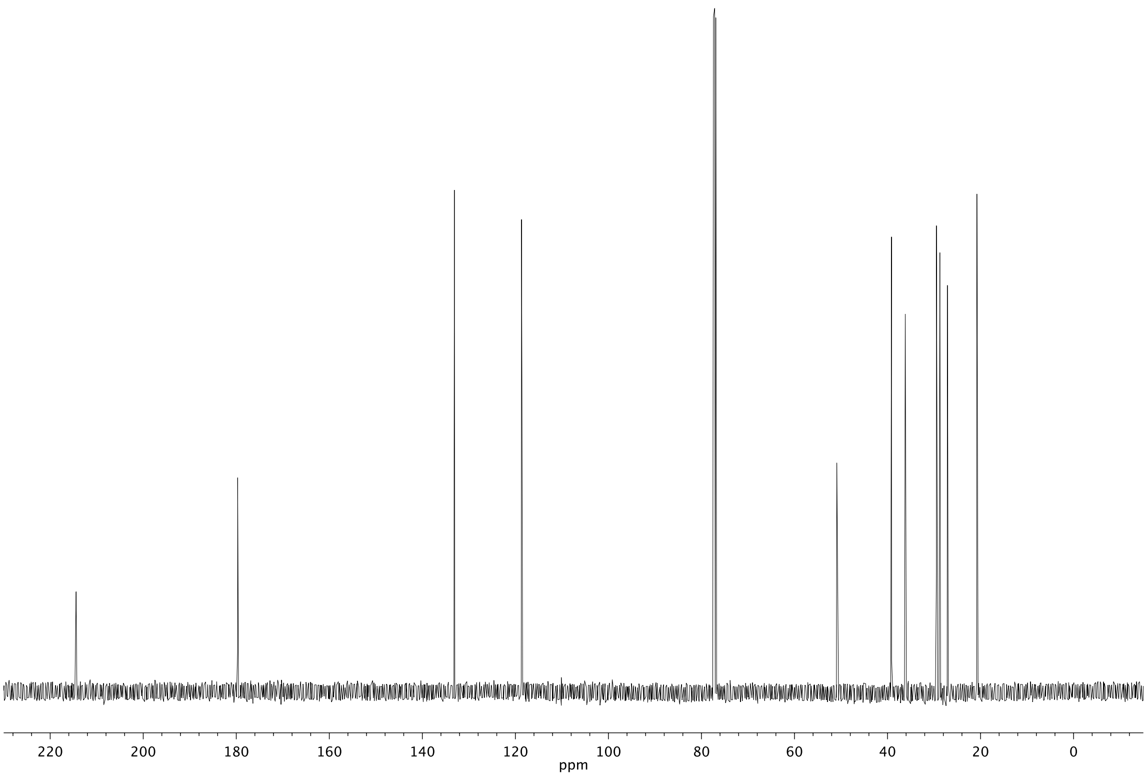
^{13}C NMR (126 MHz, CDCl$_3$) of compound **8c**.



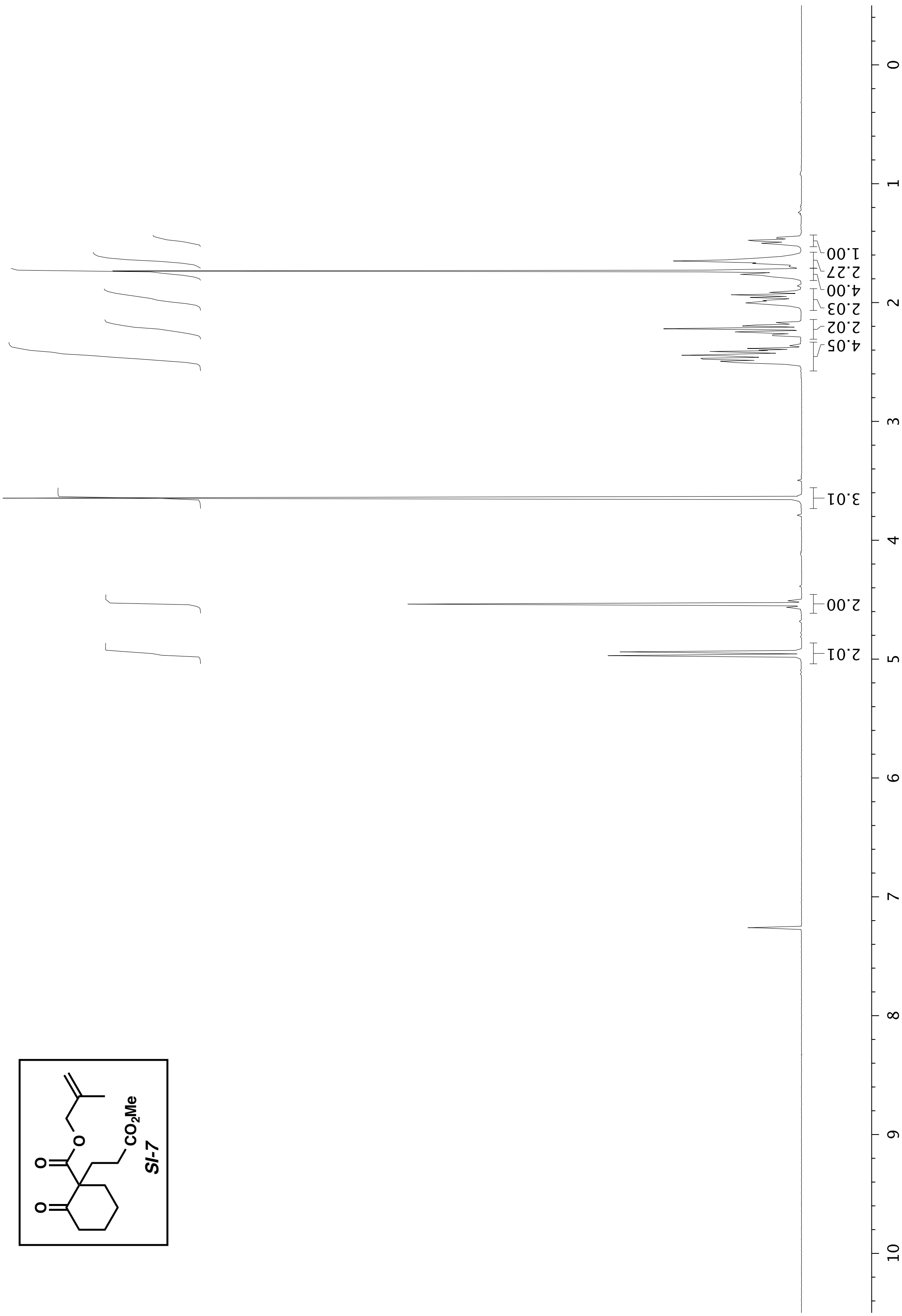
^{1}H NMR (500 MHz, CDCl$_3$) of compound **8d**.



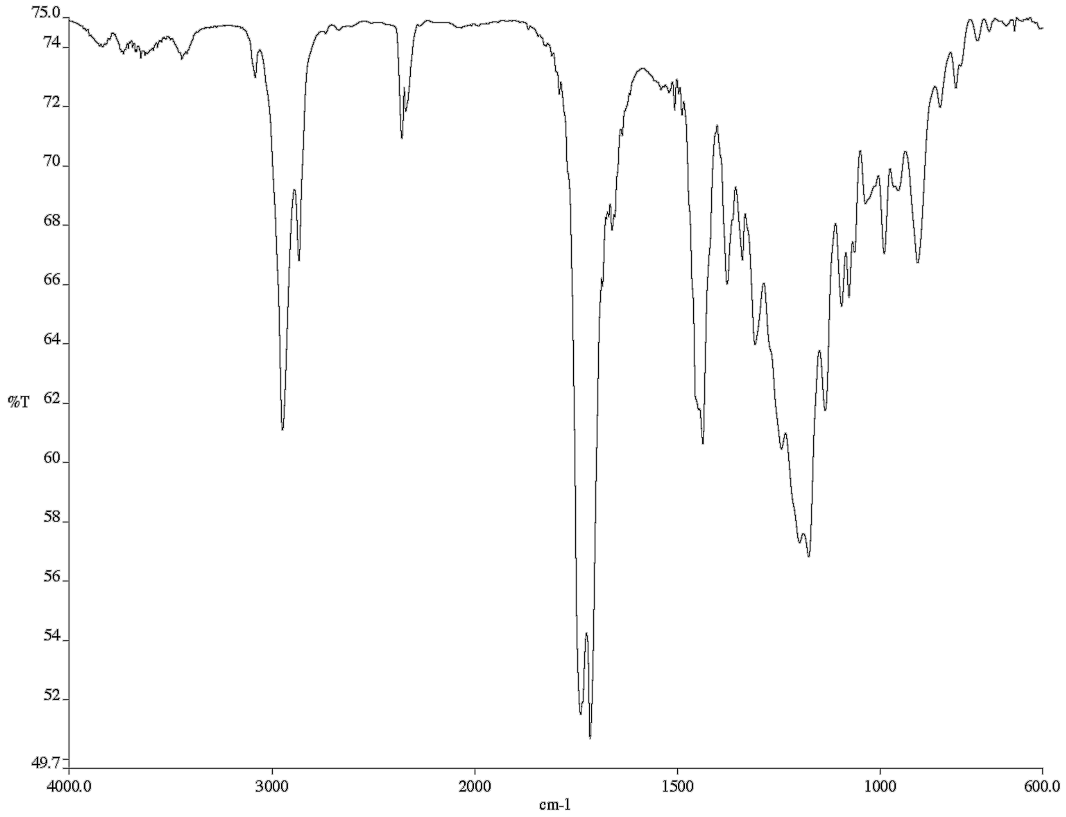
Infrared spectrum (Thin Film, NaCl) of compound **8d**.



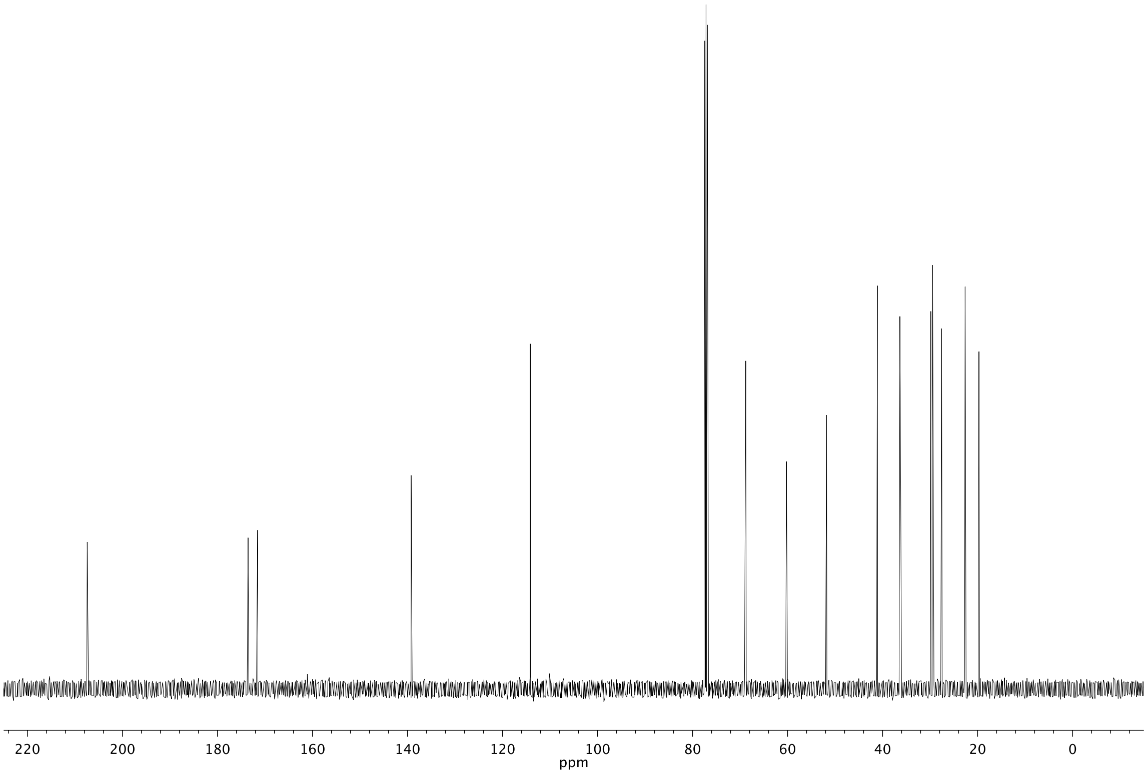
^{13}C NMR (126 MHz, CDCl$_3$) of compound **8d**.



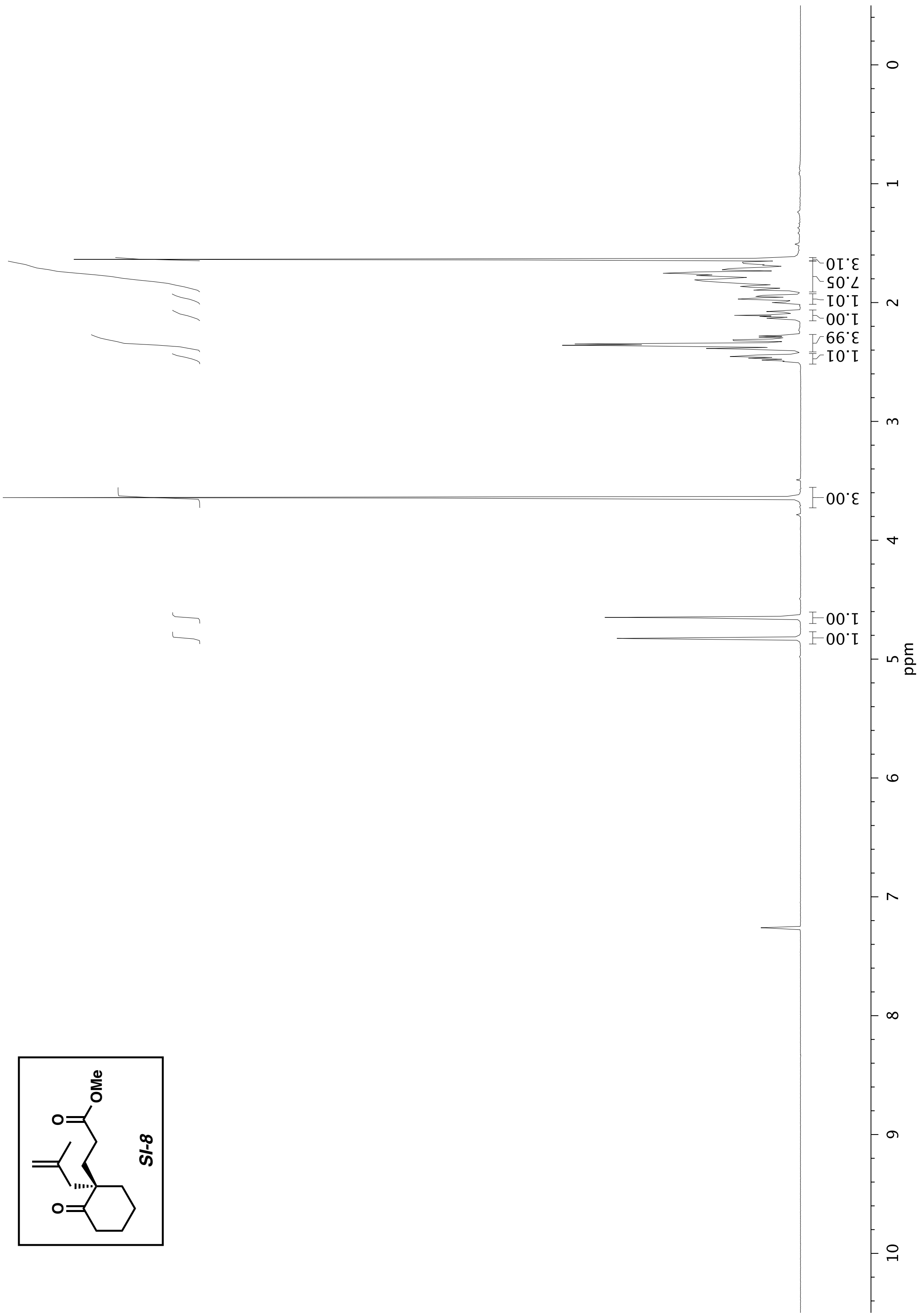
^{1}H NMR (500 MHz, CDCl$_3$) of compound **SI-7**.



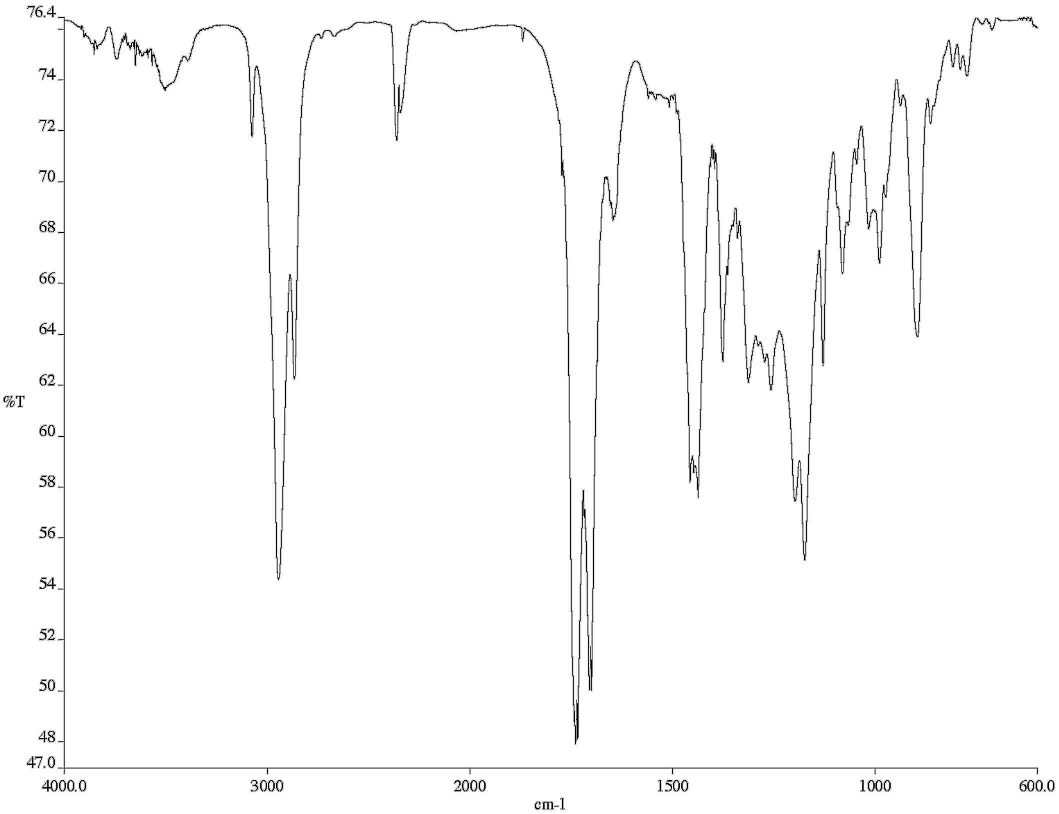
Infrared spectrum (Thin Film, NaCl) of compound **SI-7**.



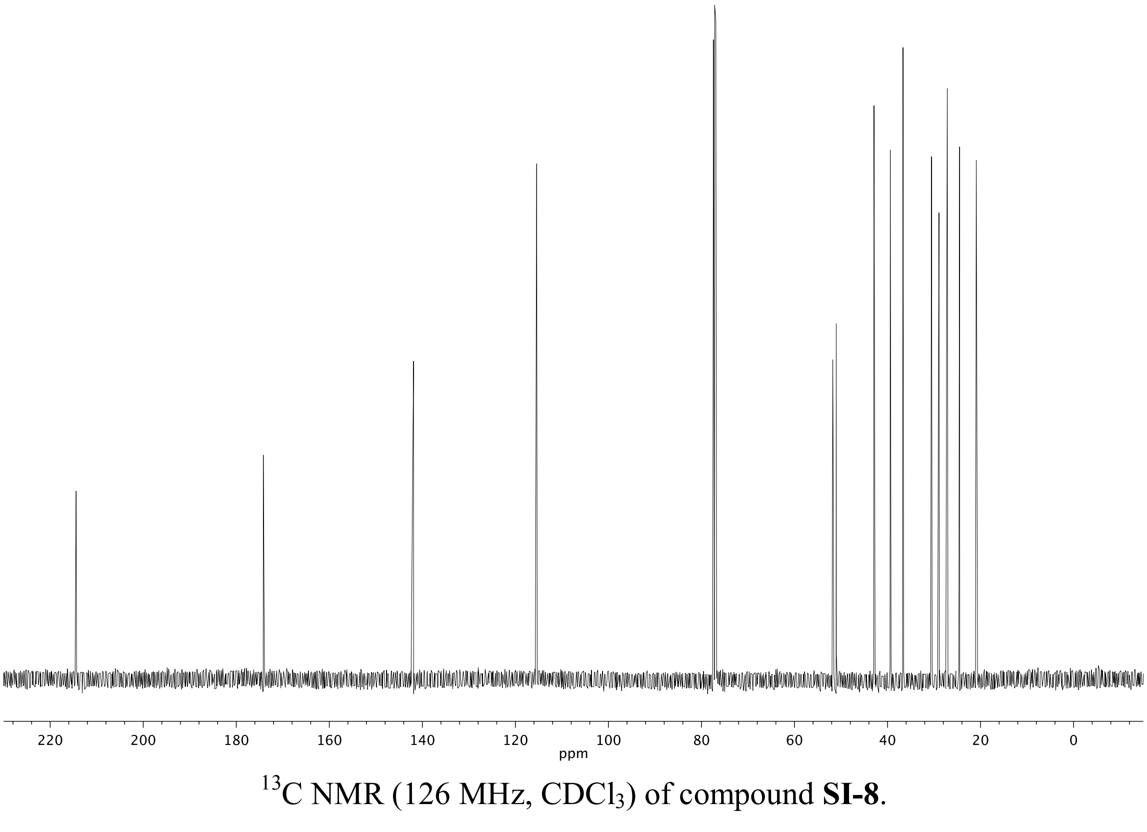
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-7**.



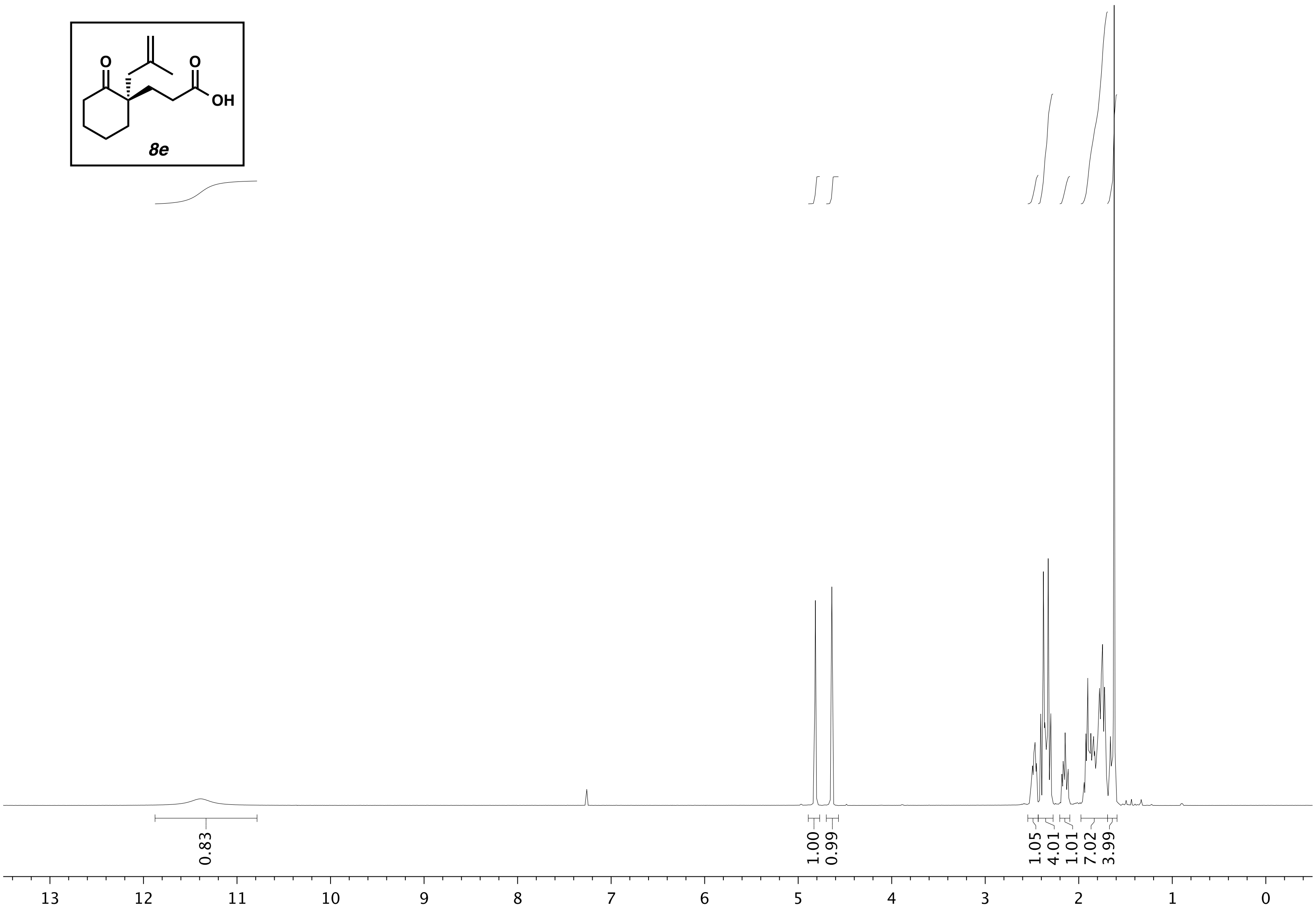
^{1}H NMR (500 MHz, CDCl$_3$) of compound **SI-8**.



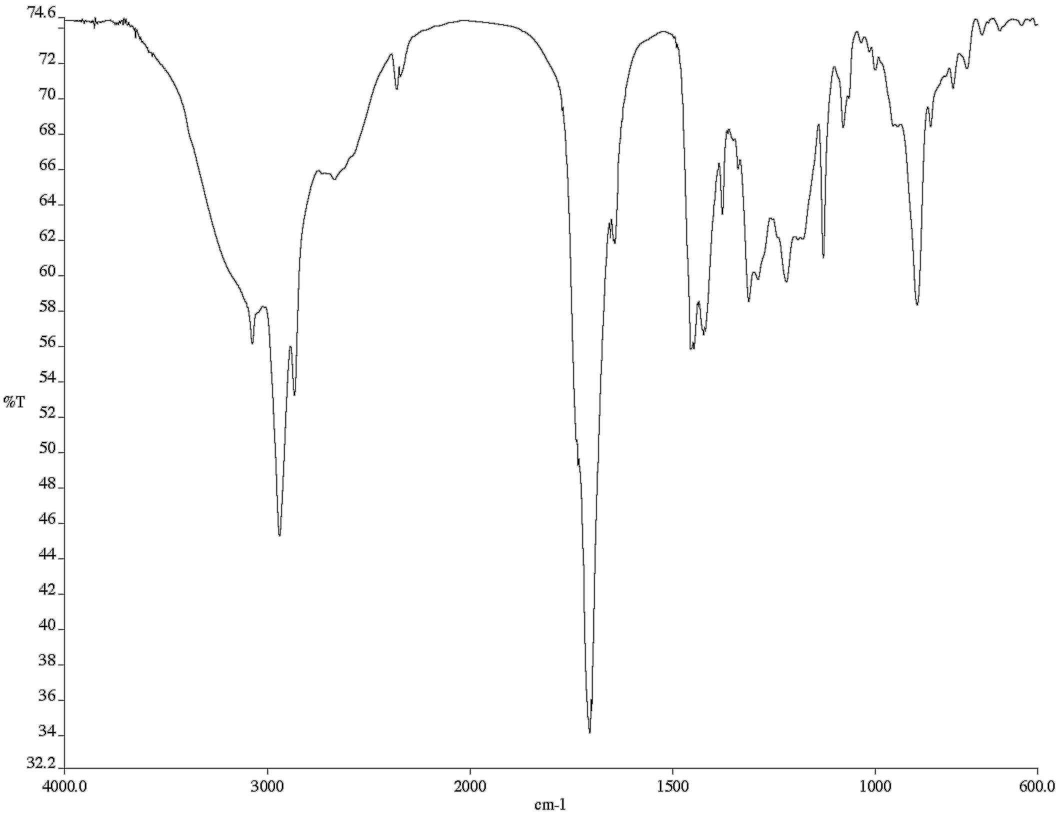
Infrared spectrum (Thin Film, NaCl) of compound **SI-8**.



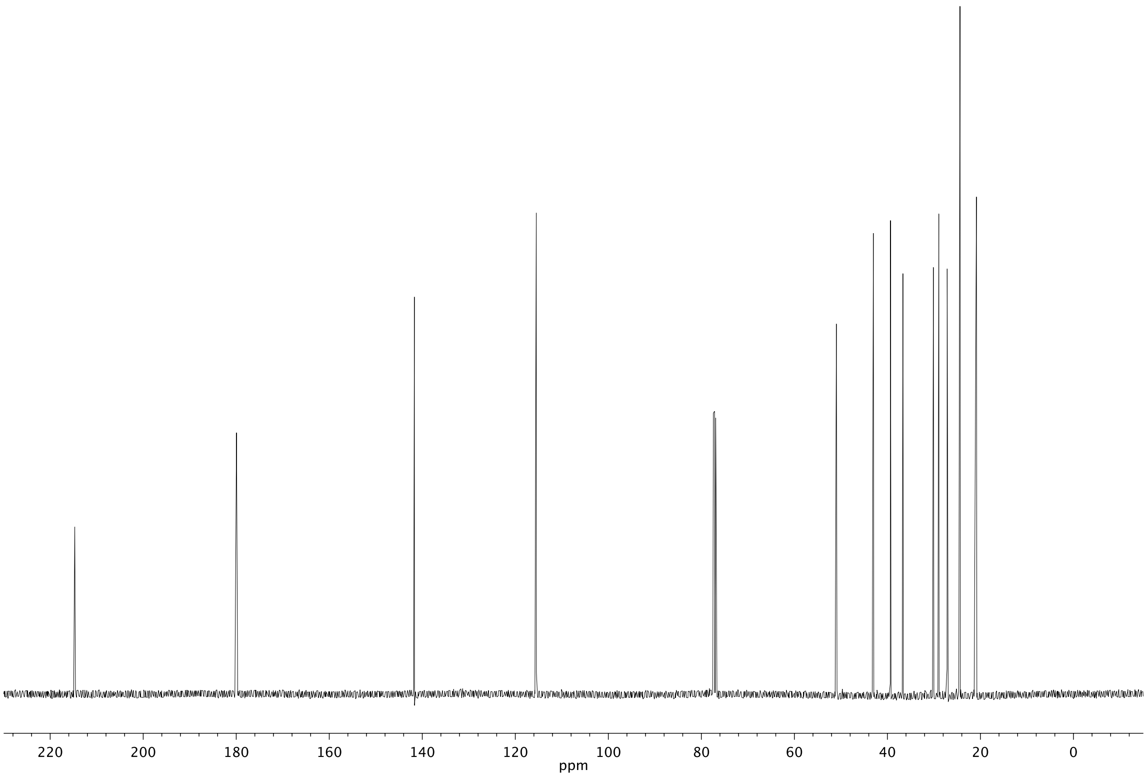
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-8**.



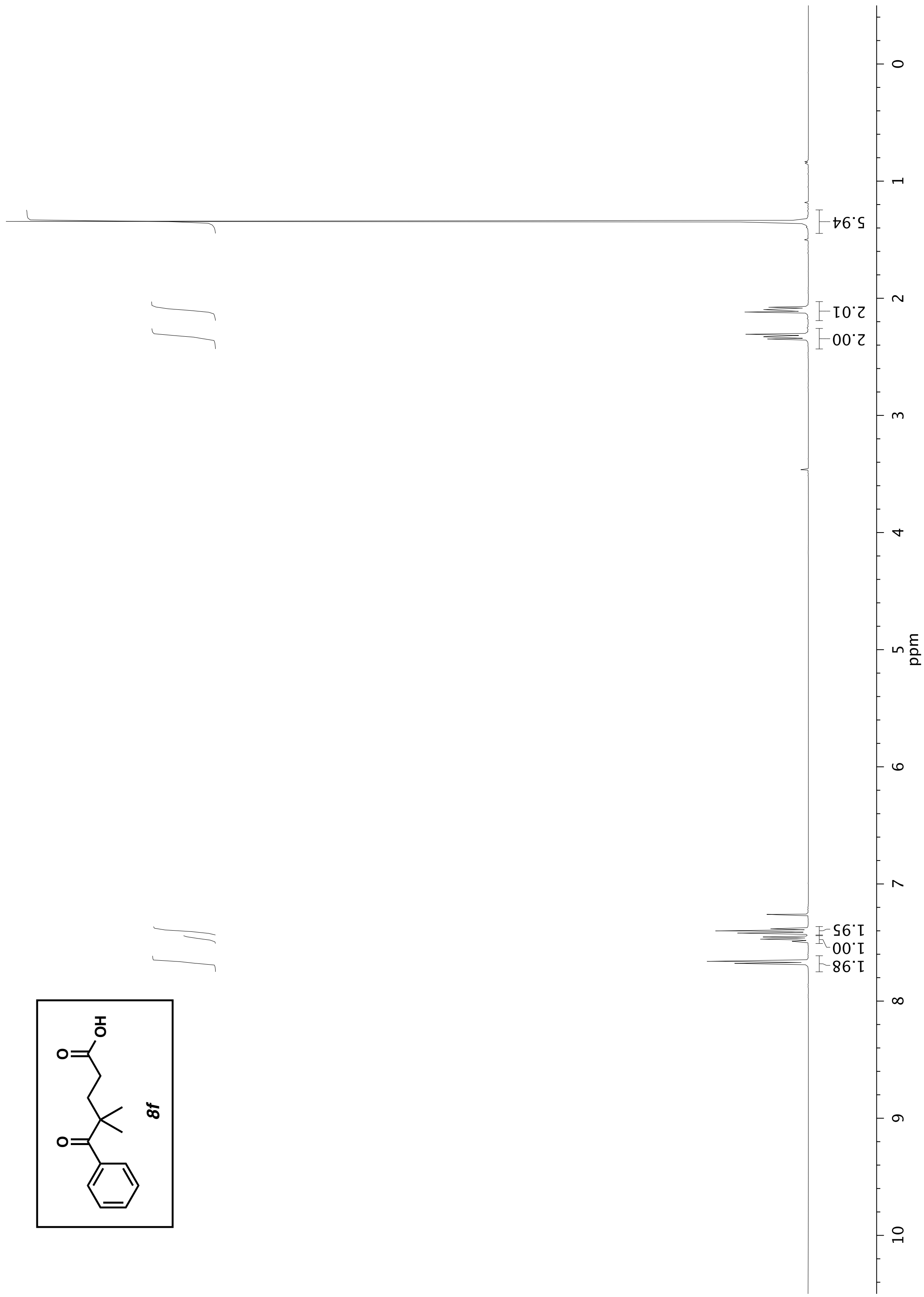
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8e**.



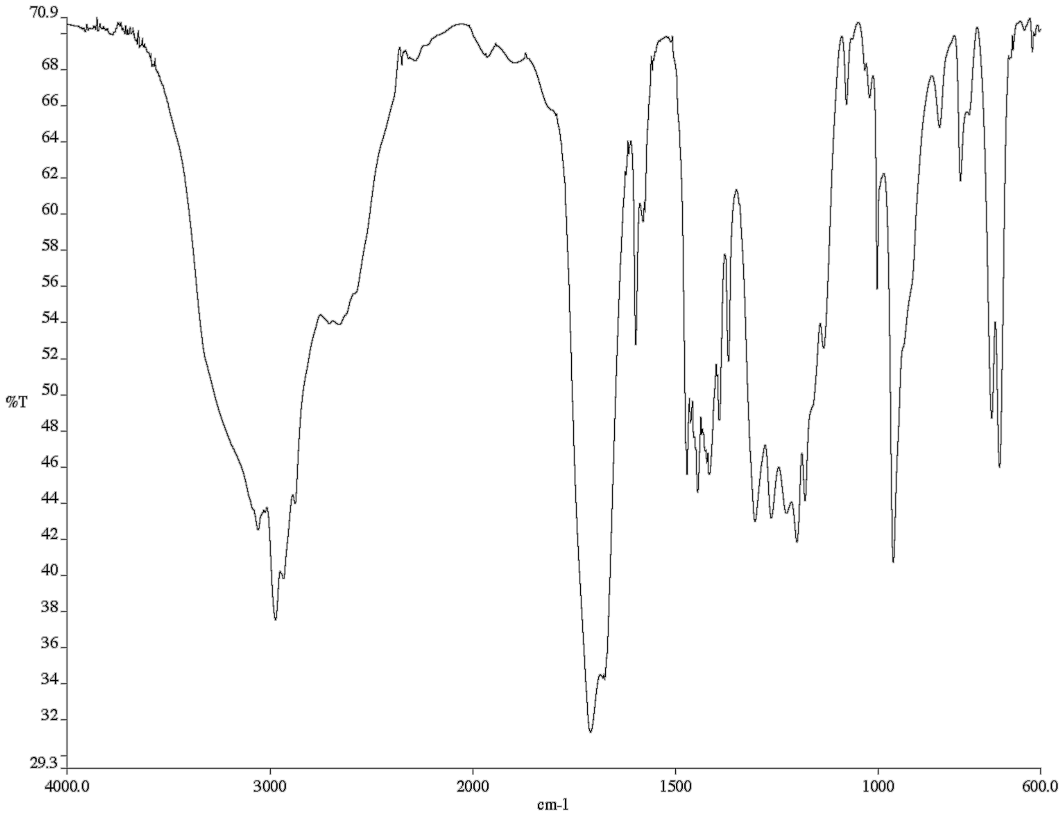
Infrared spectrum (Thin Film, NaCl) of compound **8e**.



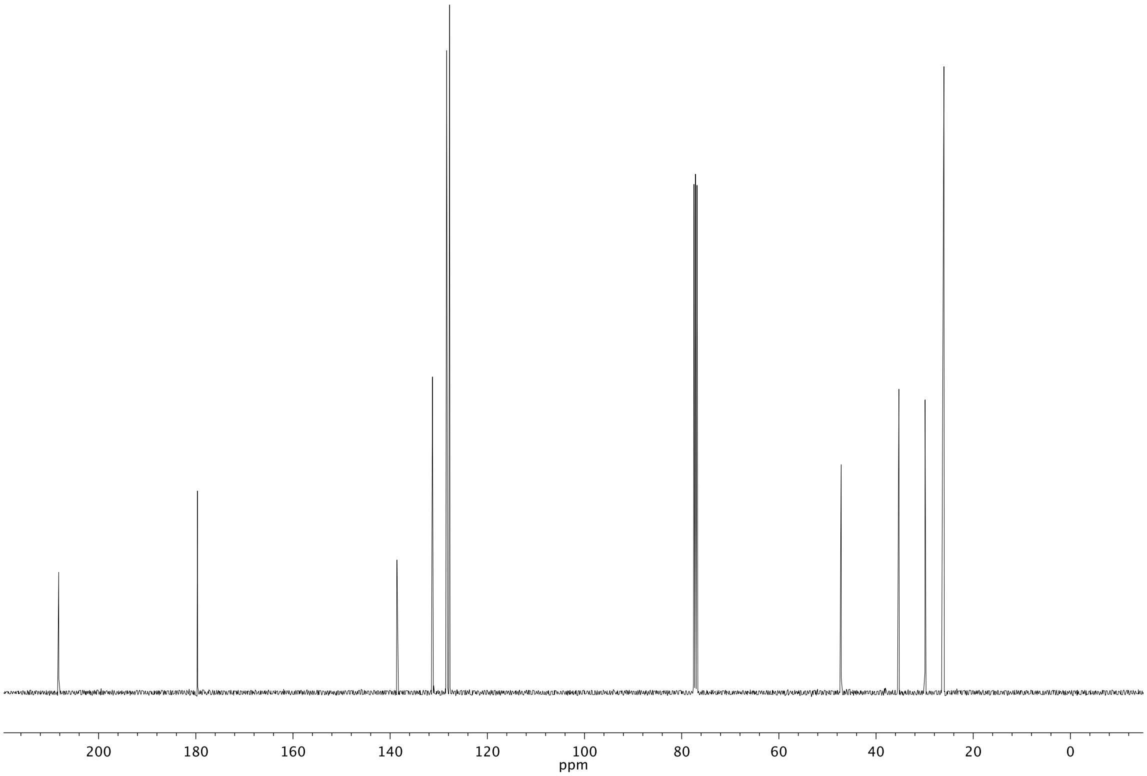
^{13}C NMR (126 MHz, $CDCl_3$) of compound **8e**.



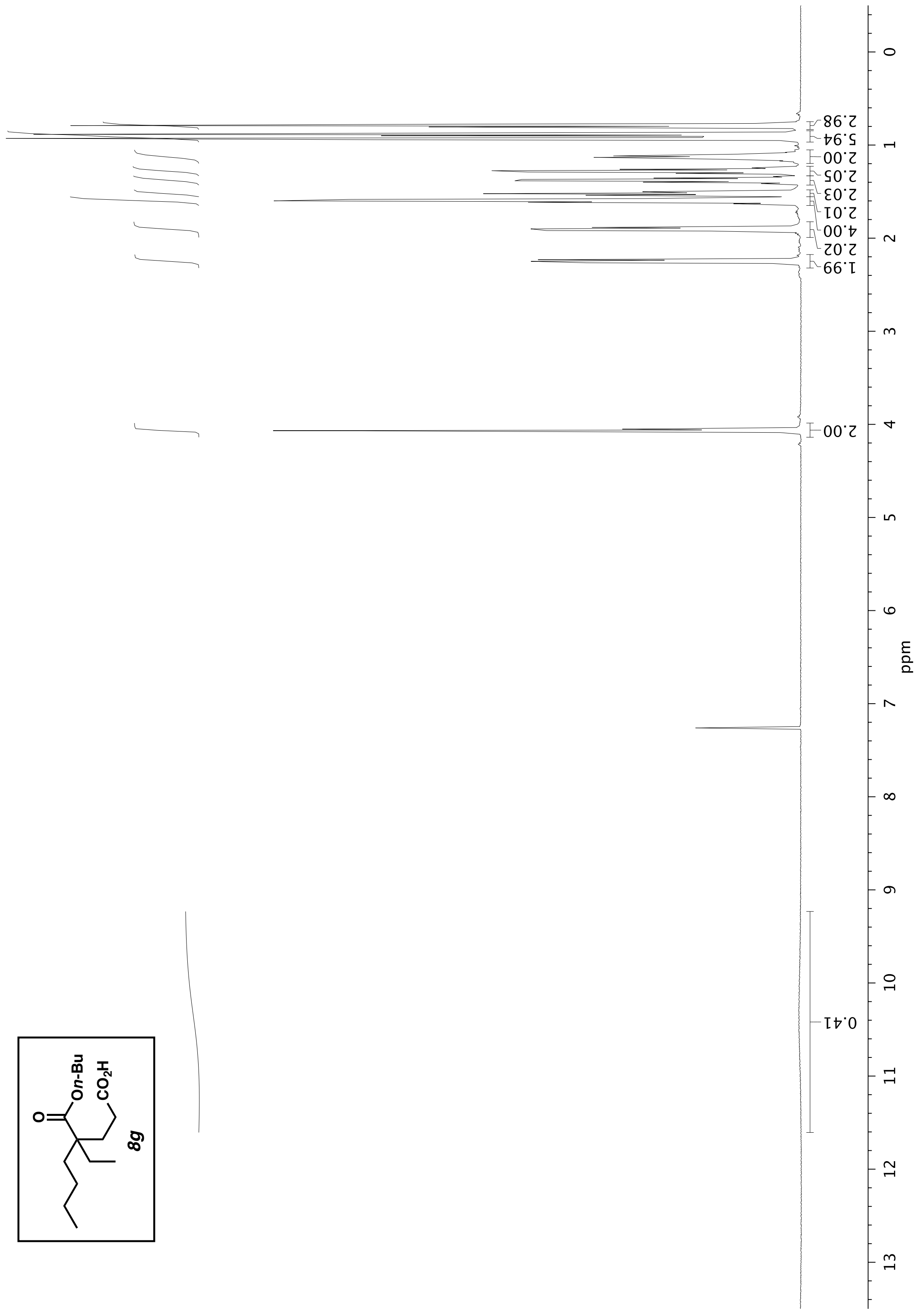
^{1}H NMR (400 MHz, $CDCl_3$) of compound **8f**.



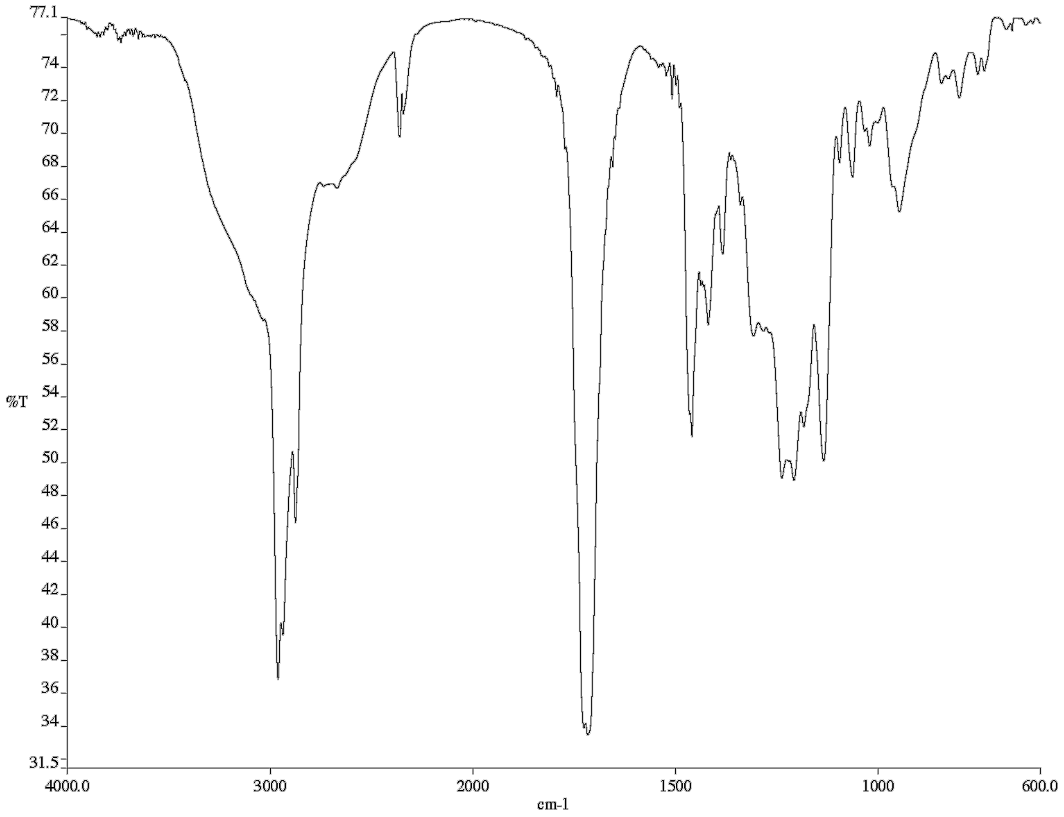
Infrared spectrum (Thin Film, NaCl) of compound **8f**.



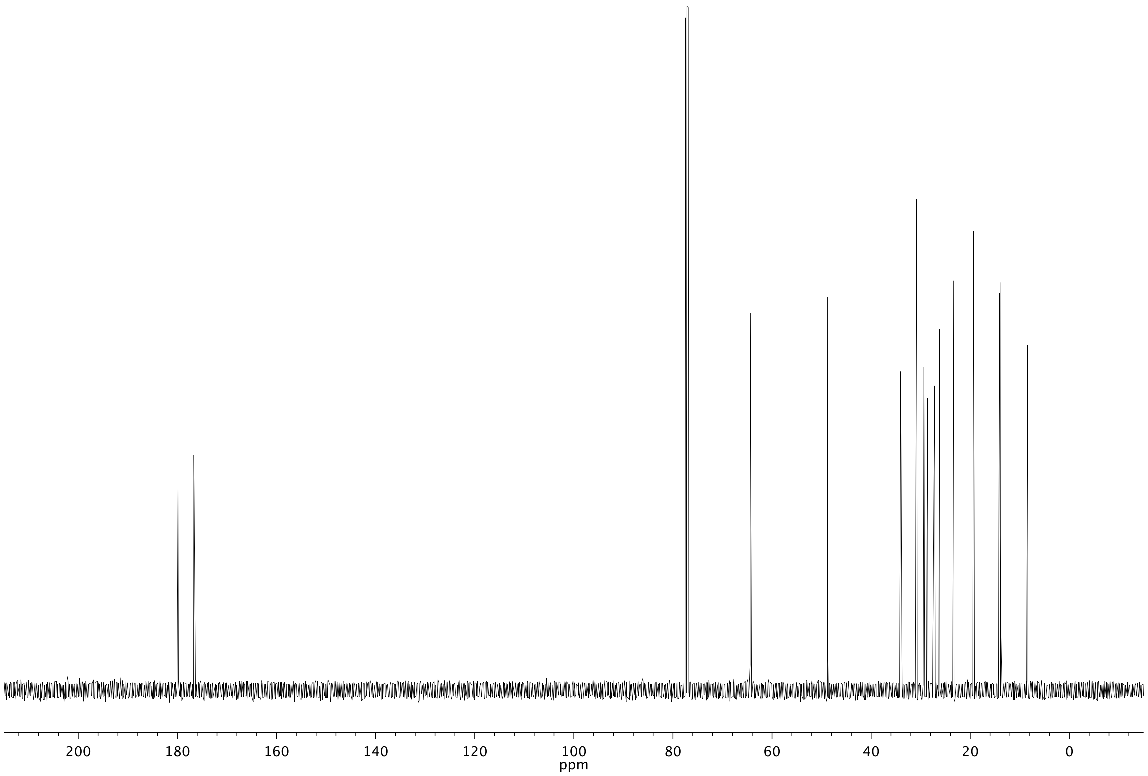
^{13}C NMR (101 MHz, CDCl$_3$) of compound **8f**.



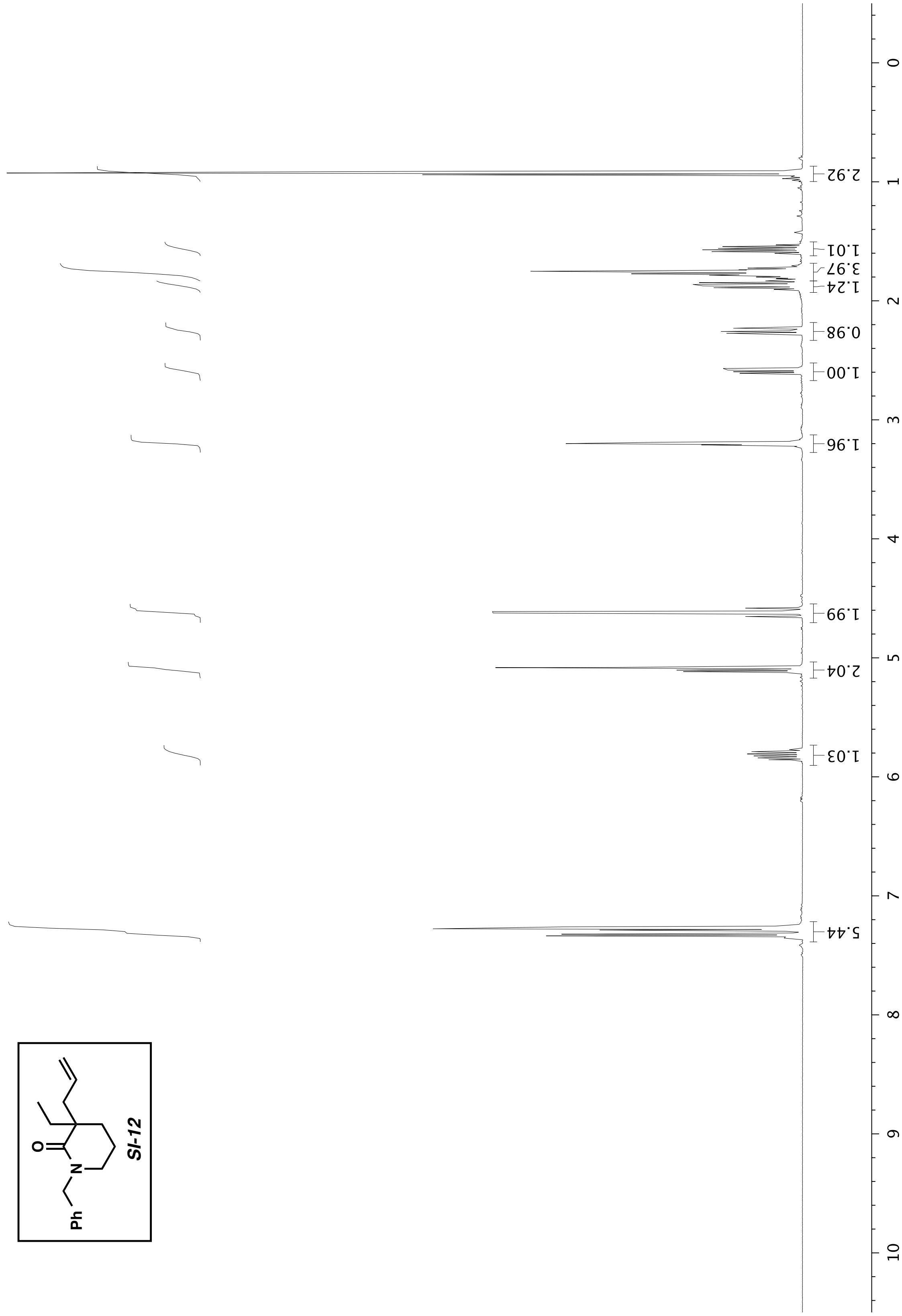
^{1}H NMR (500 MHz, CDCl$_3$) of compound **8g**.



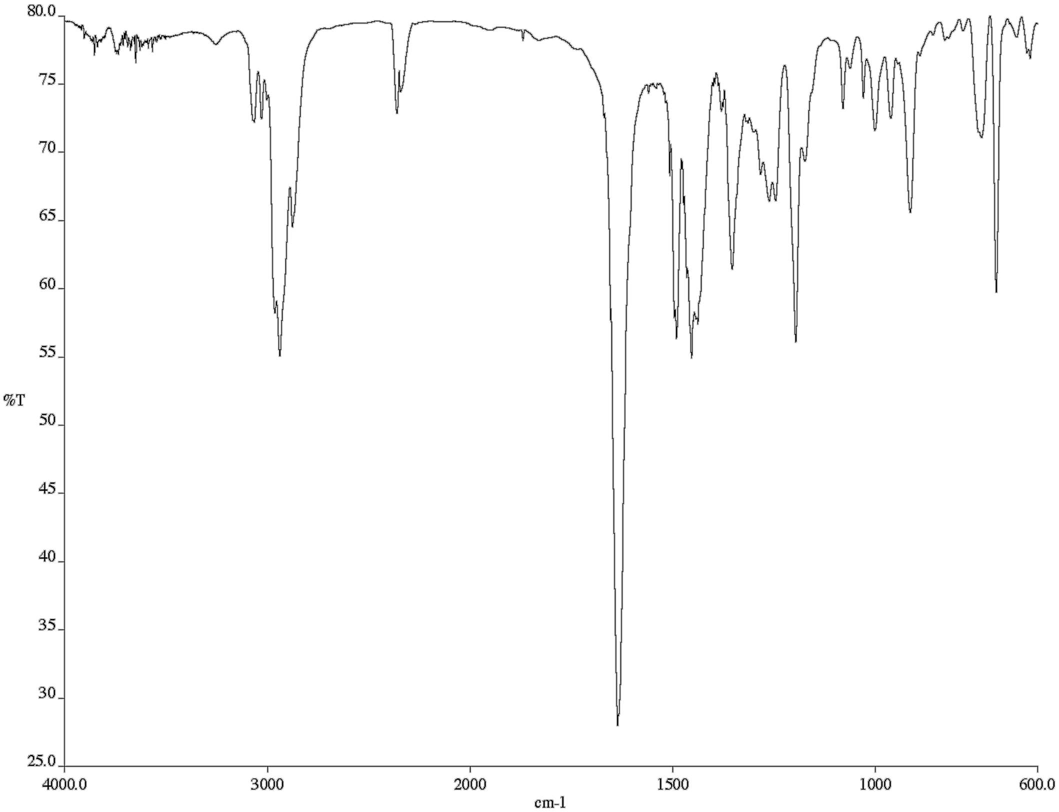
Infrared spectrum (Thin Film, NaCl) of compound **8g**.



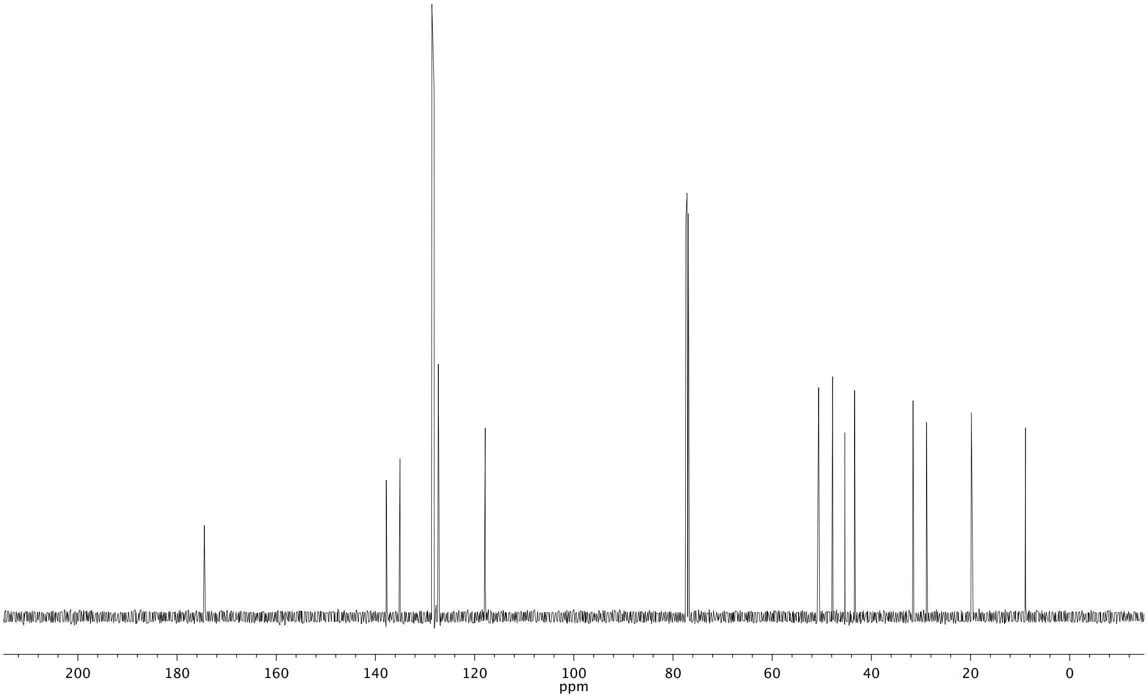
^{13}C NMR (126 MHz, CDCl$_3$) of compound **8g**.



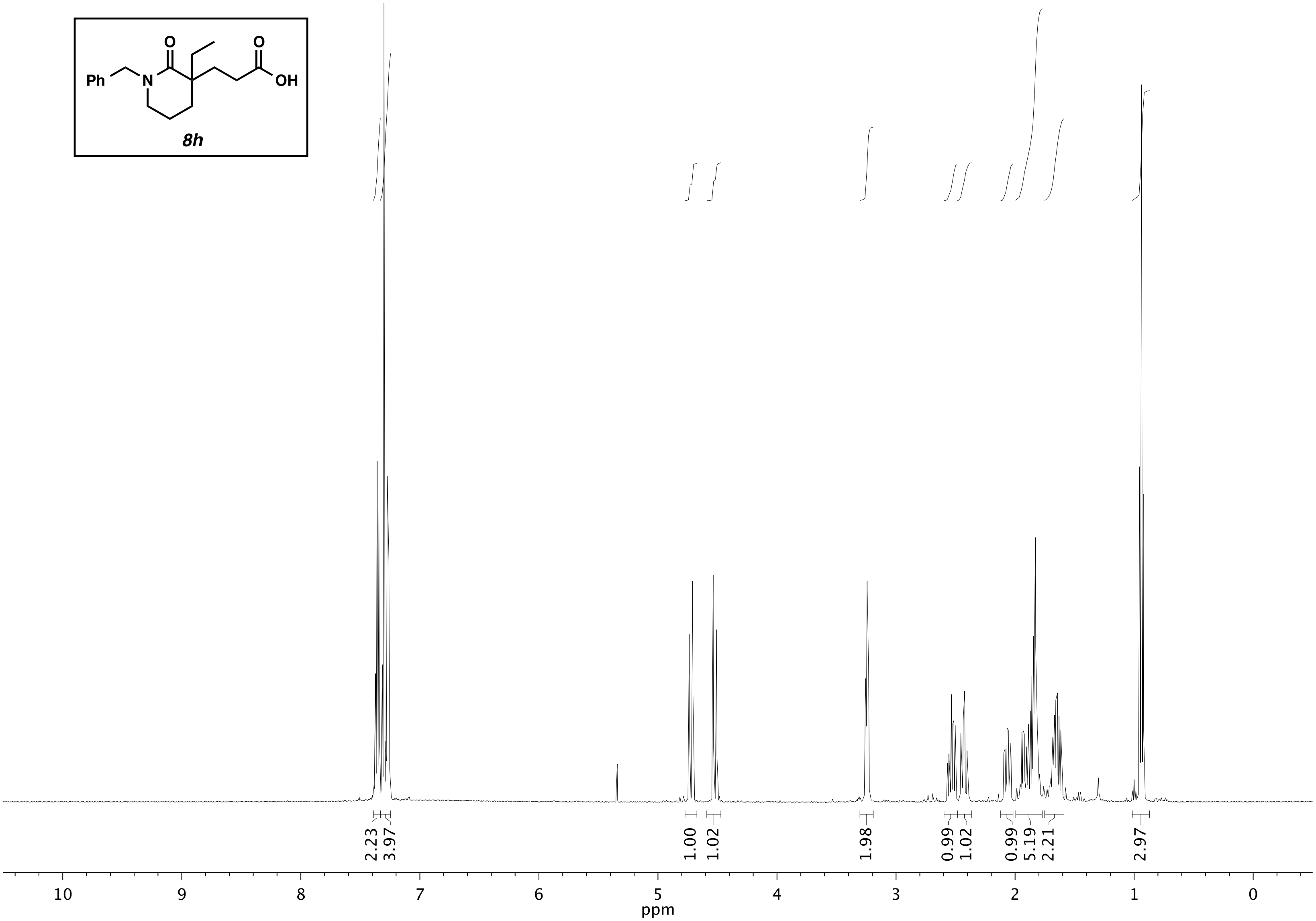
^{1}H NMR (500 MHz, CDCl$_3$) of compound **SI-12**.



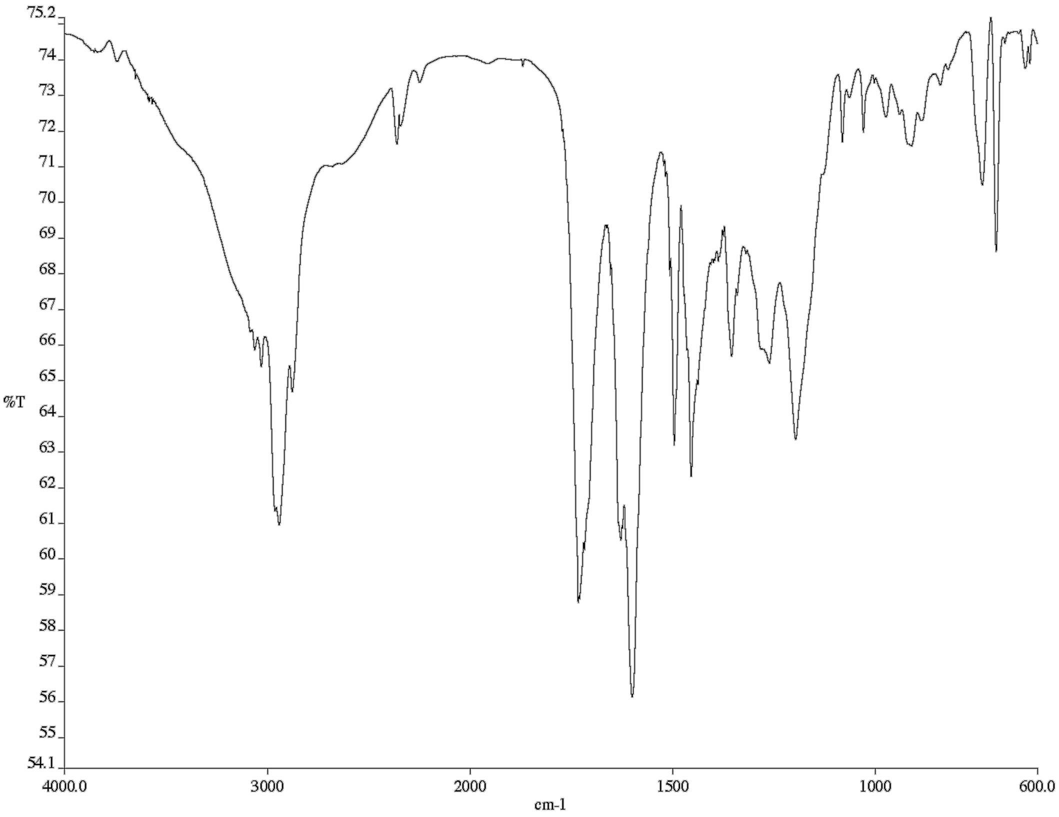
Infrared spectrum (Thin Film, NaCl) of compound **SI-12**.



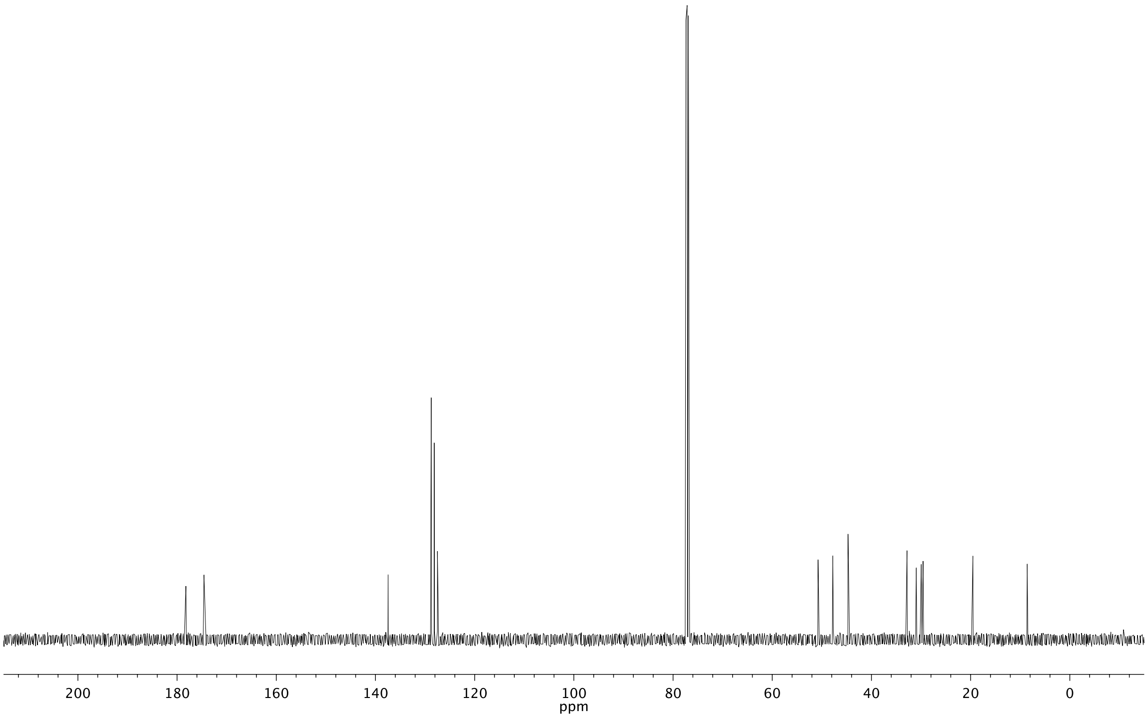
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-12**.



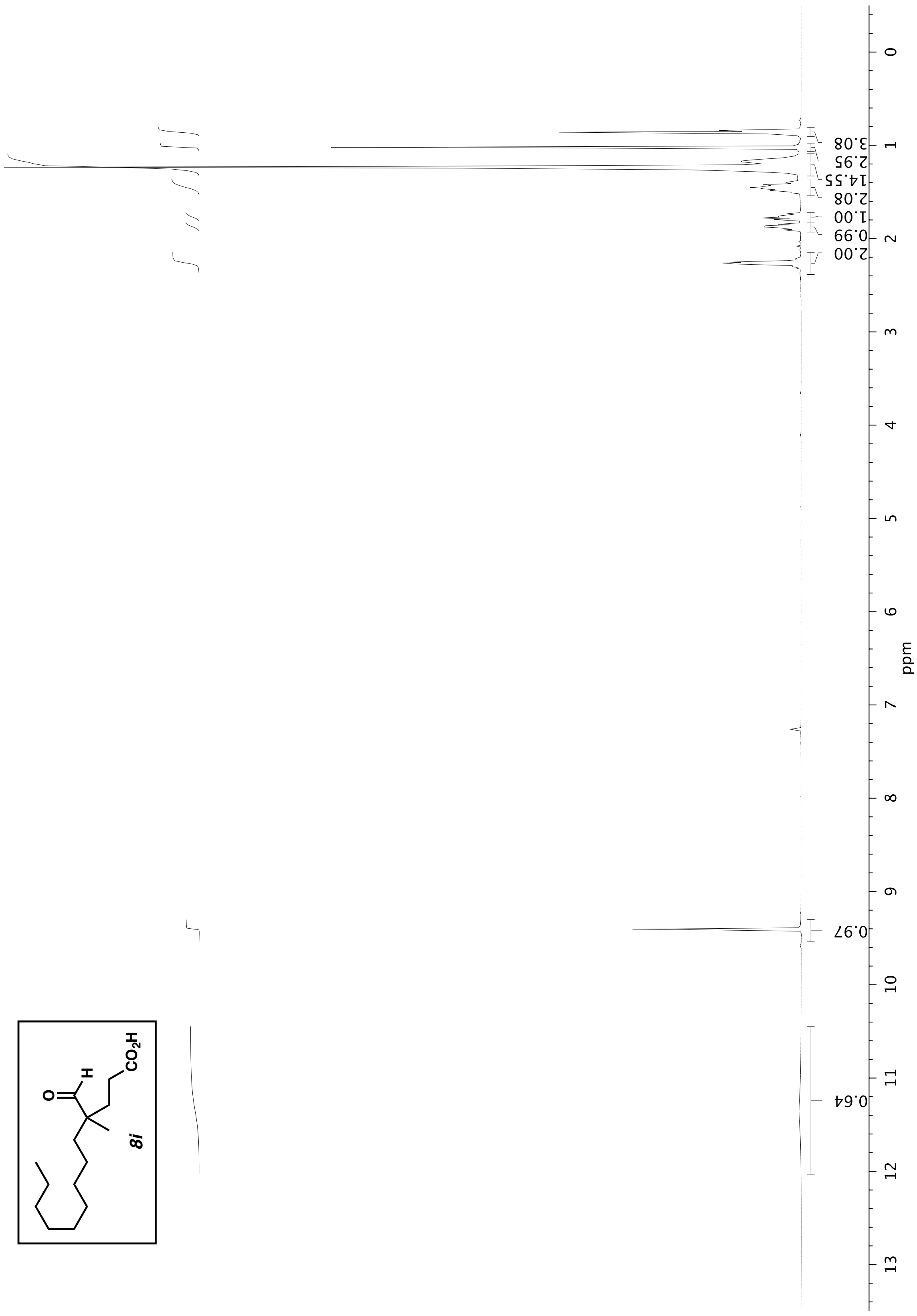
^{1}H NMR (500 MHz, CDCl$_3$) of compound **8h**.



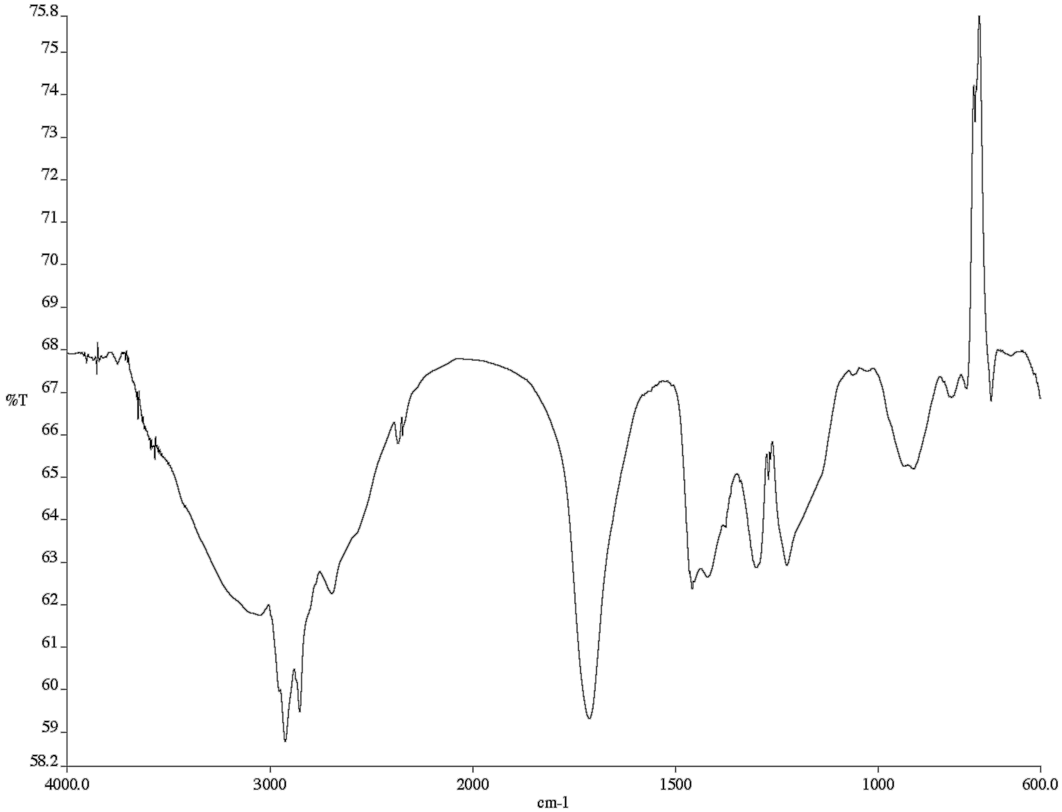
Infrared spectrum (Thin Film, NaCl) of compound **8h**.



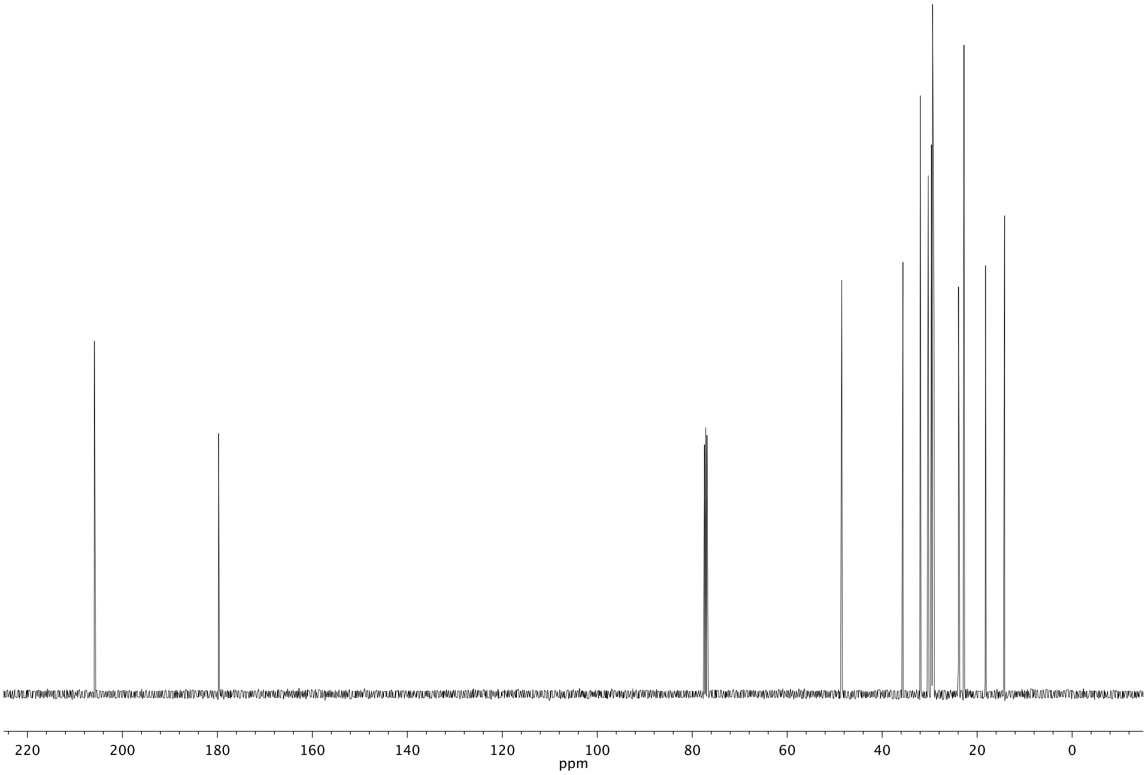
^{13}C NMR (126 MHz, CDCl$_3$) of compound **8h**.



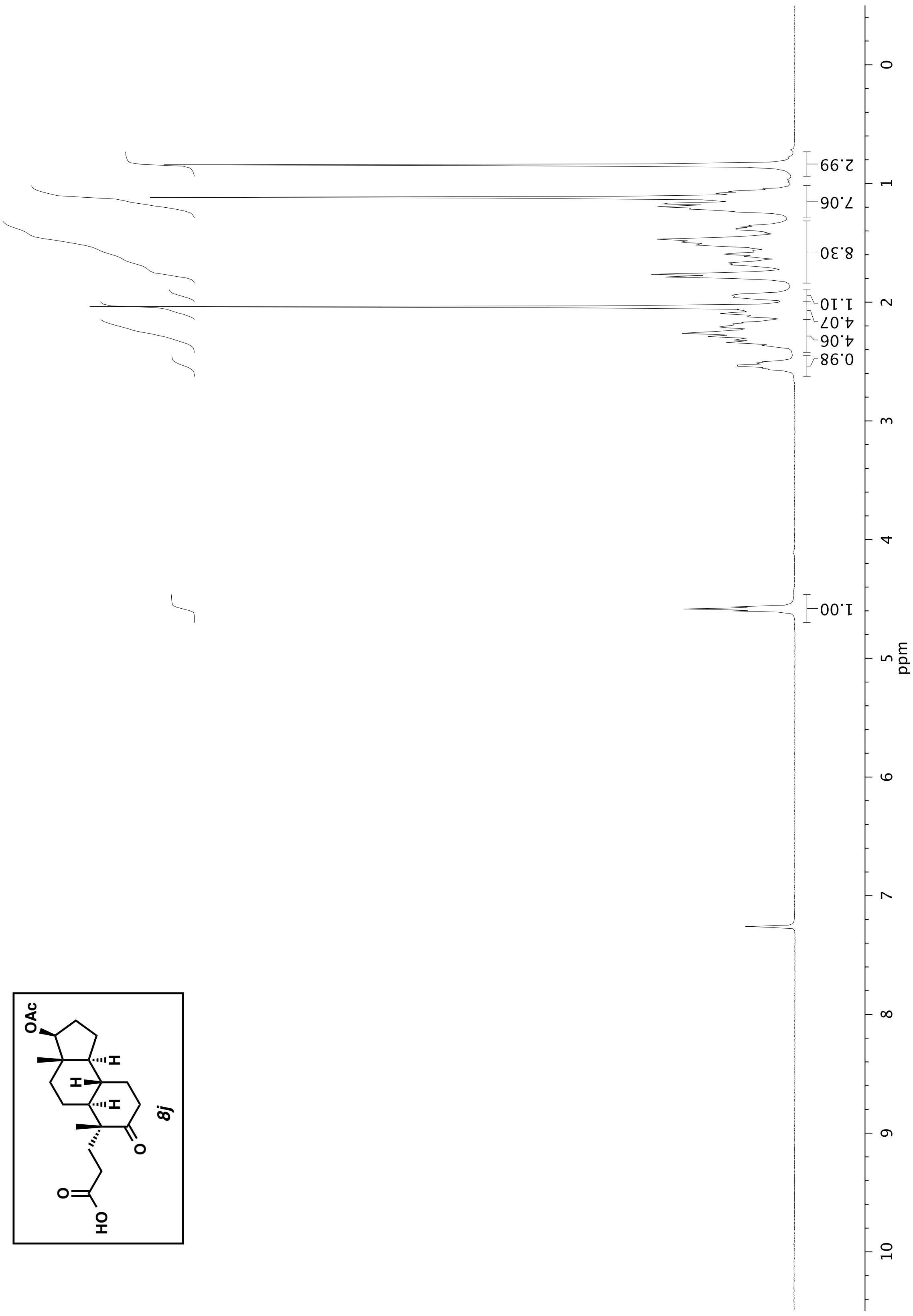
^{1}H NMR (500 MHz, CDCl$_3$) of compound **8i**.



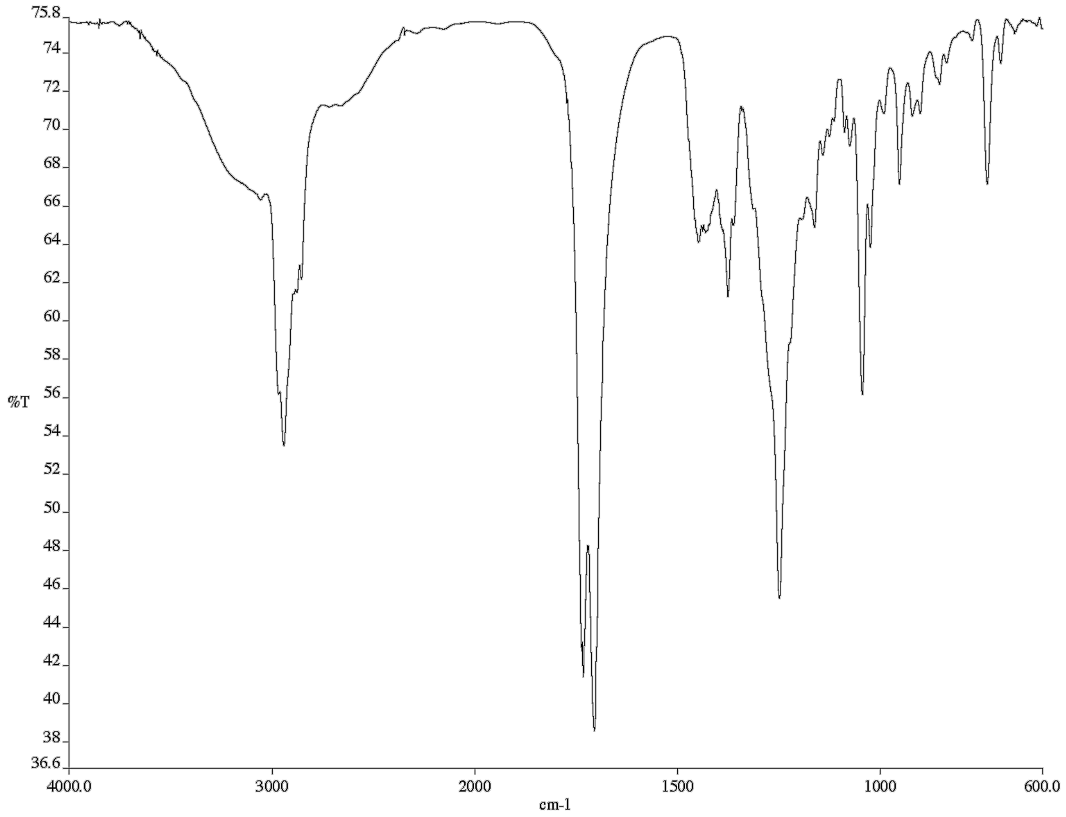
Infrared spectrum (Thin Film, NaCl) of compound **8i**.



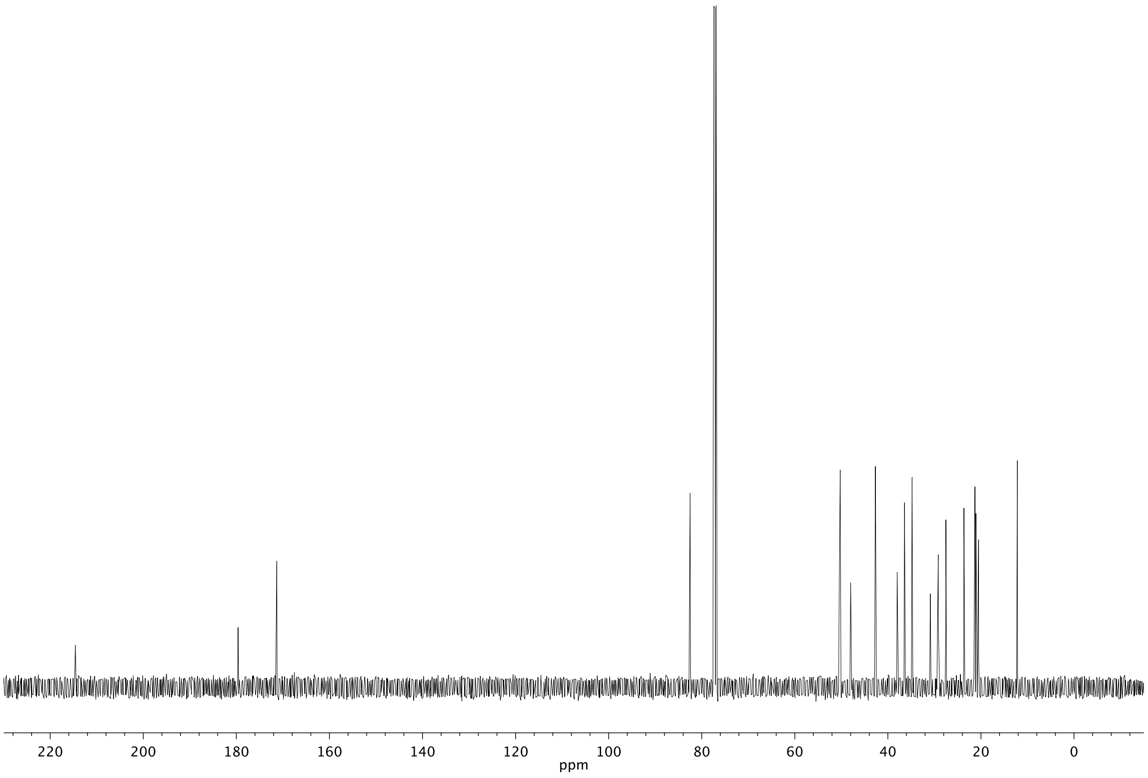
^{13}C NMR (126 MHz, CDCl$_3$) of compound **8i**.



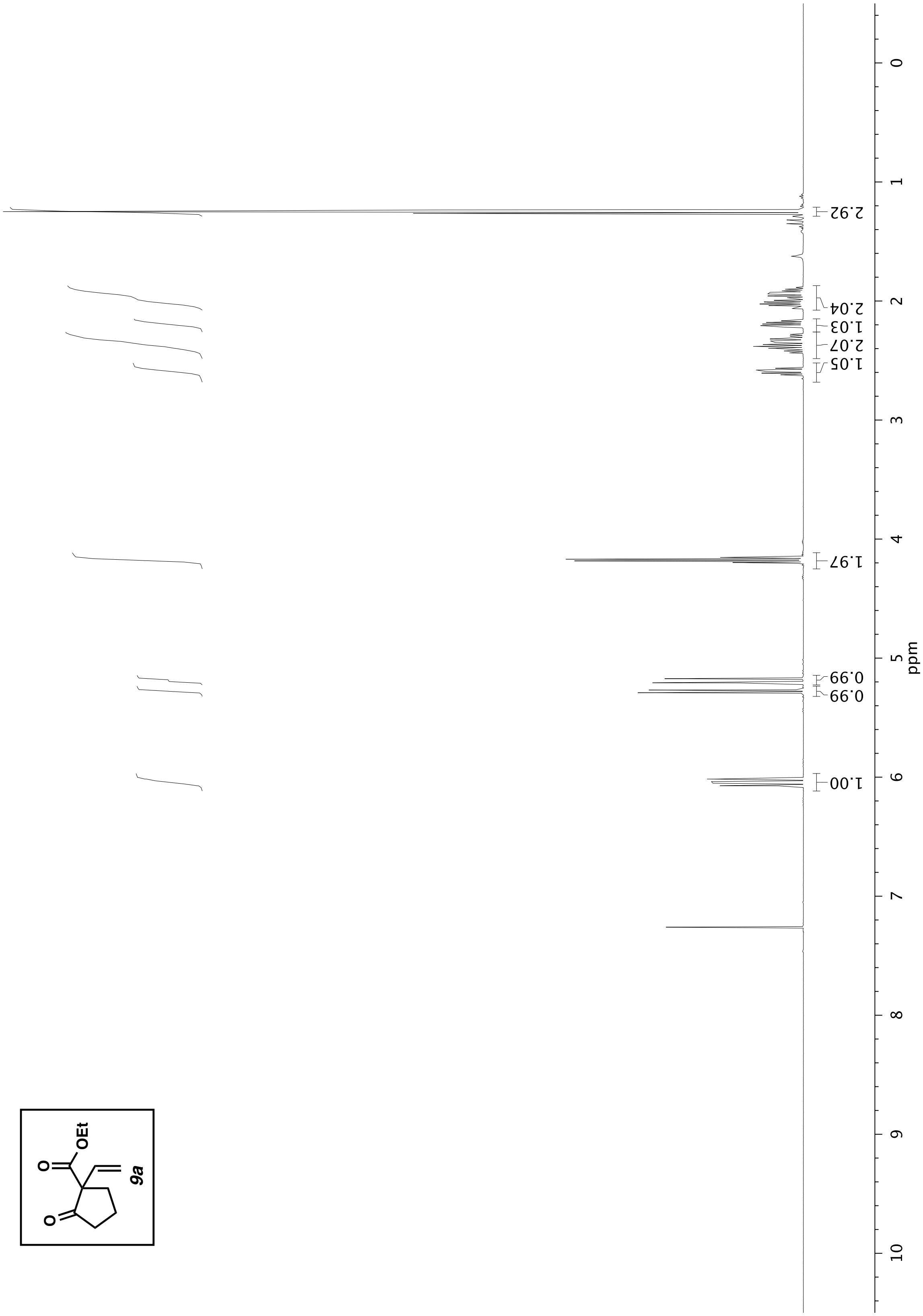
^{1}H NMR (500 MHz, CDCl$_3$) of compound **8j**.



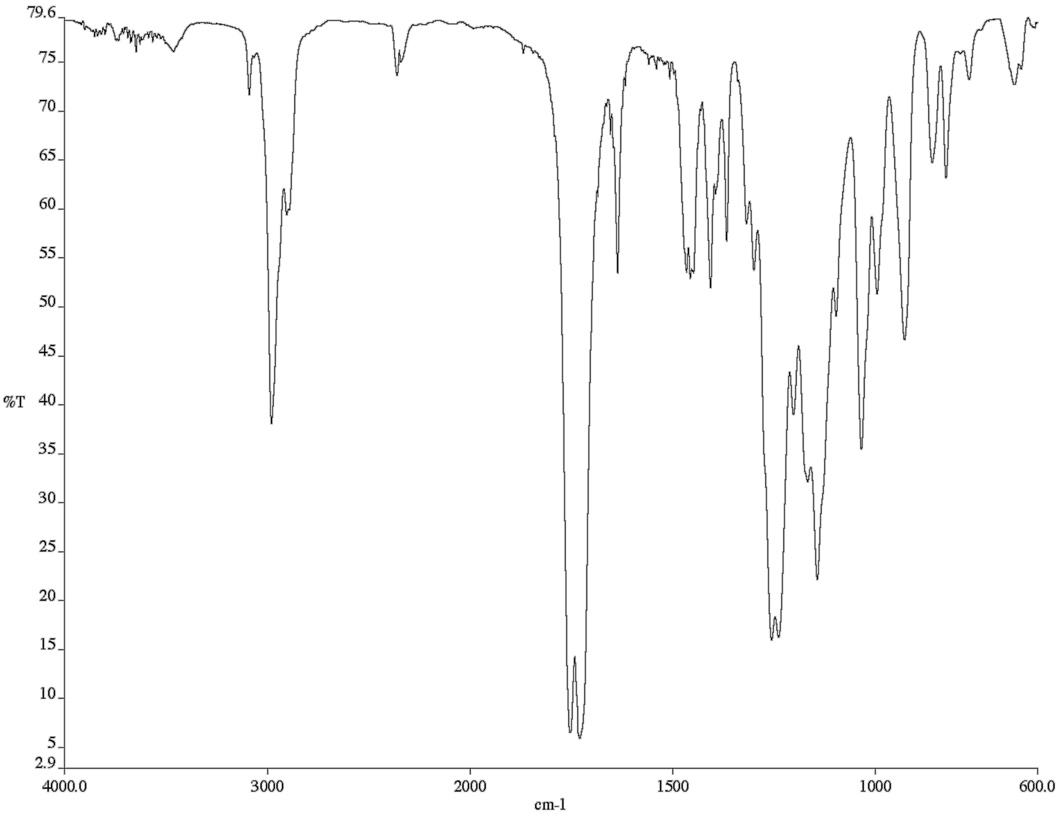
Infrared spectrum (Thin Film, NaCl) of compound **8j**.



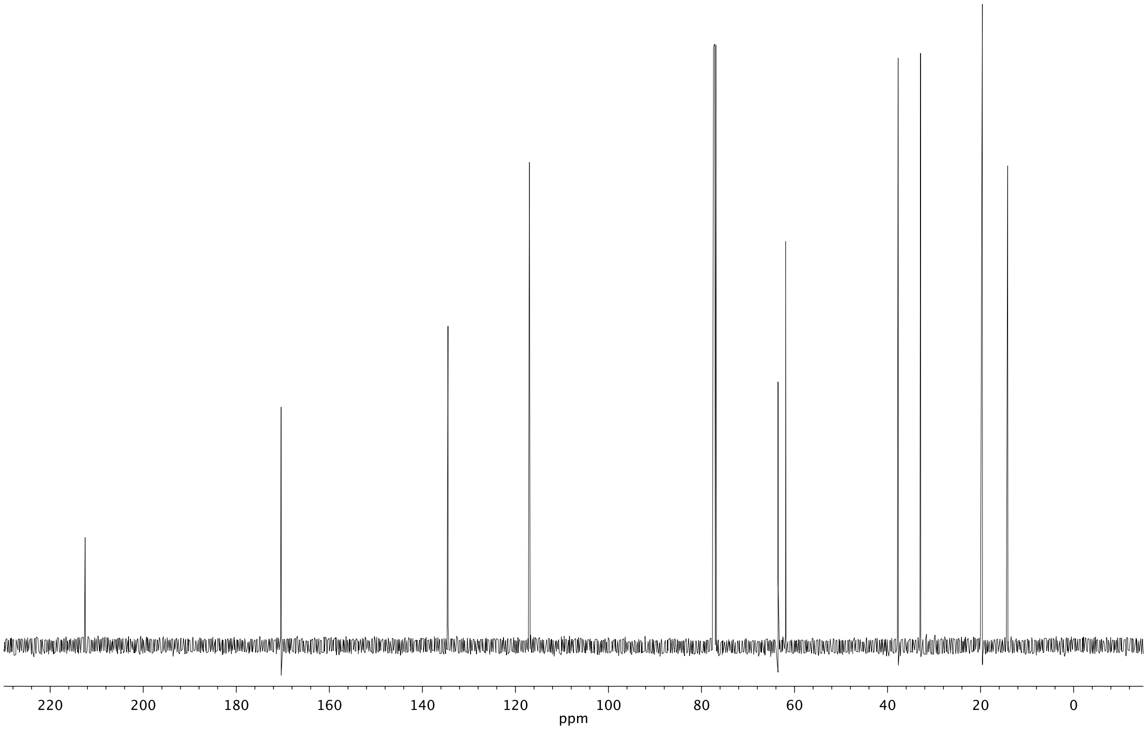
^{13}C NMR (126 MHz, CDCl$_3$) of compound **8j**.



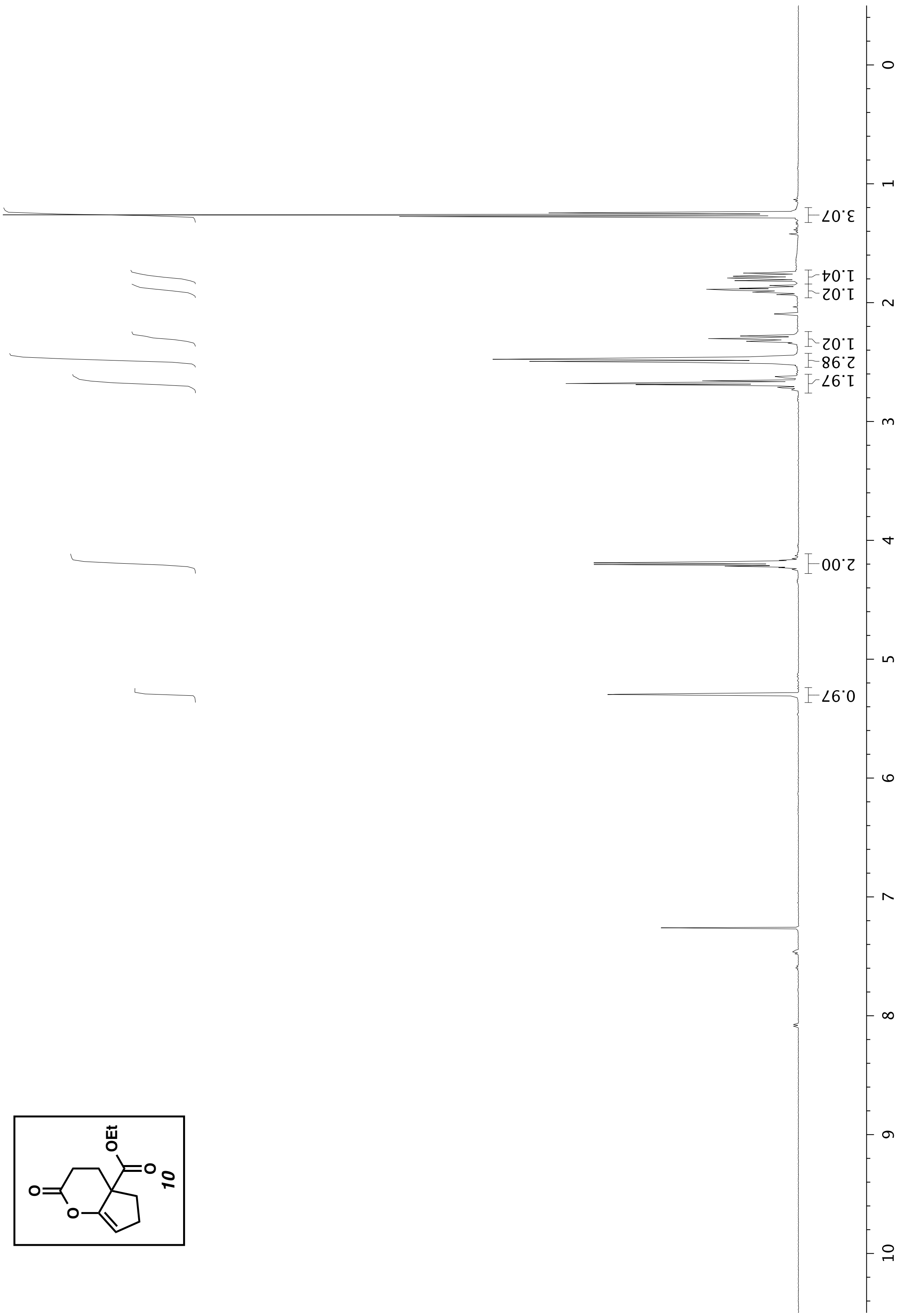
^{1}H NMR (500 MHz, $CDCl_3$) of compound **9a**.



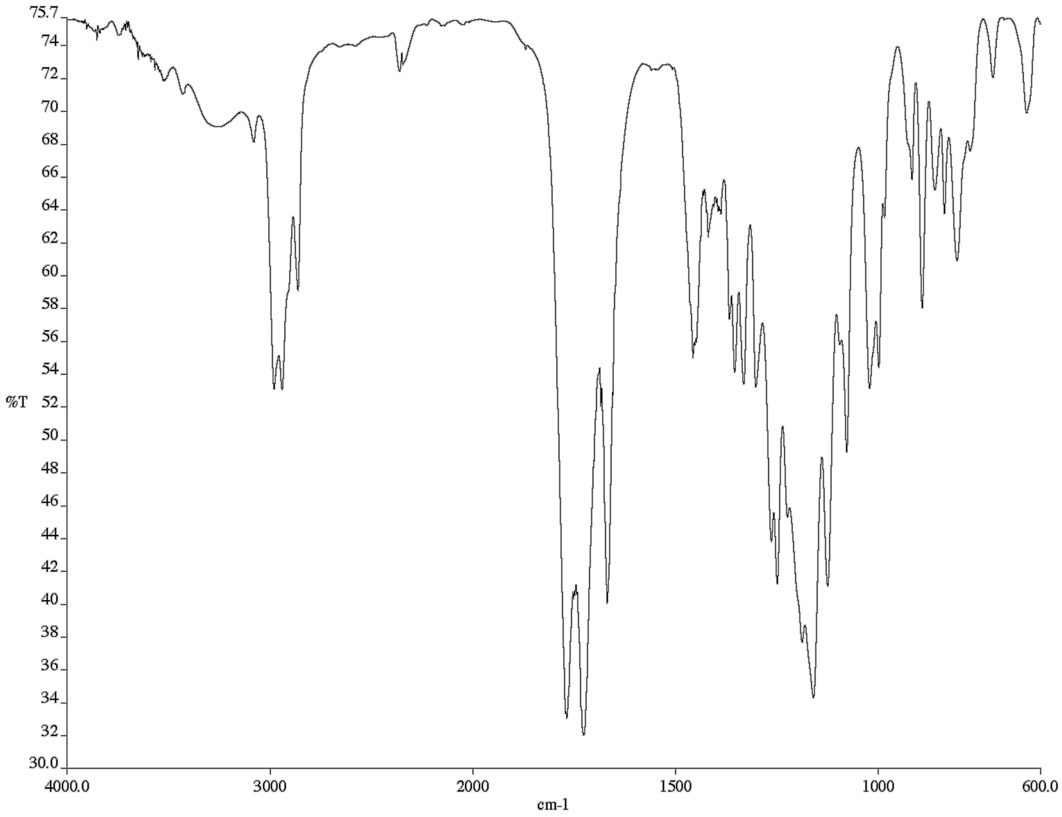
Infrared spectrum (Thin Film, NaCl) of compound **9a**.



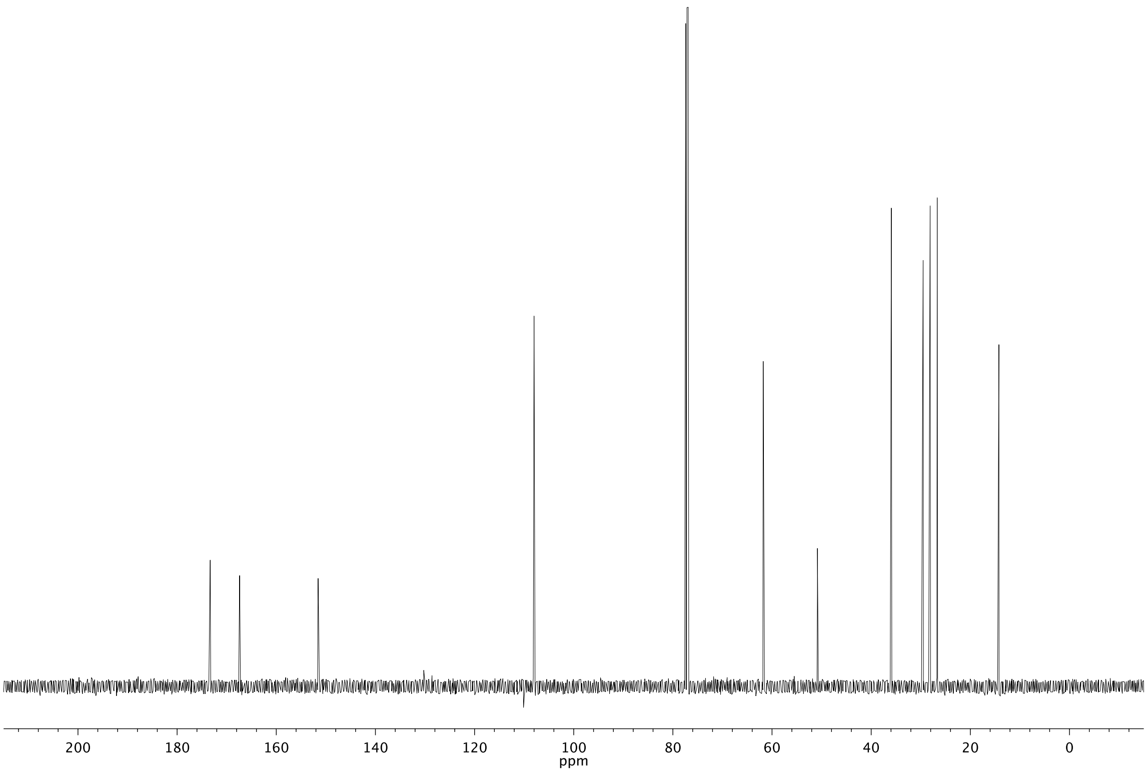
^{13}C NMR (126 MHz, CDCl$_3$) of compound **9a**.



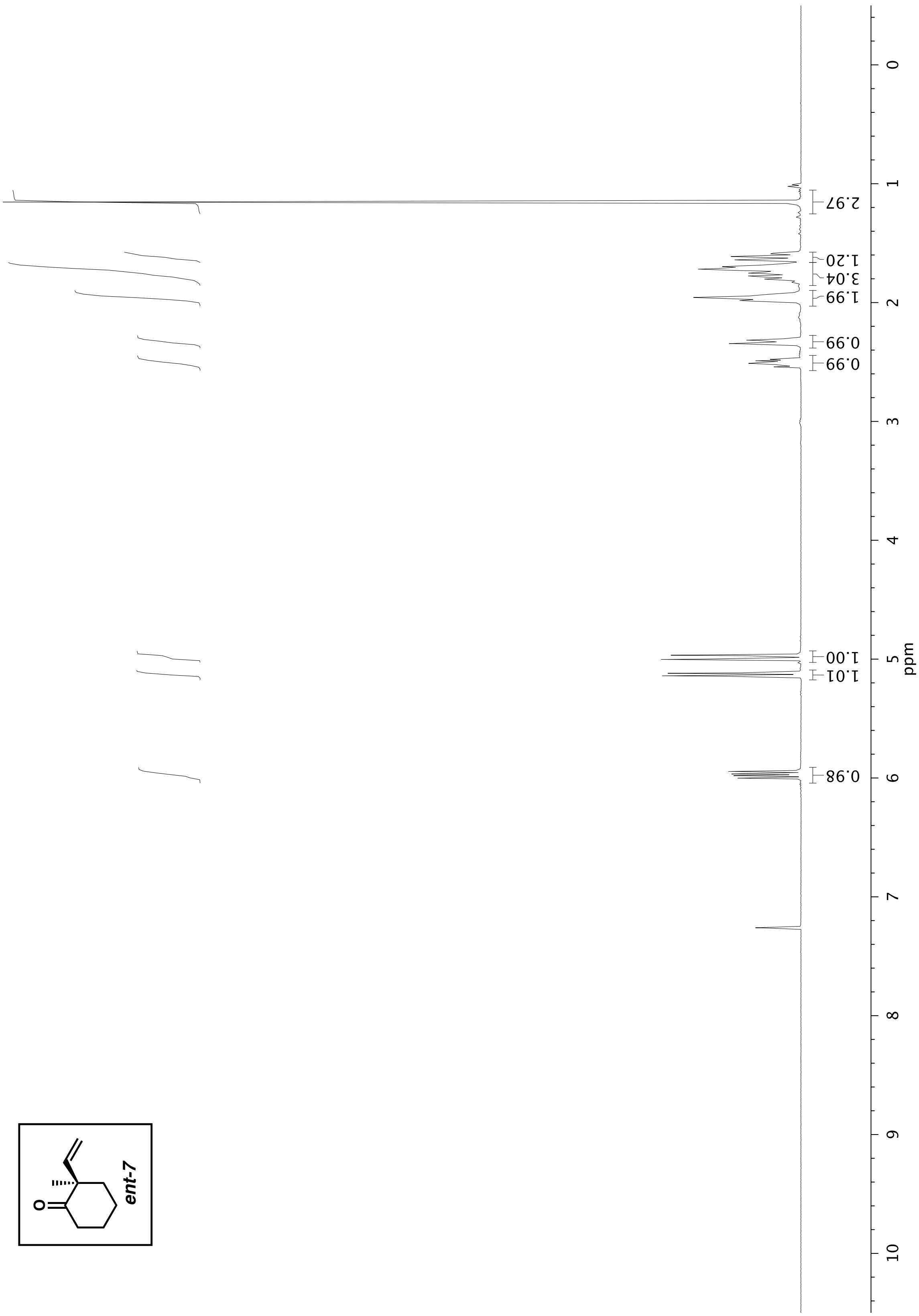
^{1}H NMR (500 MHz, CDCl$_3$) of compound **10**.



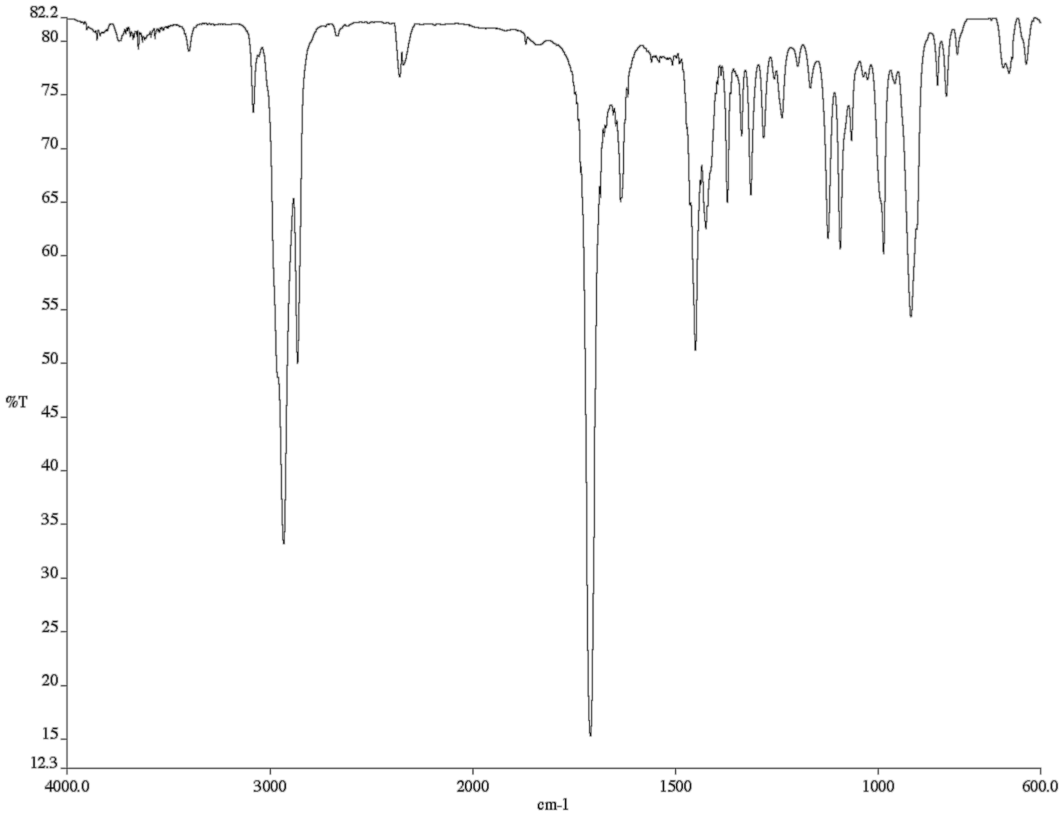
Infrared spectrum (Thin Film, NaCl) of compound **10**.



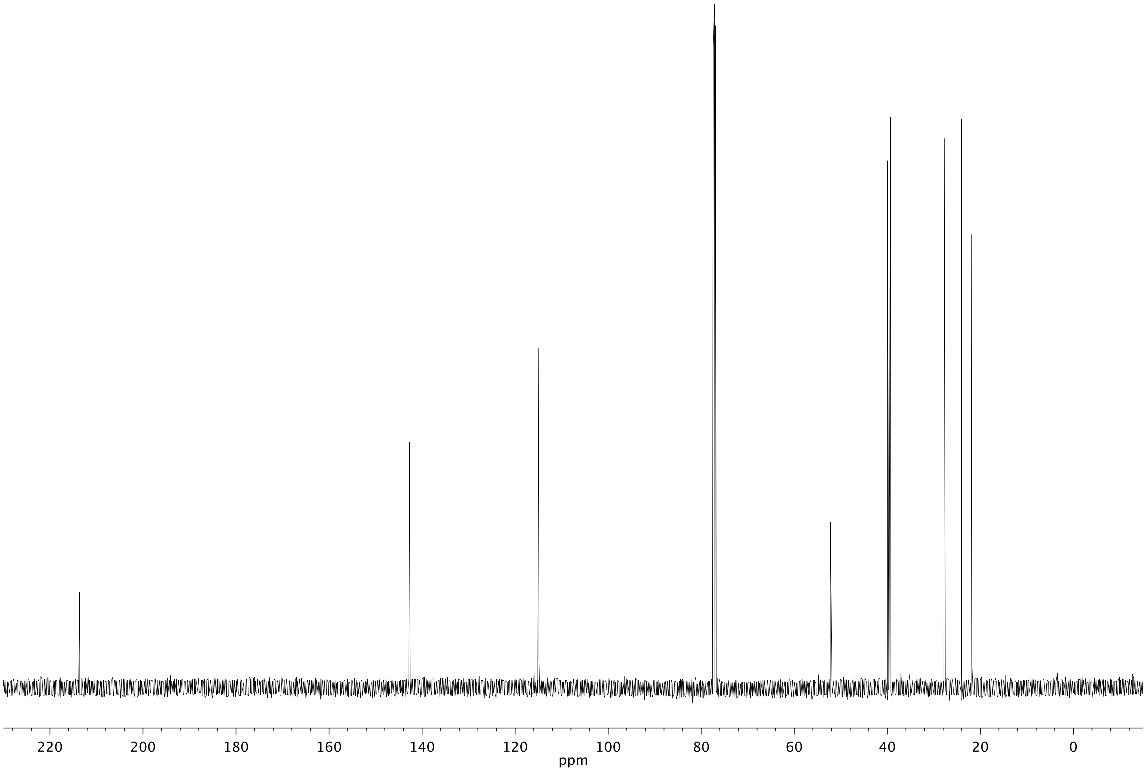
^{13}C NMR (126 MHz, CDCl$_3$) of compound **10**.



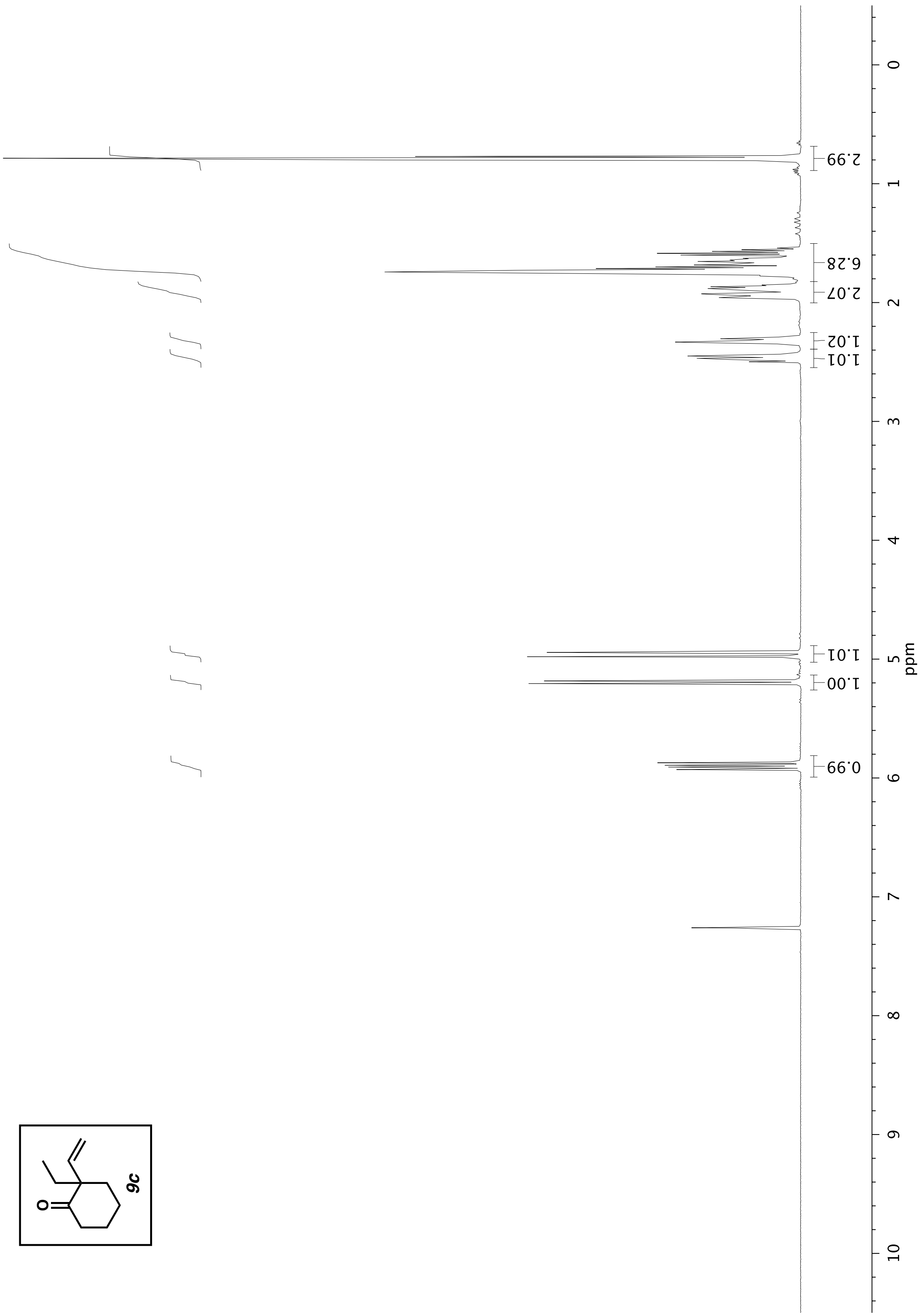
^{1}H NMR (500 MHz, CDCl$_3$) of compound **7**.



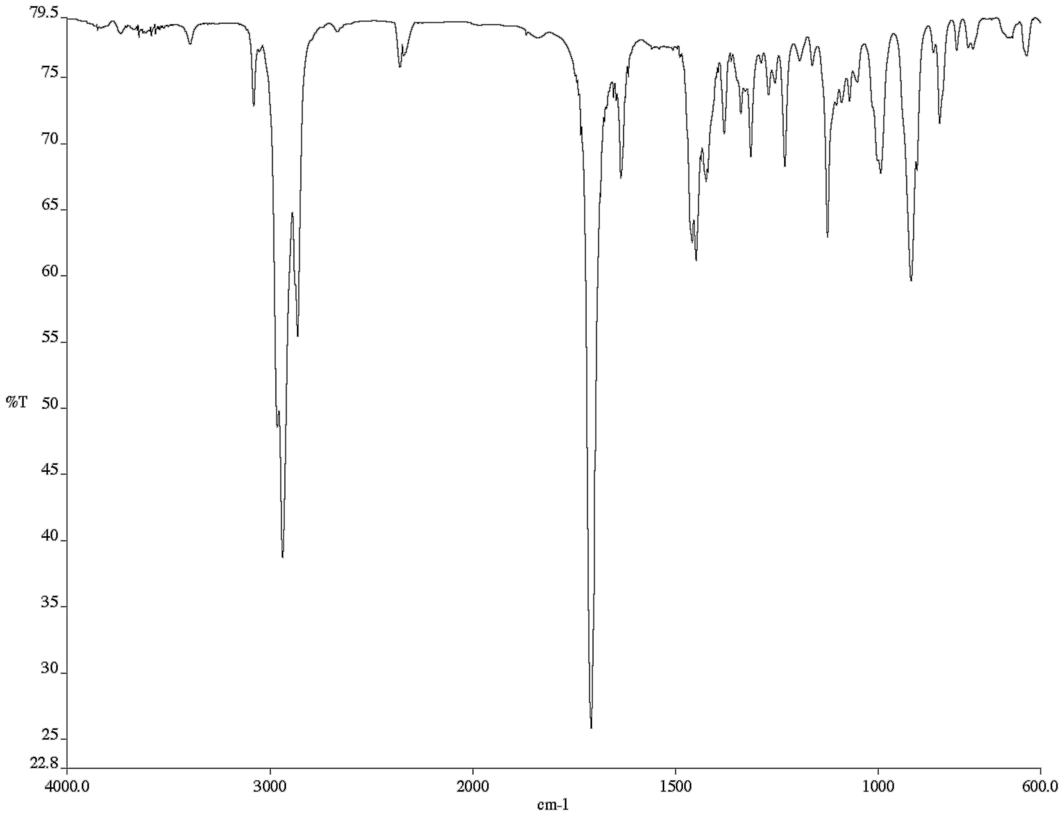
Infrared spectrum (Thin Film, NaCl) of compound **7**.



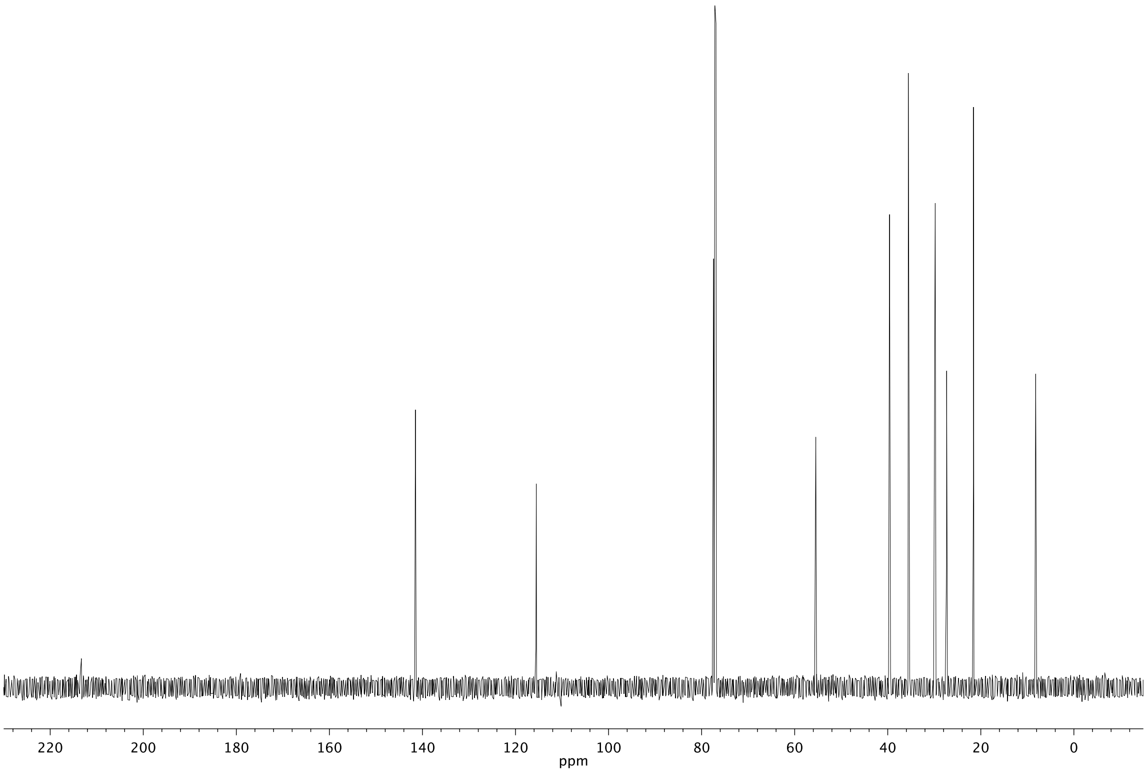
^{13}C NMR (126 MHz, CDCl$_3$) of compound **7**.



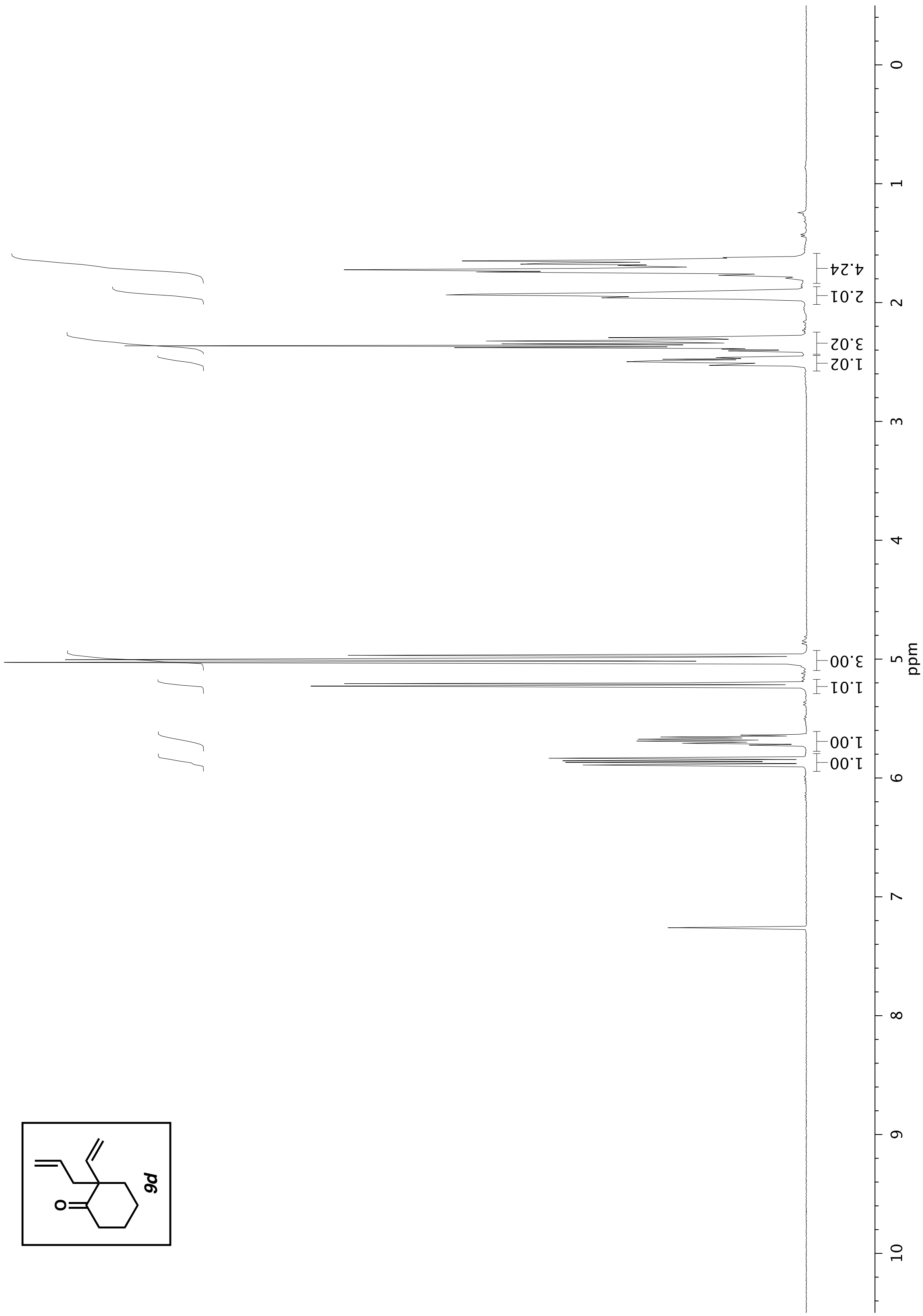
^{1}H NMR (500 MHz, CDCl$_3$) of compound **9c**.



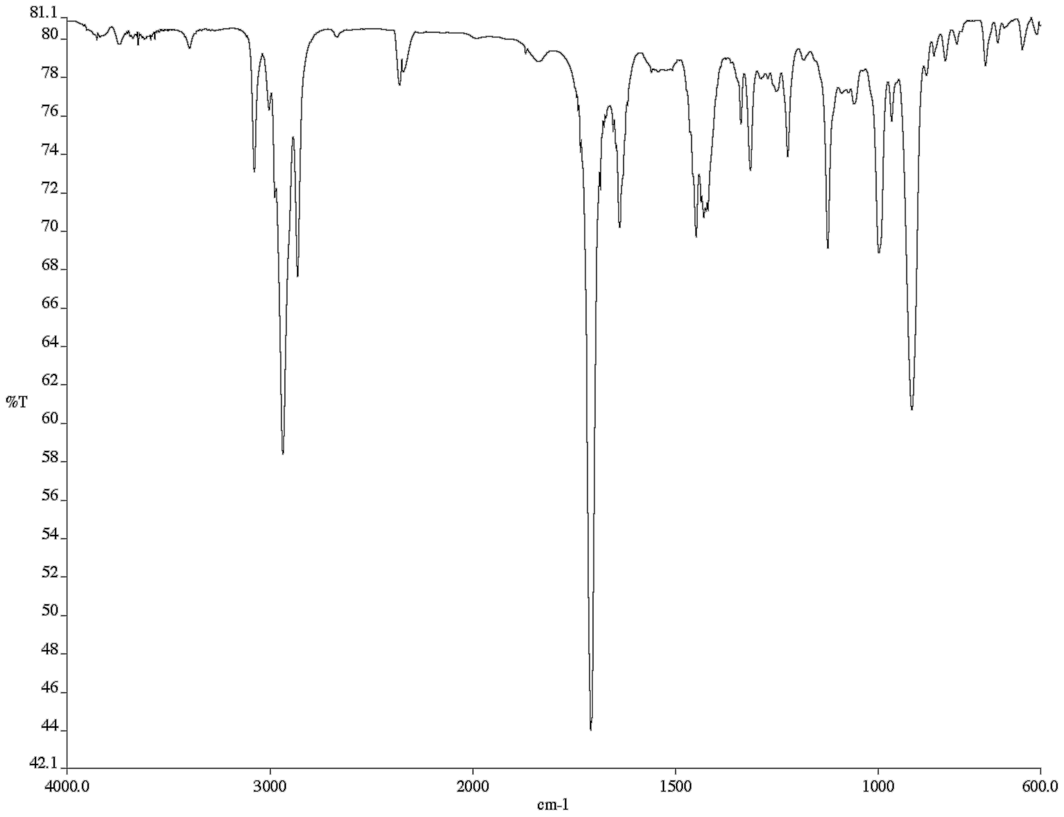
Infrared spectrum (Thin Film, NaCl) of compound **9c**.



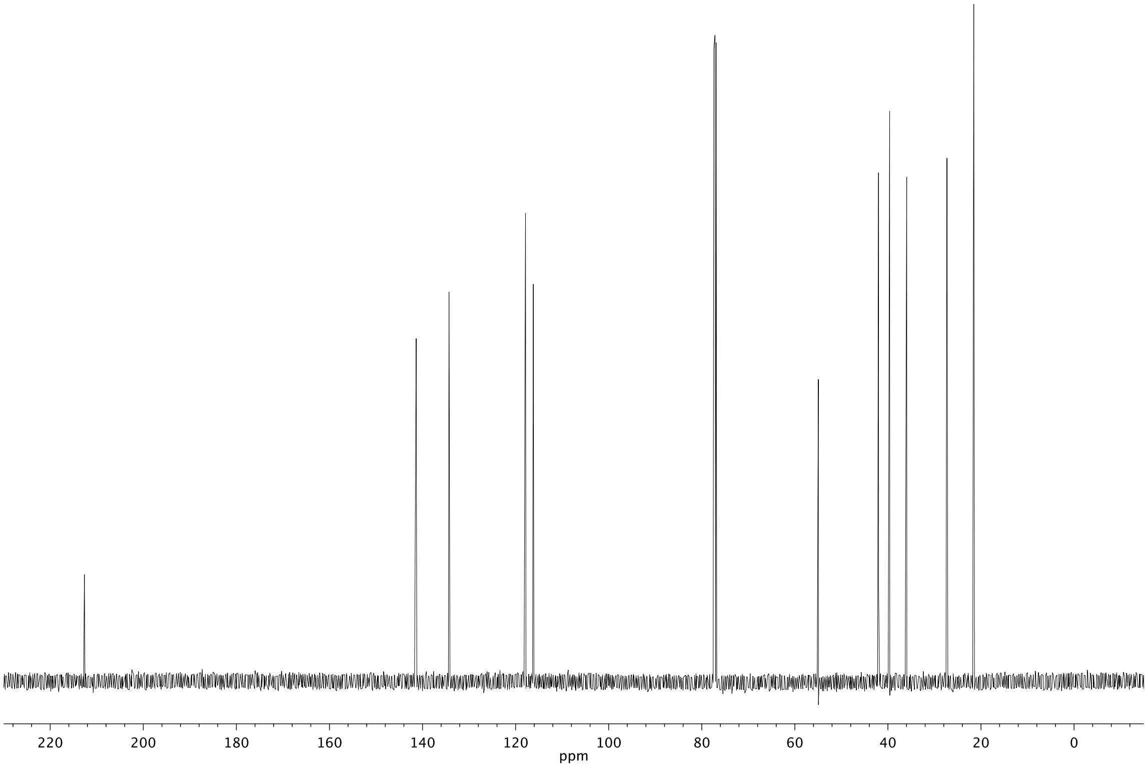
^{13}C NMR (126 MHz, CDCl$_3$) of compound **9c**.



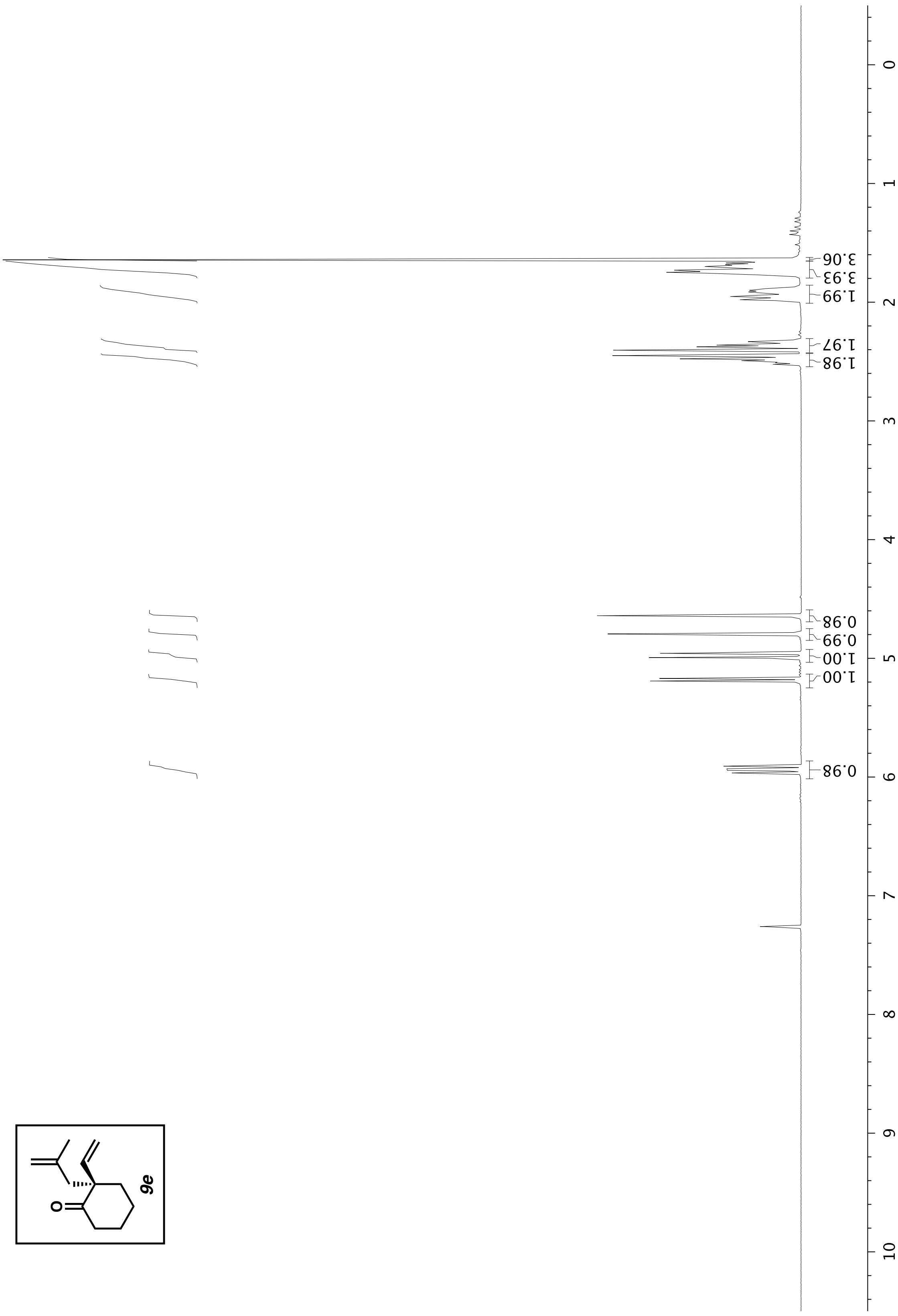
^{1}H NMR (500 MHz, CDCl$_3$) of compound **9d**.



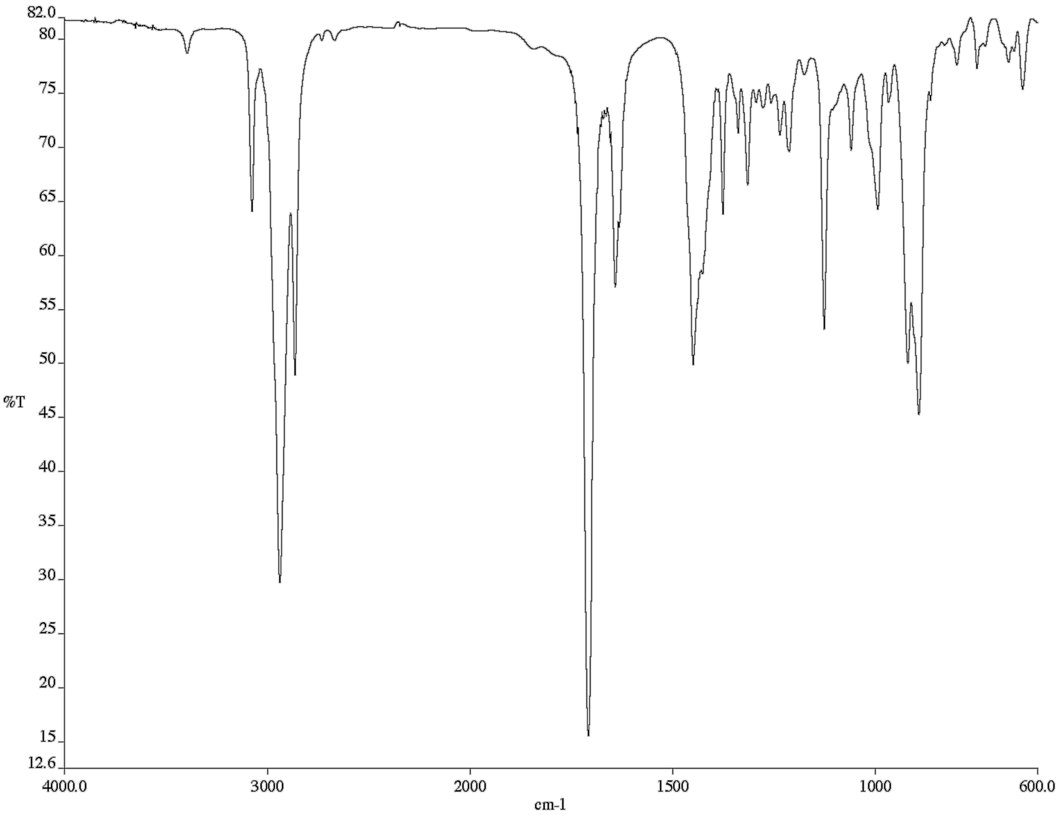
Infrared spectrum (Thin Film, NaCl) of compound **9d**.



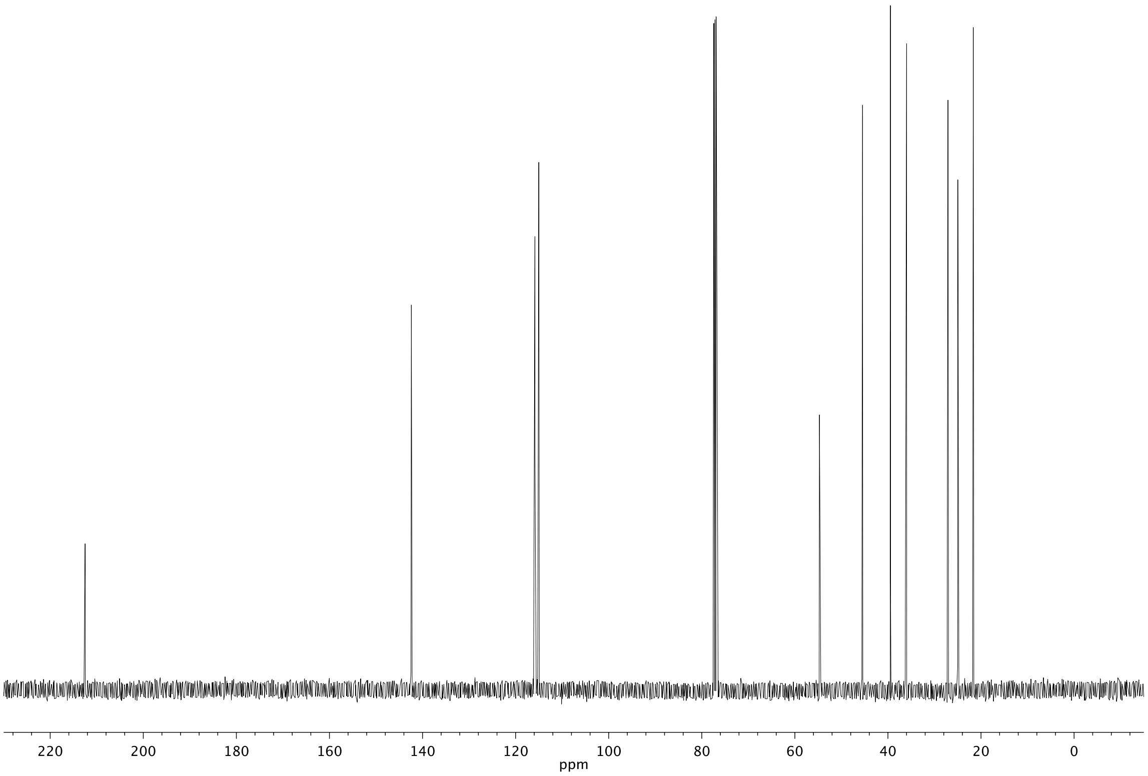
^{13}C NMR (126 MHz, CDCl$_3$) of compound **9d**.



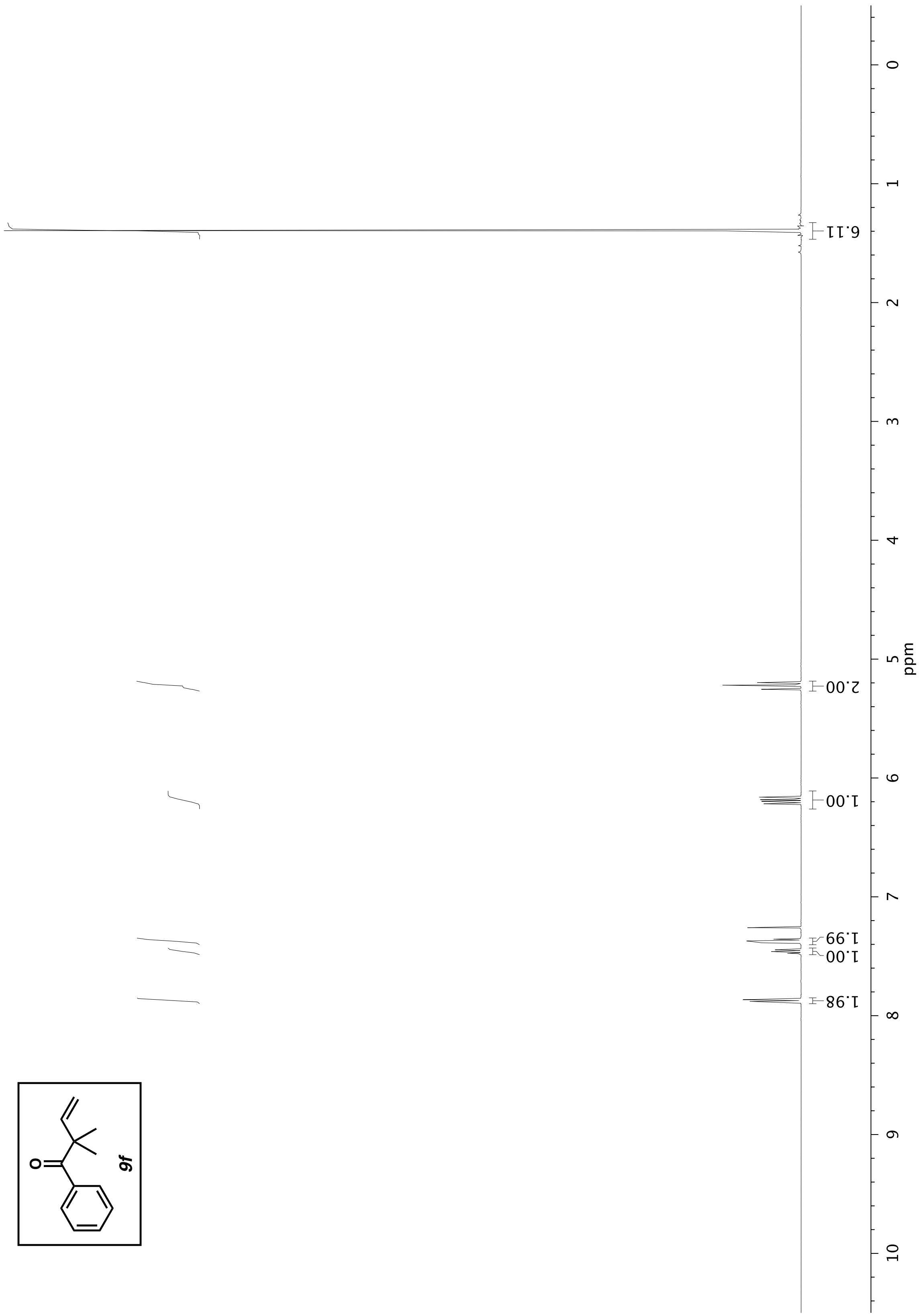
^{1}H NMR (500 MHz, CDCl$_3$) of compound **9e**.



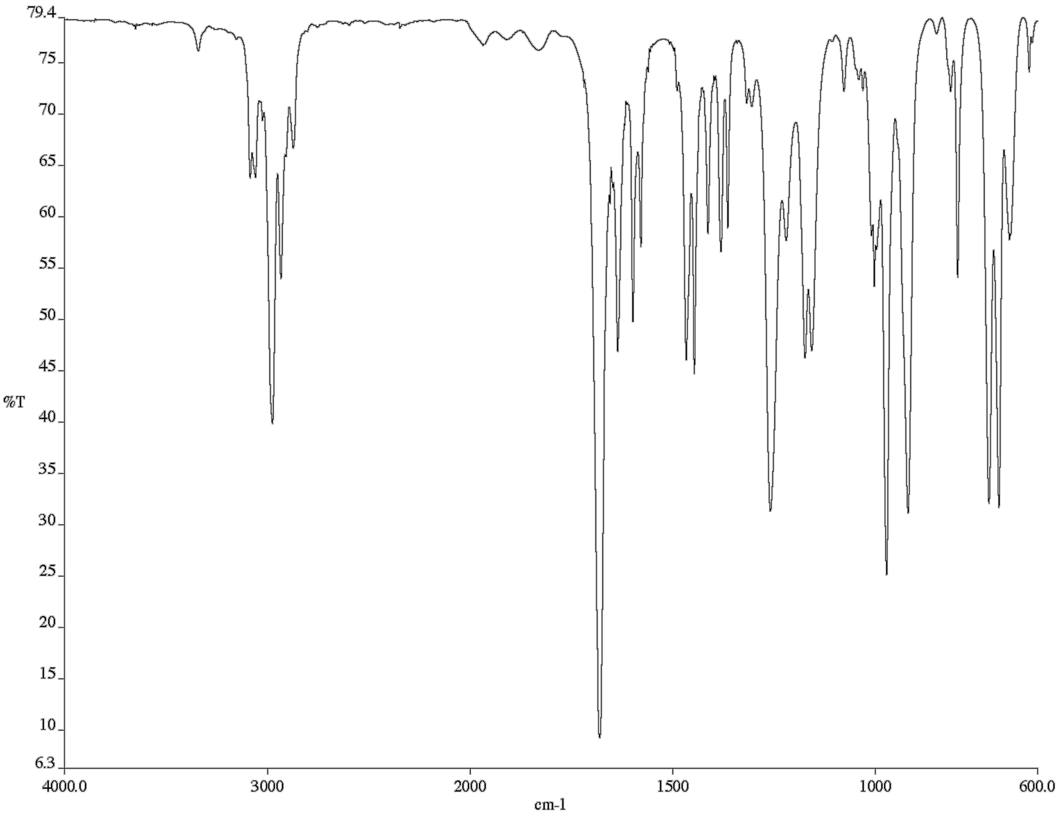
Infrared spectrum (Thin Film, NaCl) of compound **9e**.



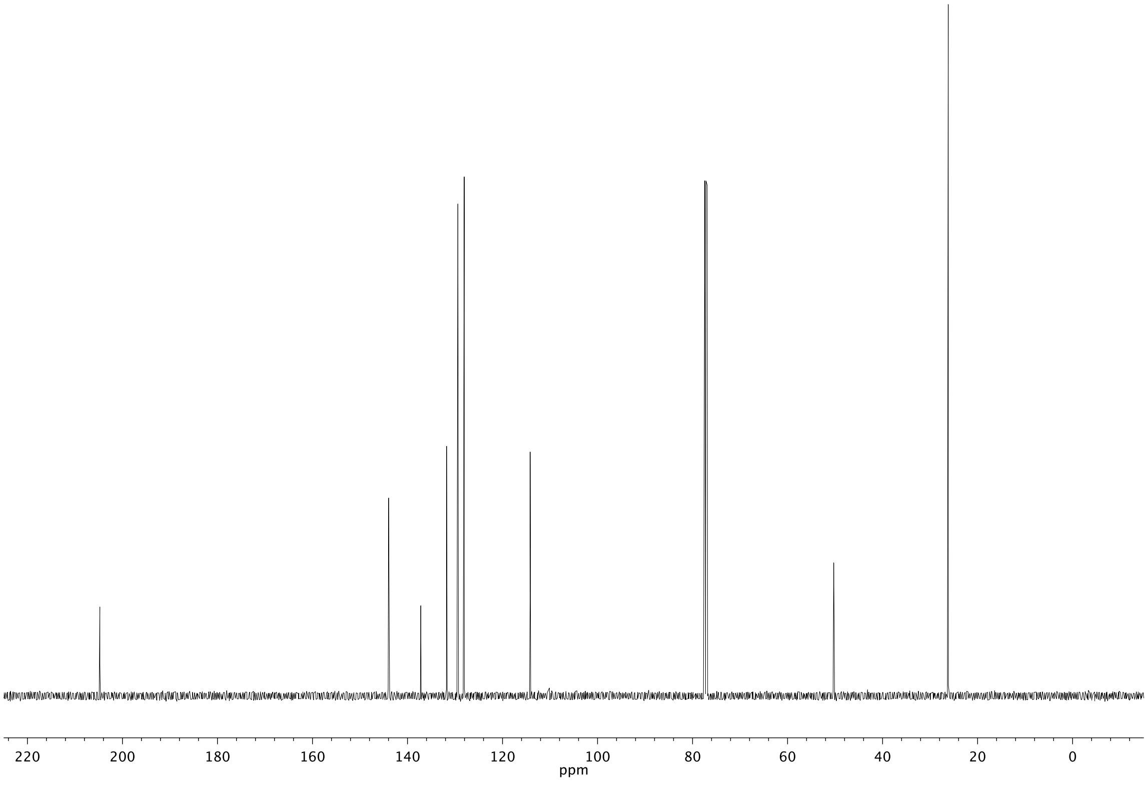
^{13}C NMR (126 MHz, CDCl$_3$) of compound **9e**.



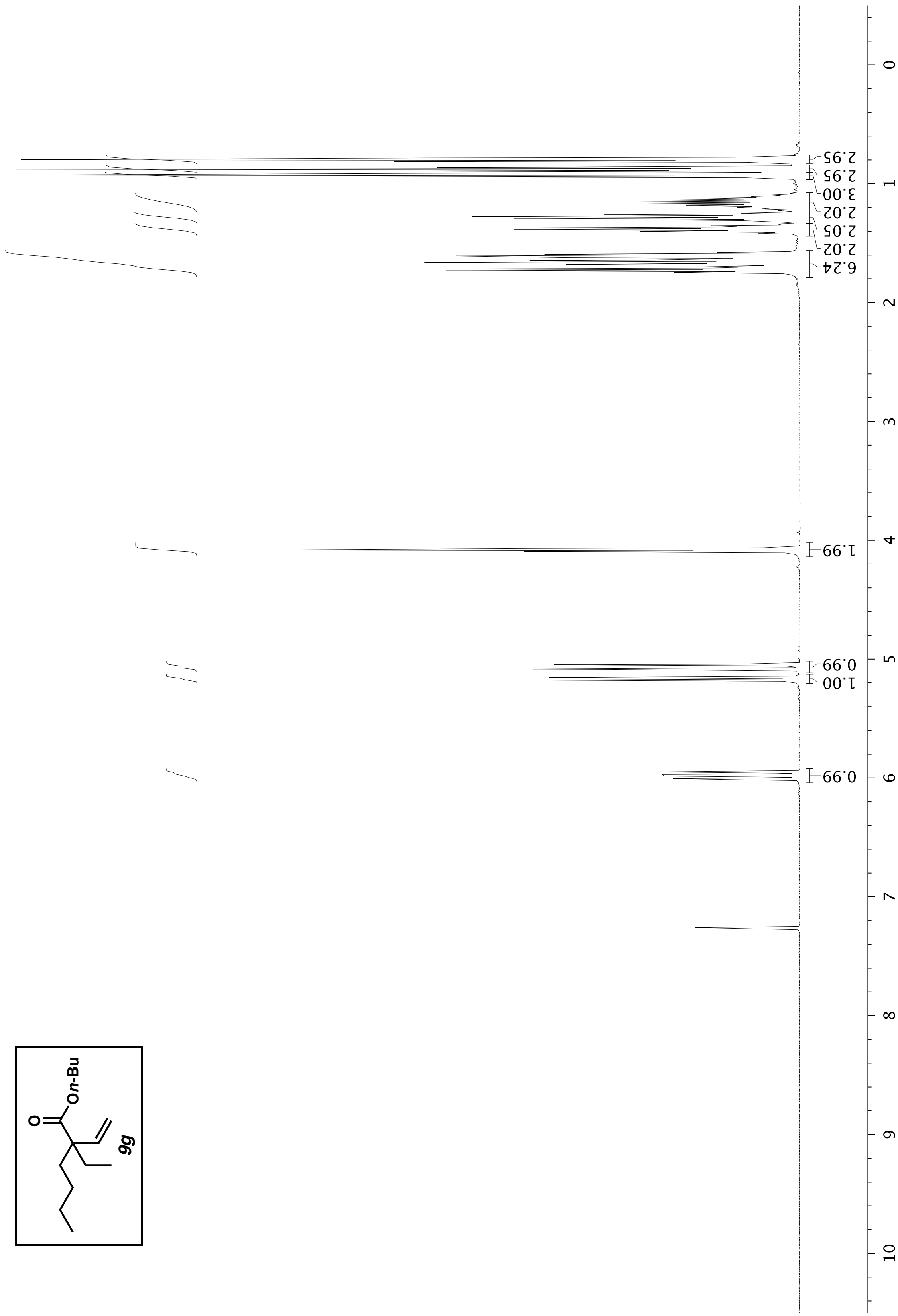
^{1}H NMR (500 MHz, $CDCl_3$) of compound **9f**.



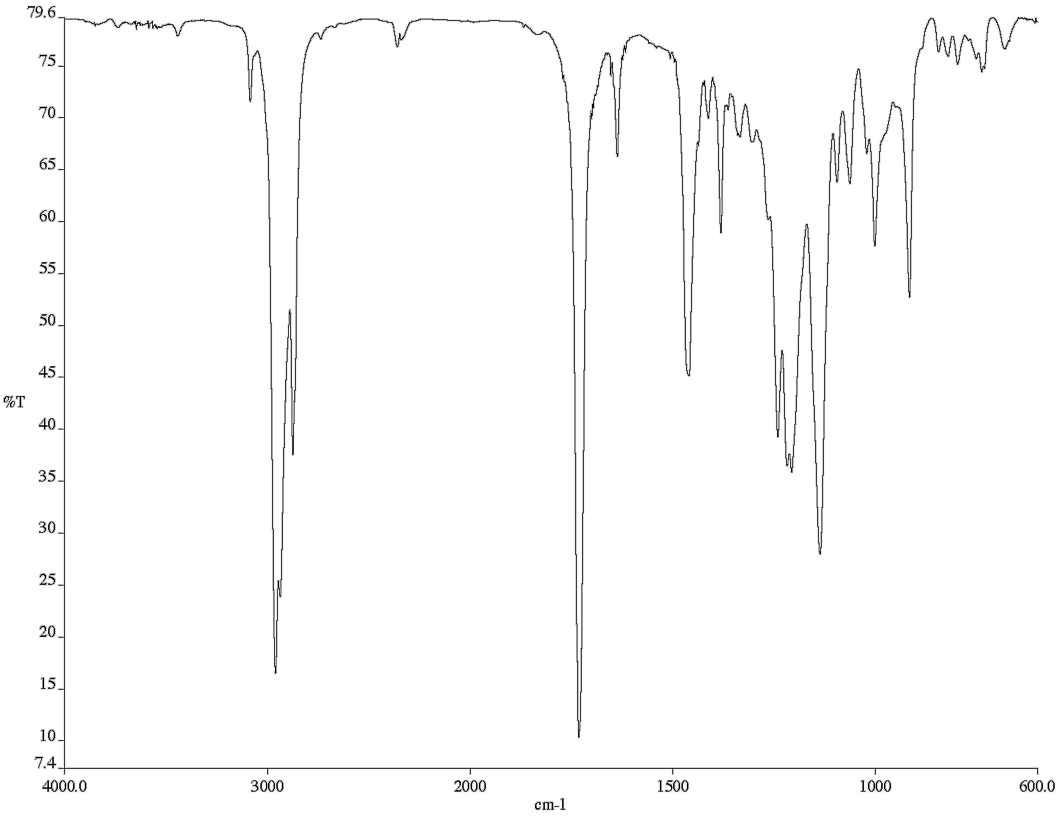
Infrared spectrum (Thin Film, NaCl) of compound **9f**.



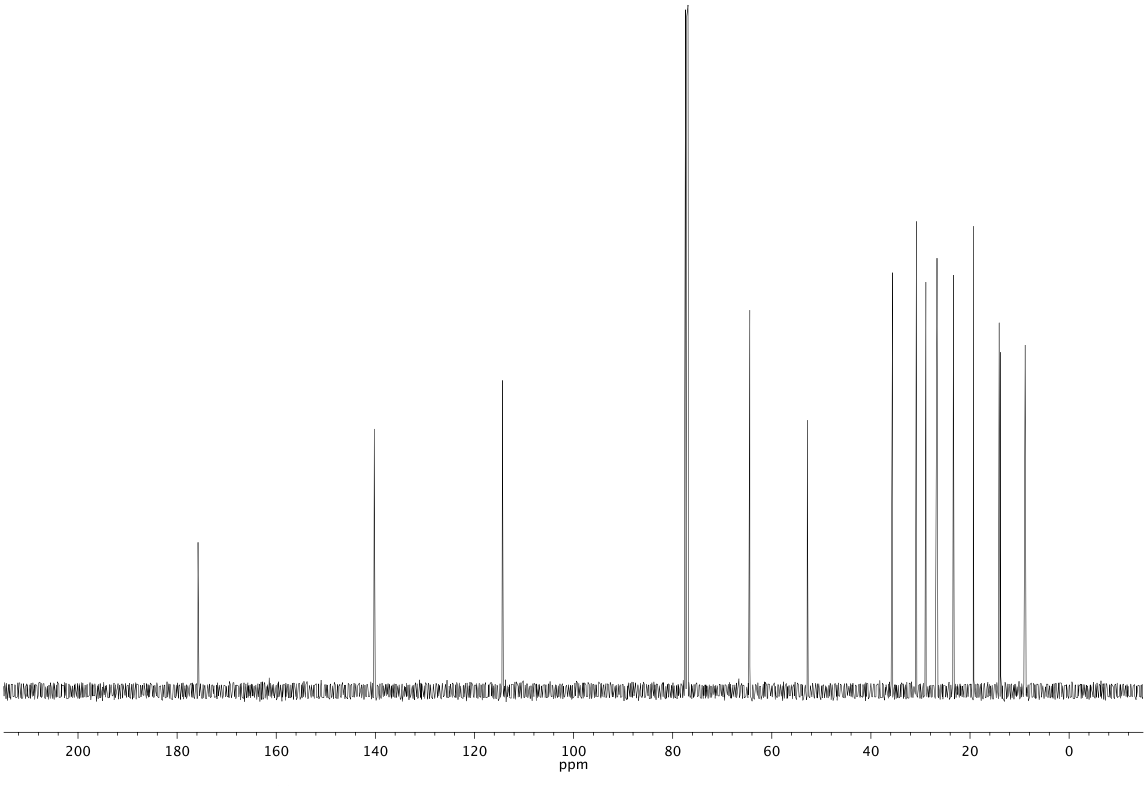
^{13}C NMR (126 MHz, $CDCl_3$) of compound **9f**.



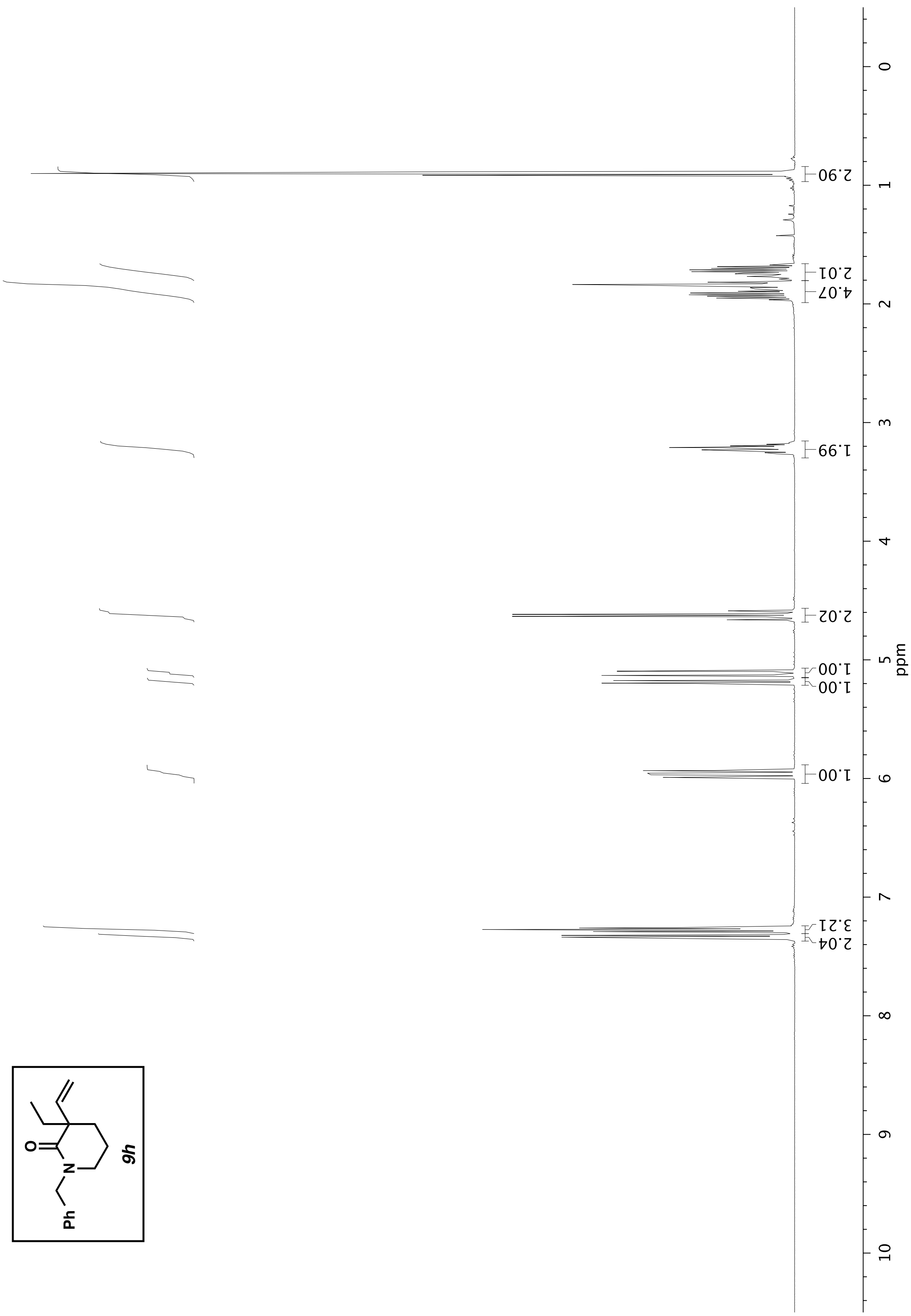
^{1}H NMR (500 MHz, CDCl$_3$) of compound **9g**.



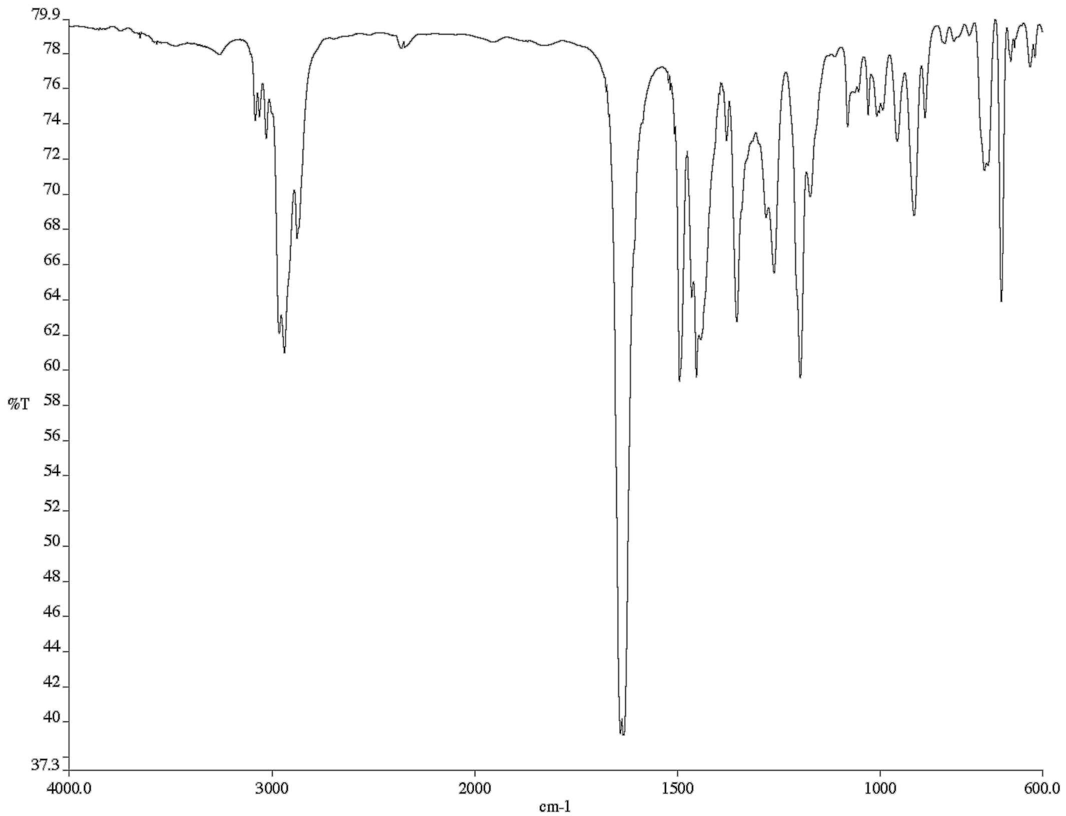
Infrared spectrum (Thin Film, NaCl) of compound **9g**.



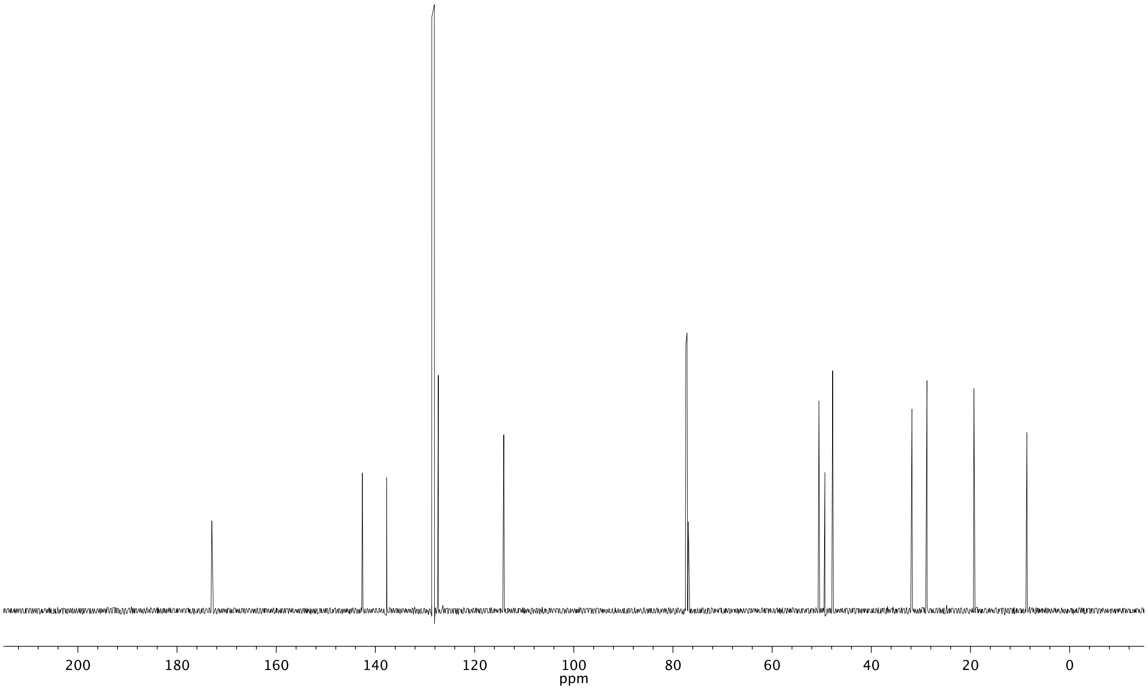
^{13}C NMR (126 MHz, $CDCl_3$) of compound **9g**.



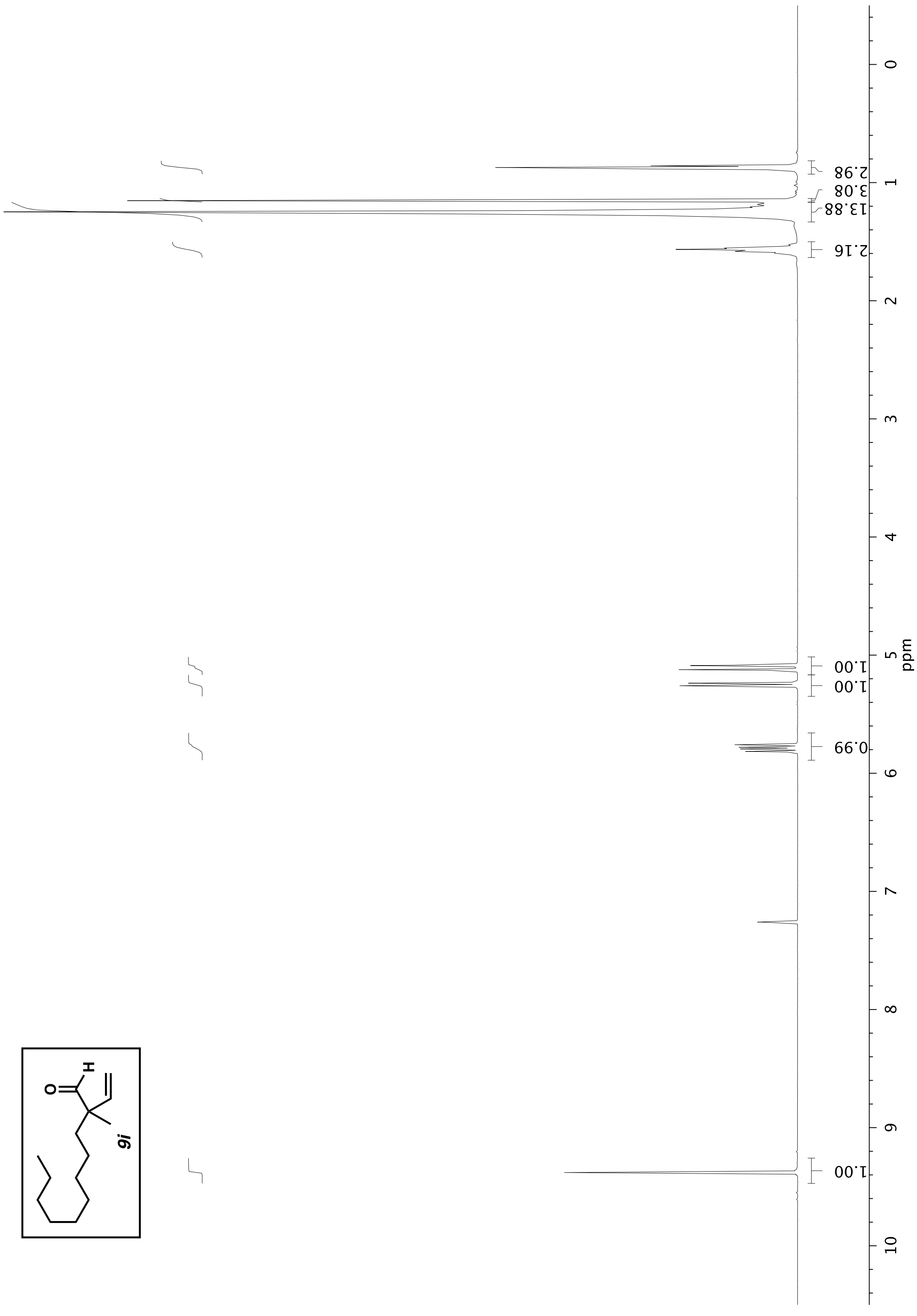
^{1}H NMR (500 MHz, CDCl$_3$) of compound **9h**.



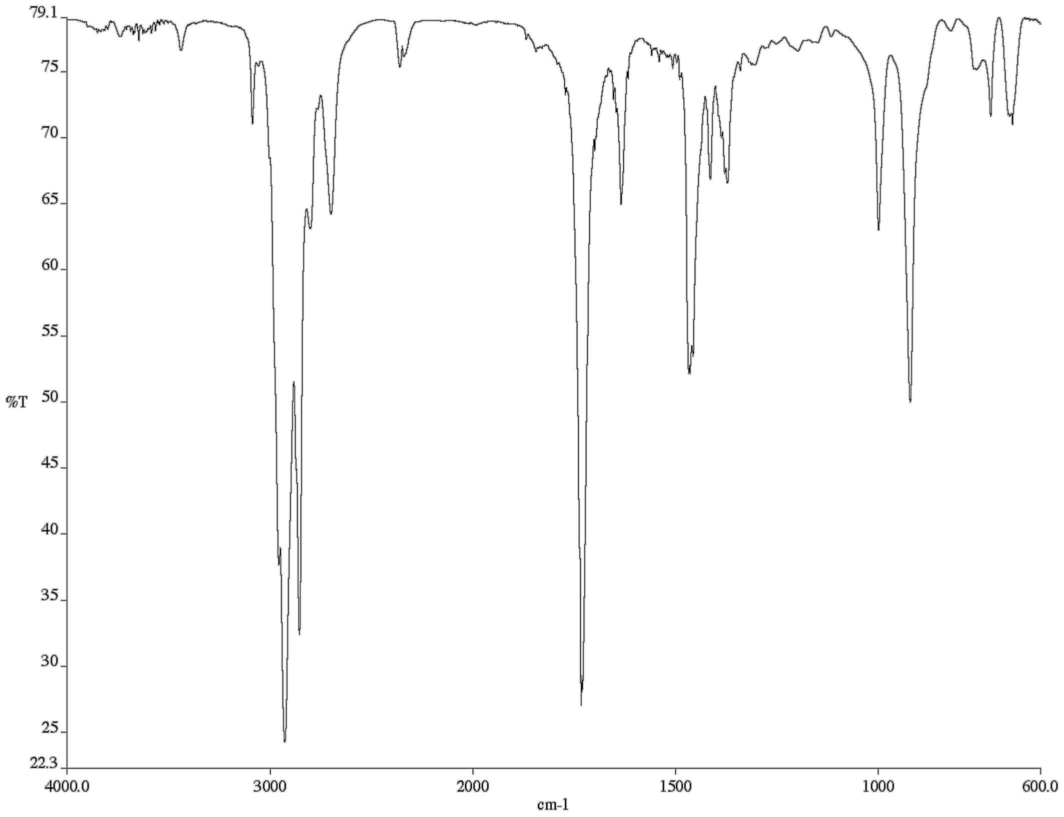
Infrared spectrum (Thin Film, NaCl) of compound **9h**.



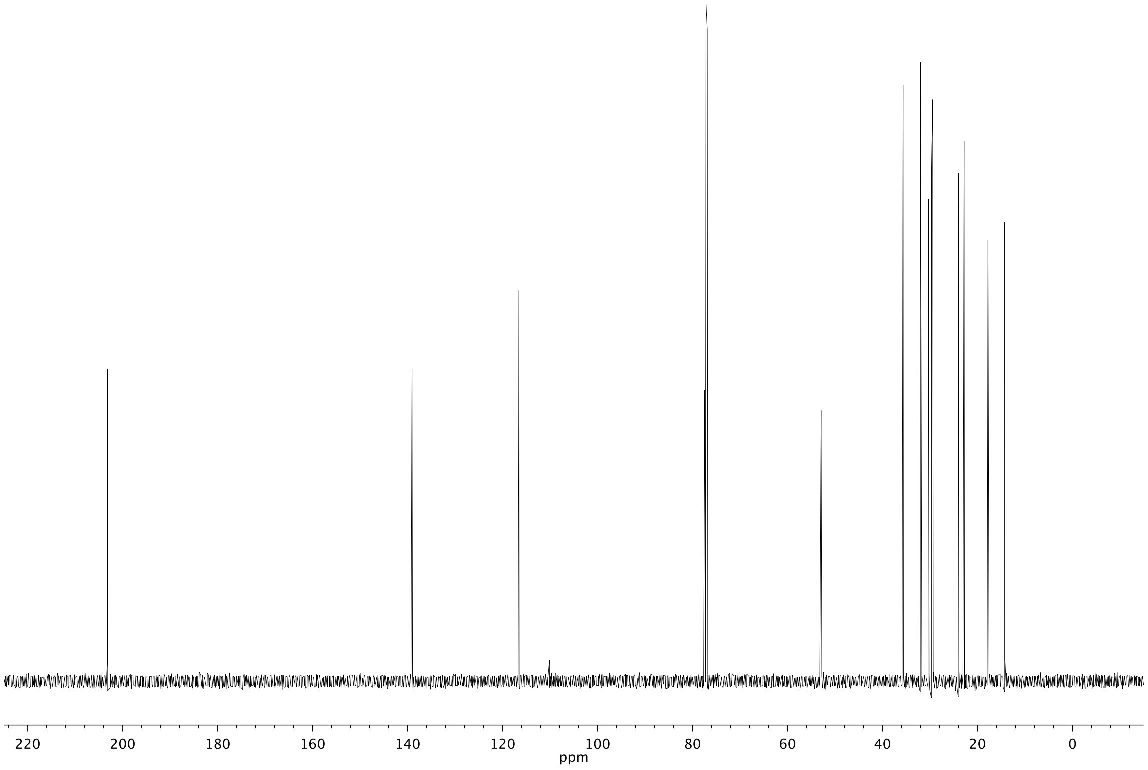
^{13}C NMR (126 MHz, CDCl$_3$) of compound **9h**.



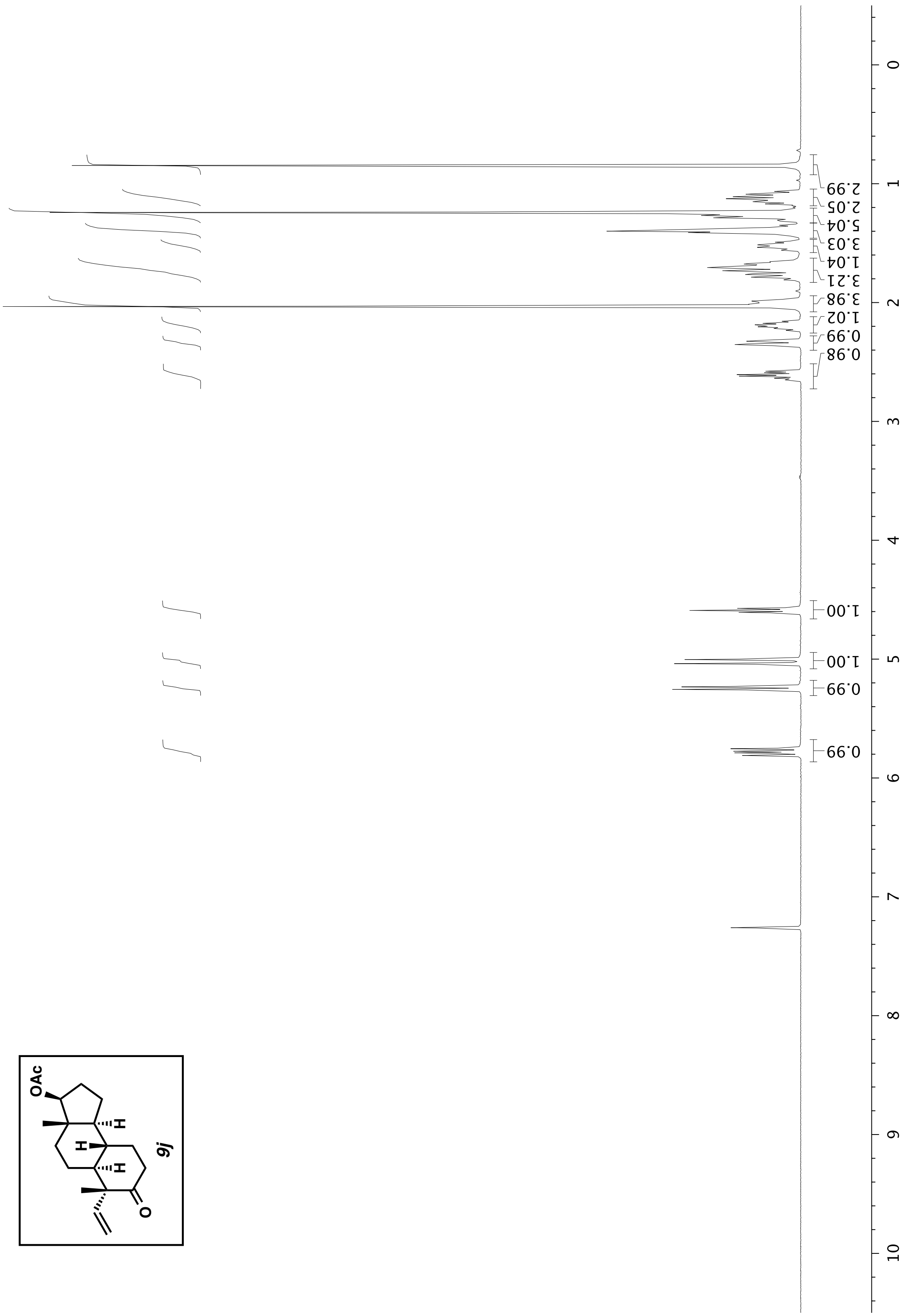
^{1}H NMR (500 MHz, CDCl$_3$) of compound **9i**.



Infrared spectrum (Thin Film, NaCl) of compound **9i**.



^{13}C NMR (126 MHz, $CDCl_3$) of compound **9i**.



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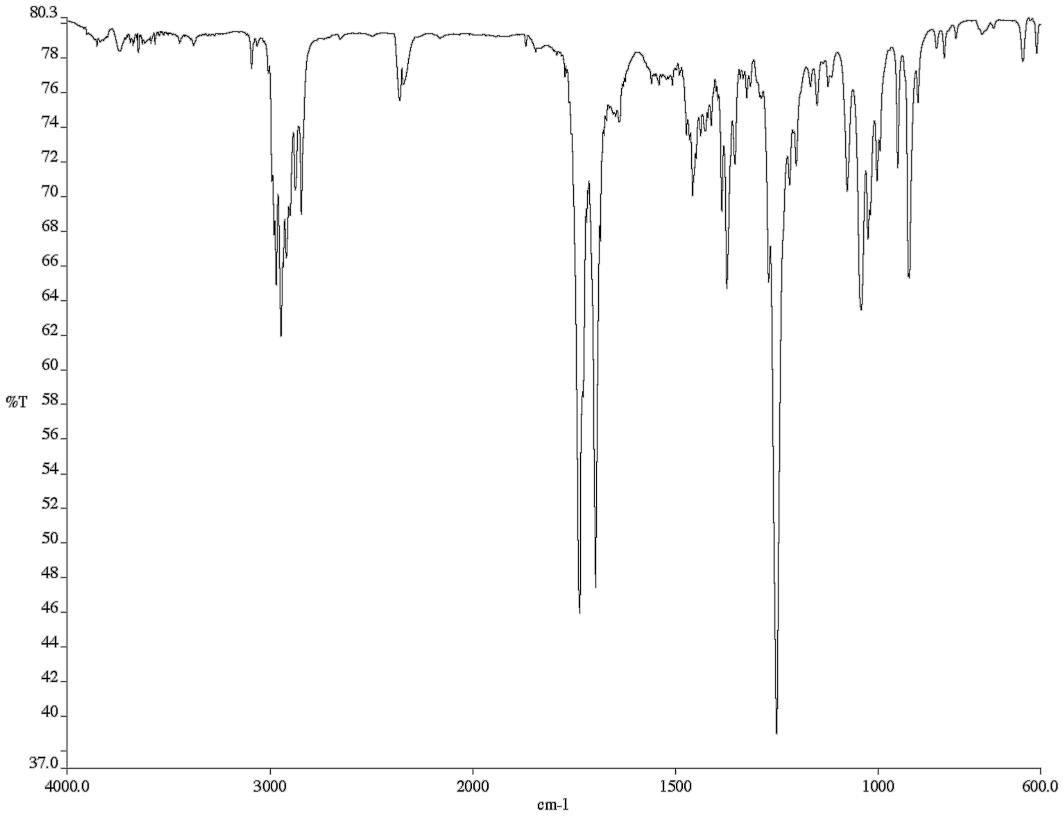
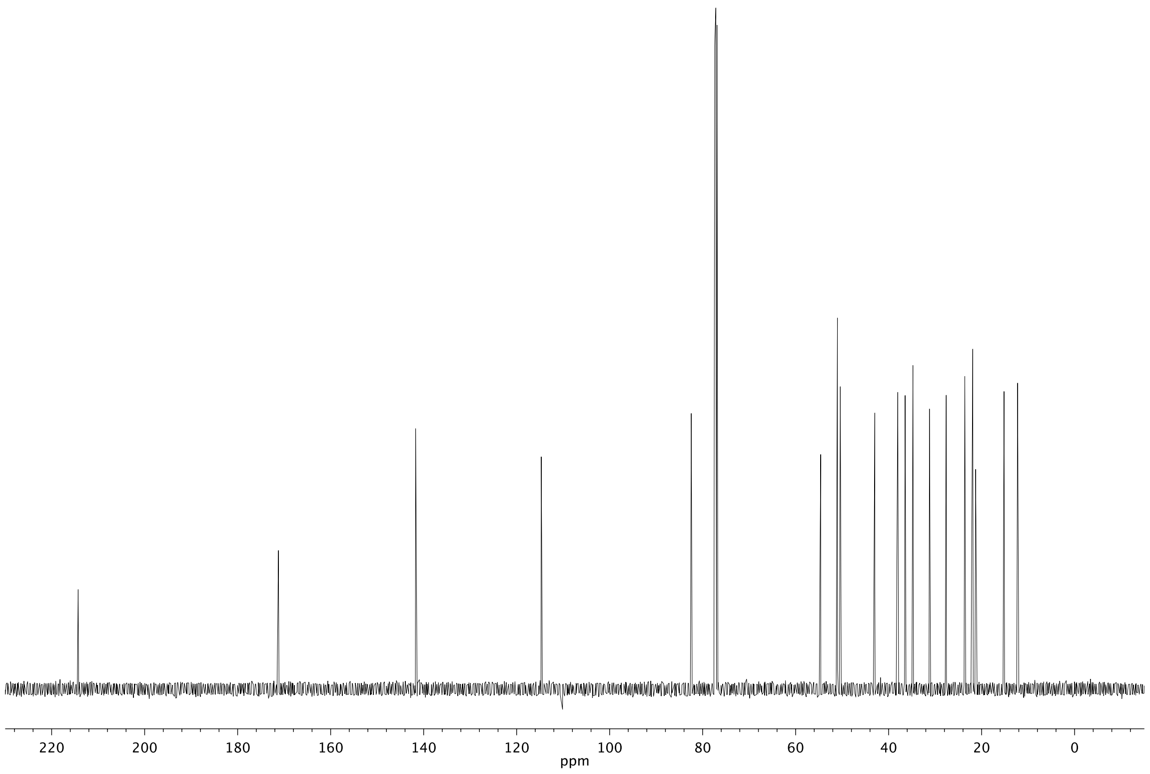
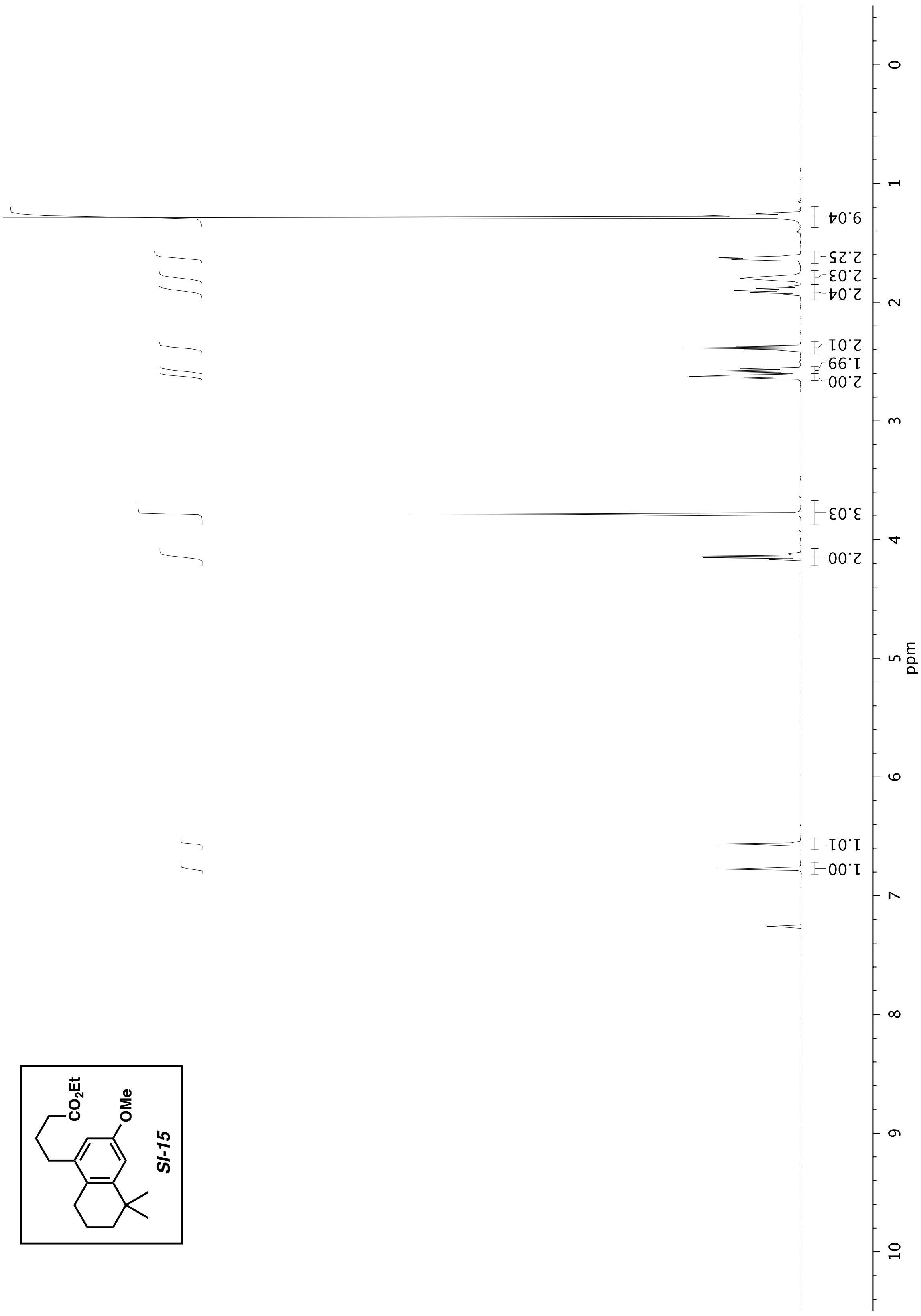


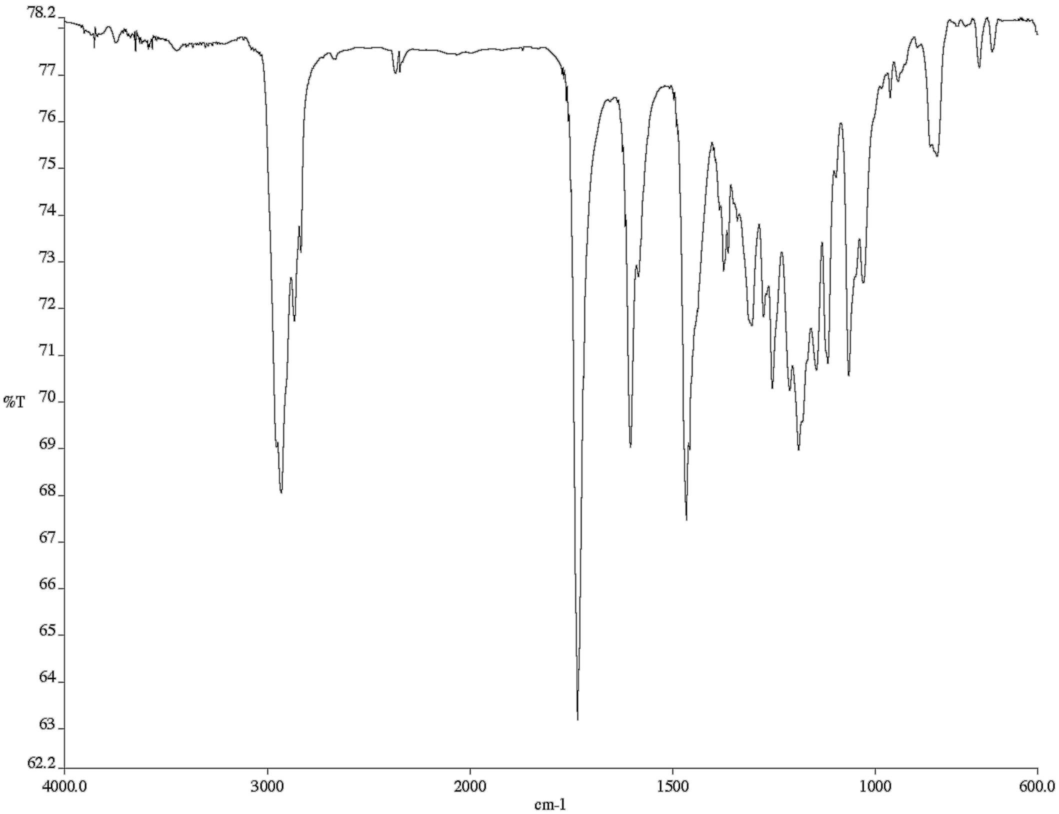
Infrared spectrum (Thin Film, NaCl) of compound **9j**.



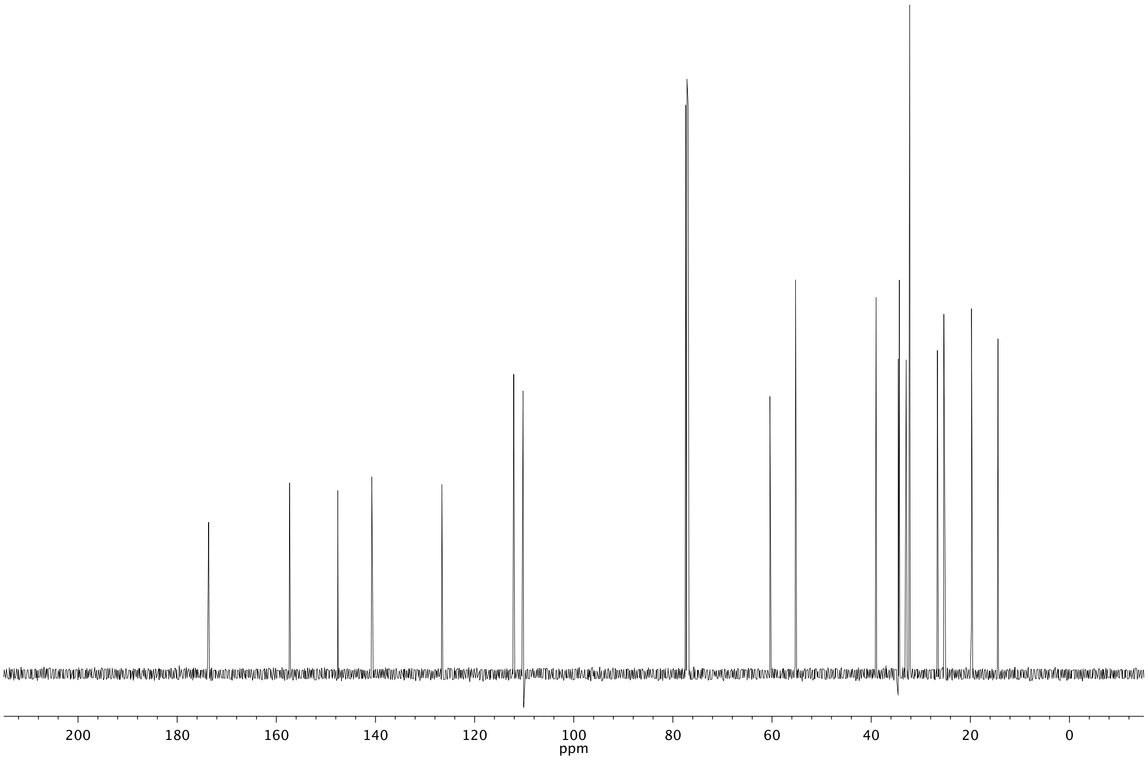
^{13}C NMR (126 MHz, $CDCl_3$) of compound **9j**.



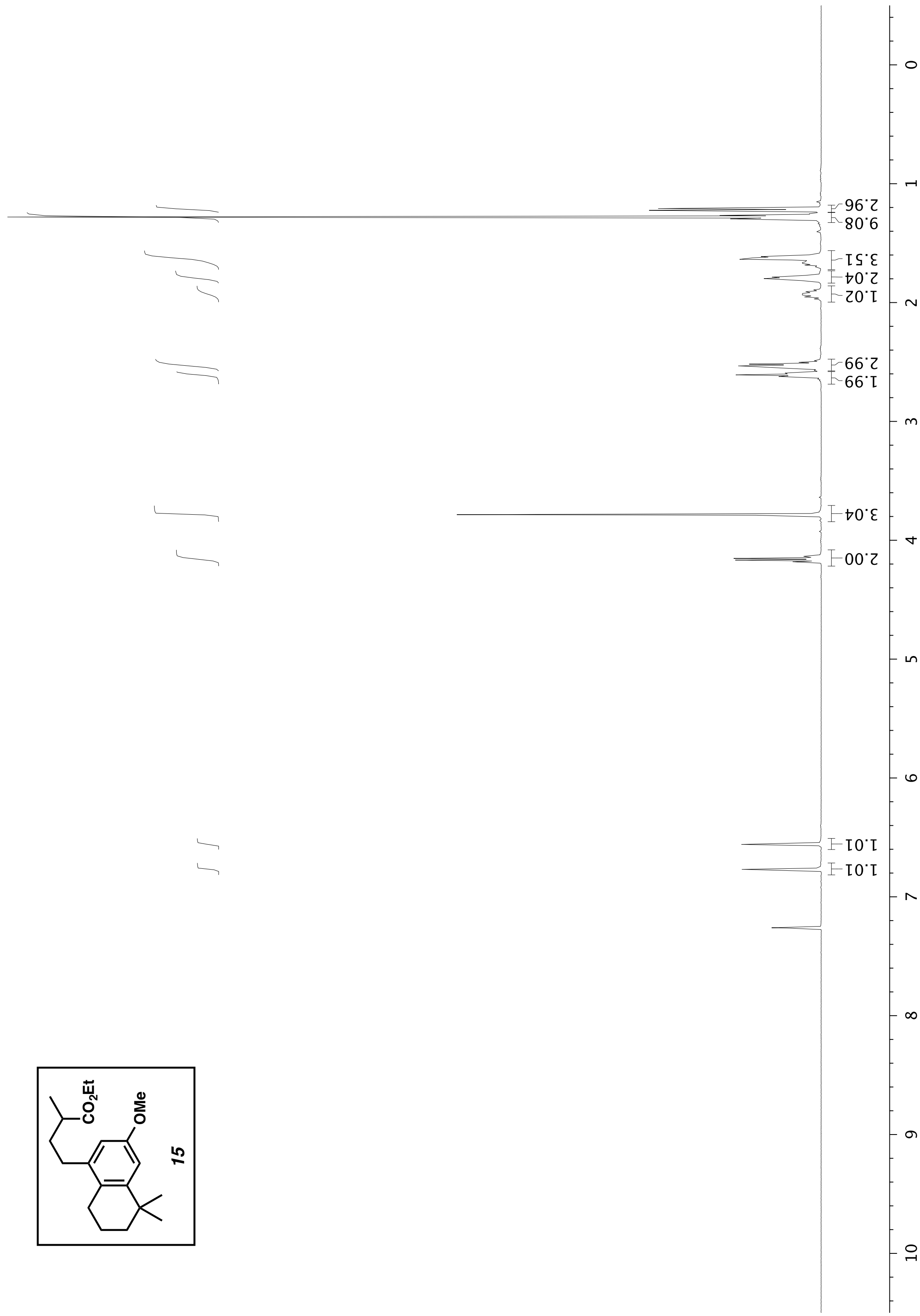
^{1}H NMR (500 MHz, CDCl$_3$) of compound **SI-15**.



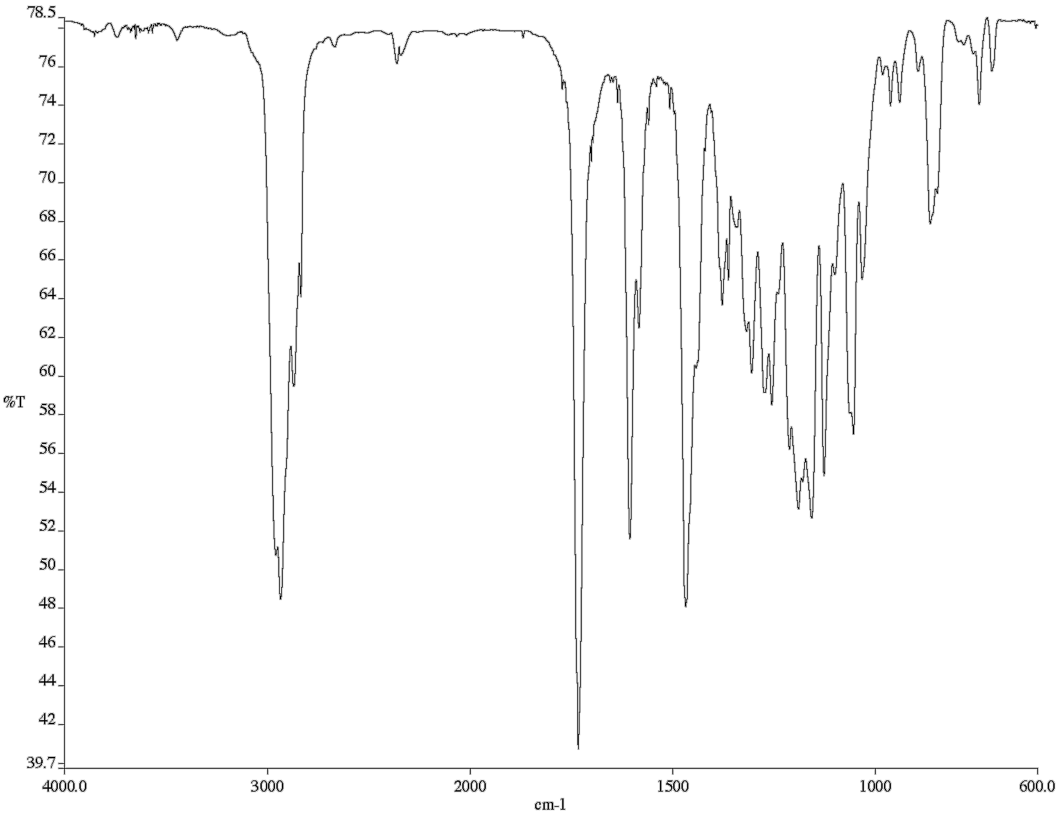
Infrared spectrum (Thin Film, NaCl) of compound **SI-15**.



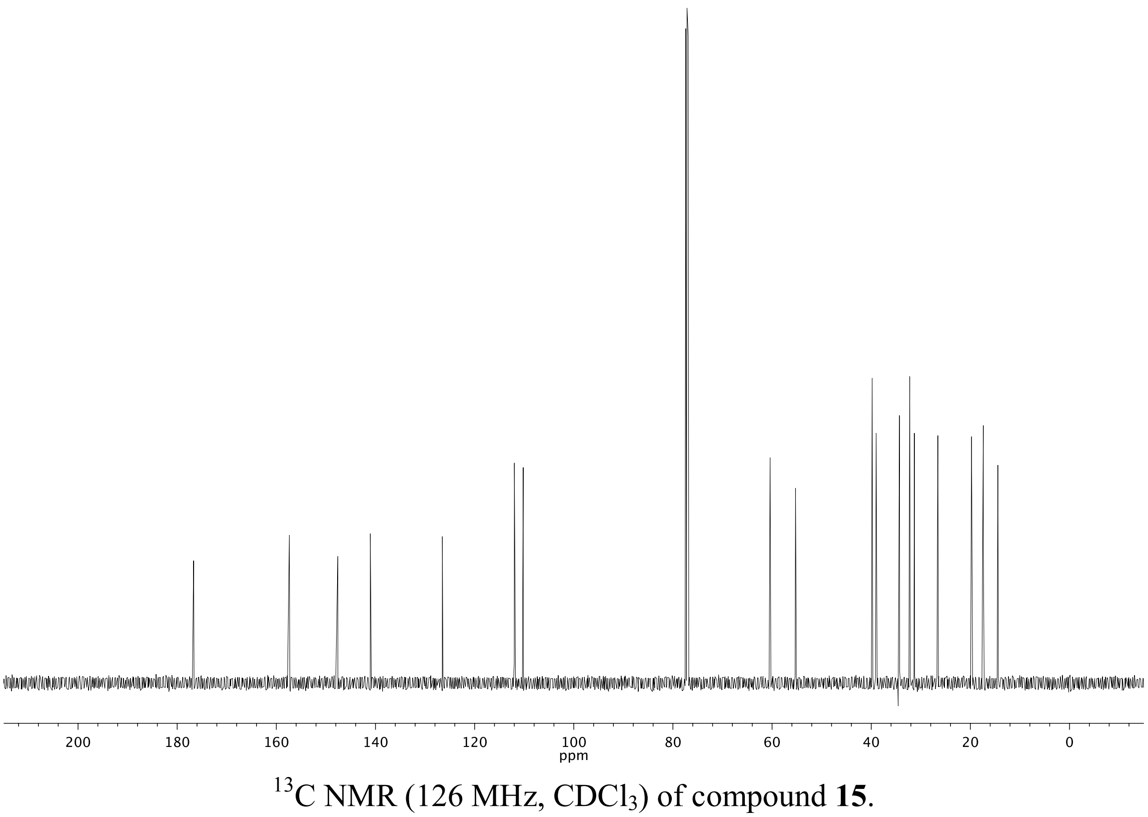
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-15**.



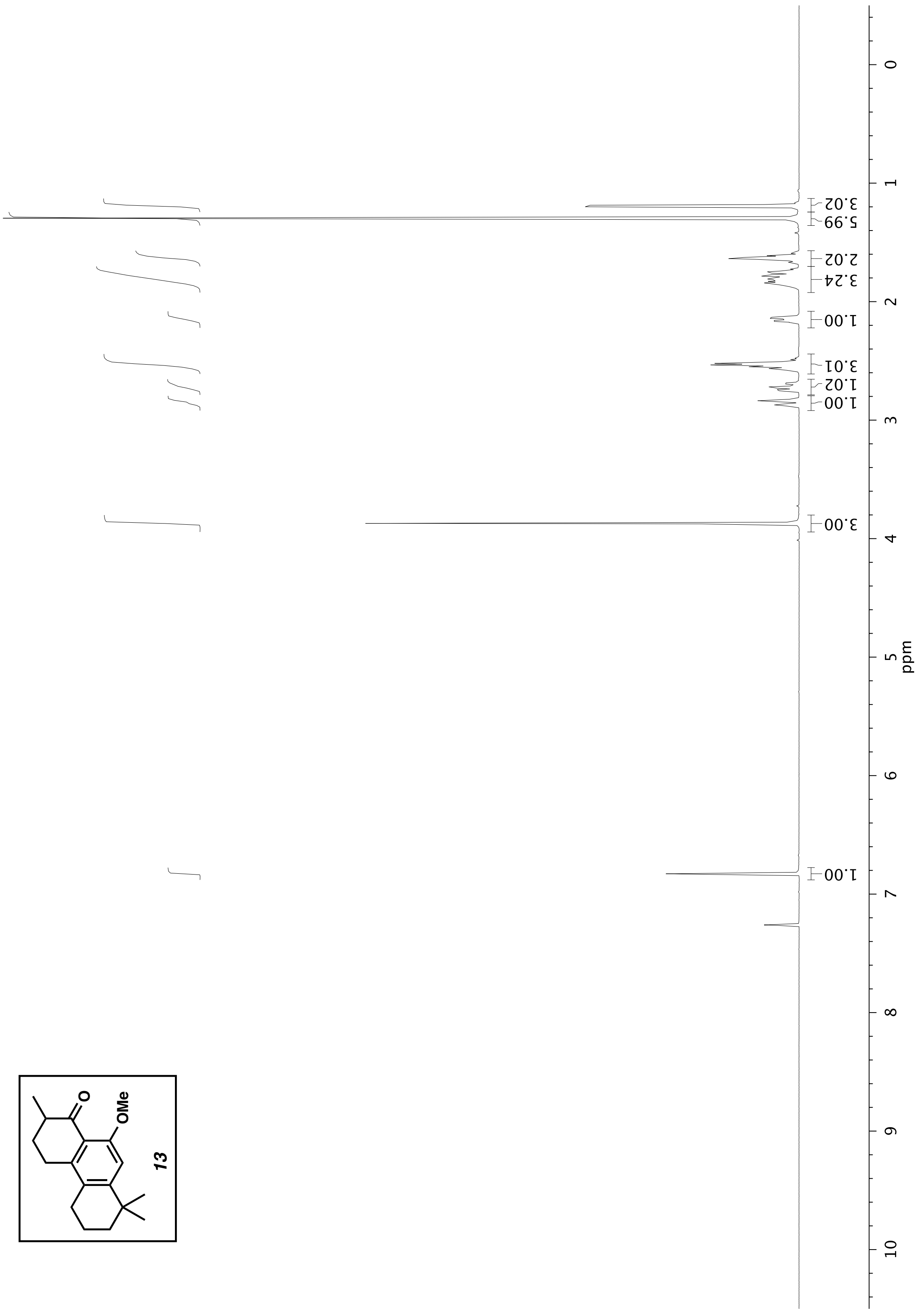
^{1}H NMR (500 MHz, CDCl$_3$) of compound **15**.



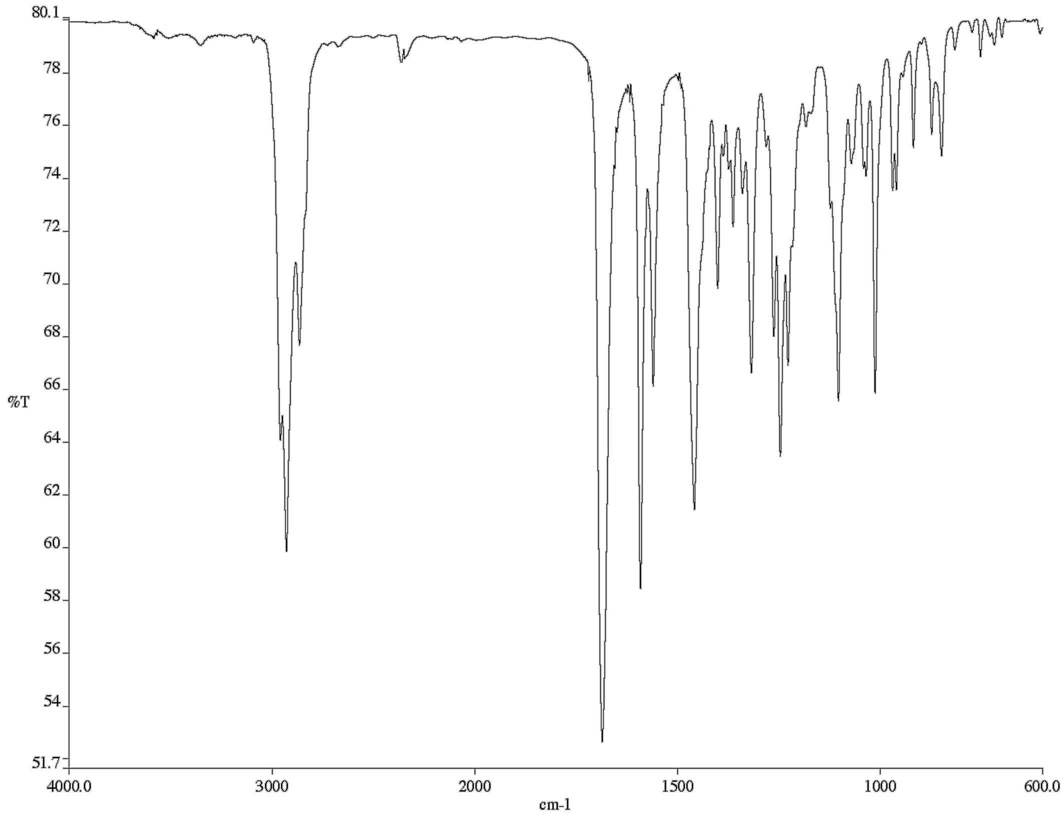
Infrared spectrum (Thin Film, NaCl) of compound **15**.



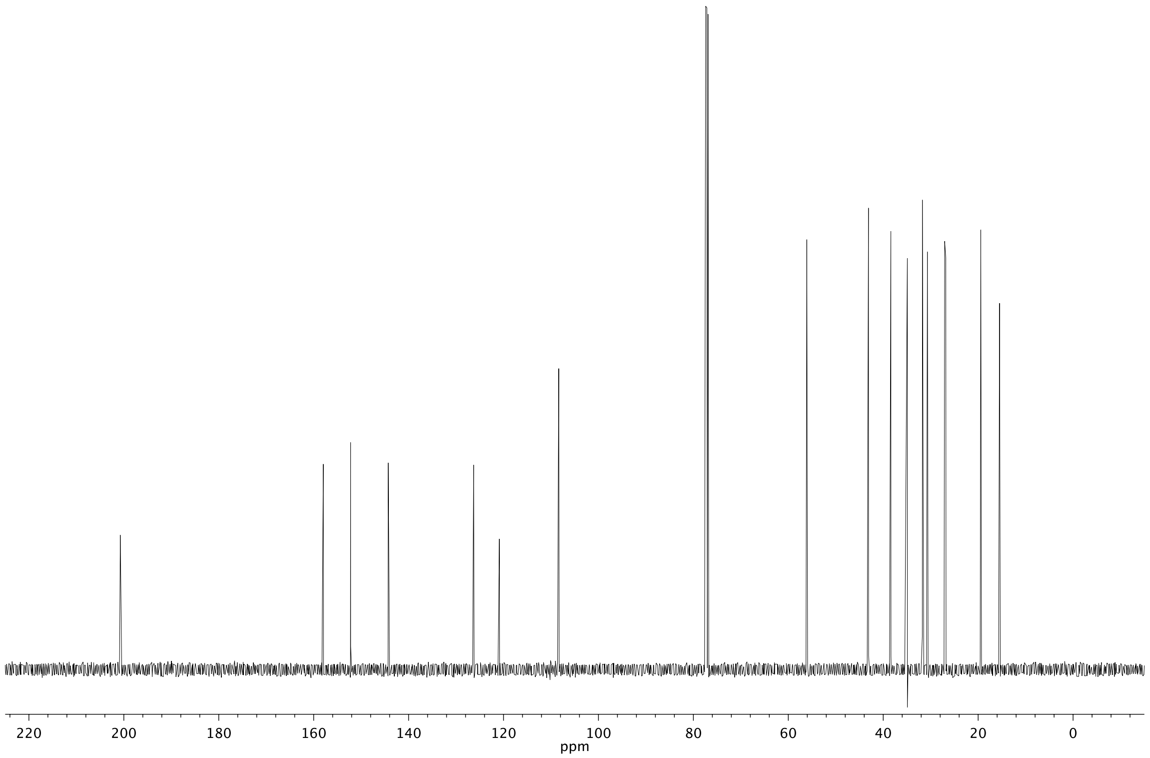
^{13}C NMR (126 MHz, $CDCl_3$) of compound **15**.



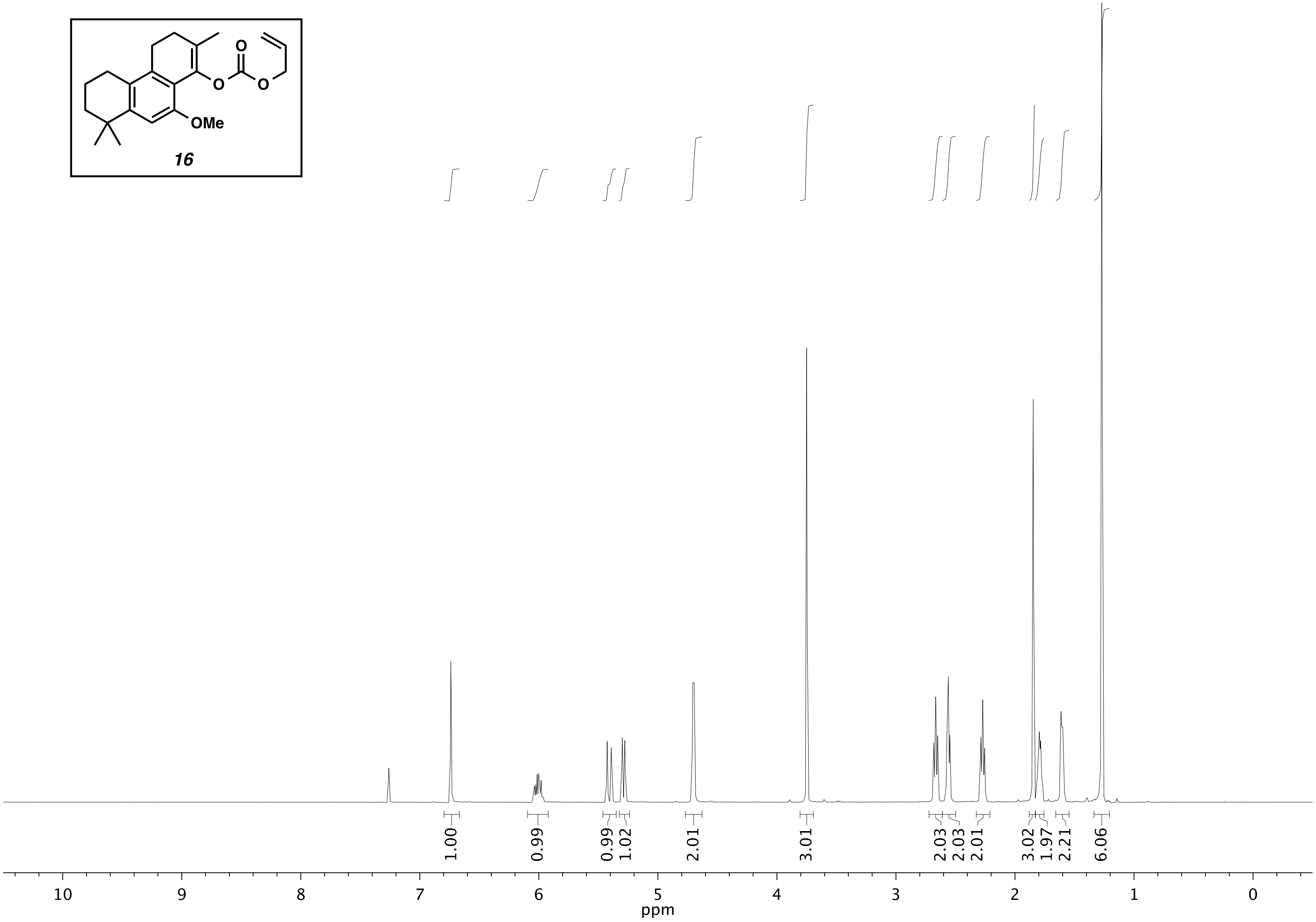
^{1}H NMR (500 MHz, CDCl$_3$) of compound **13**.



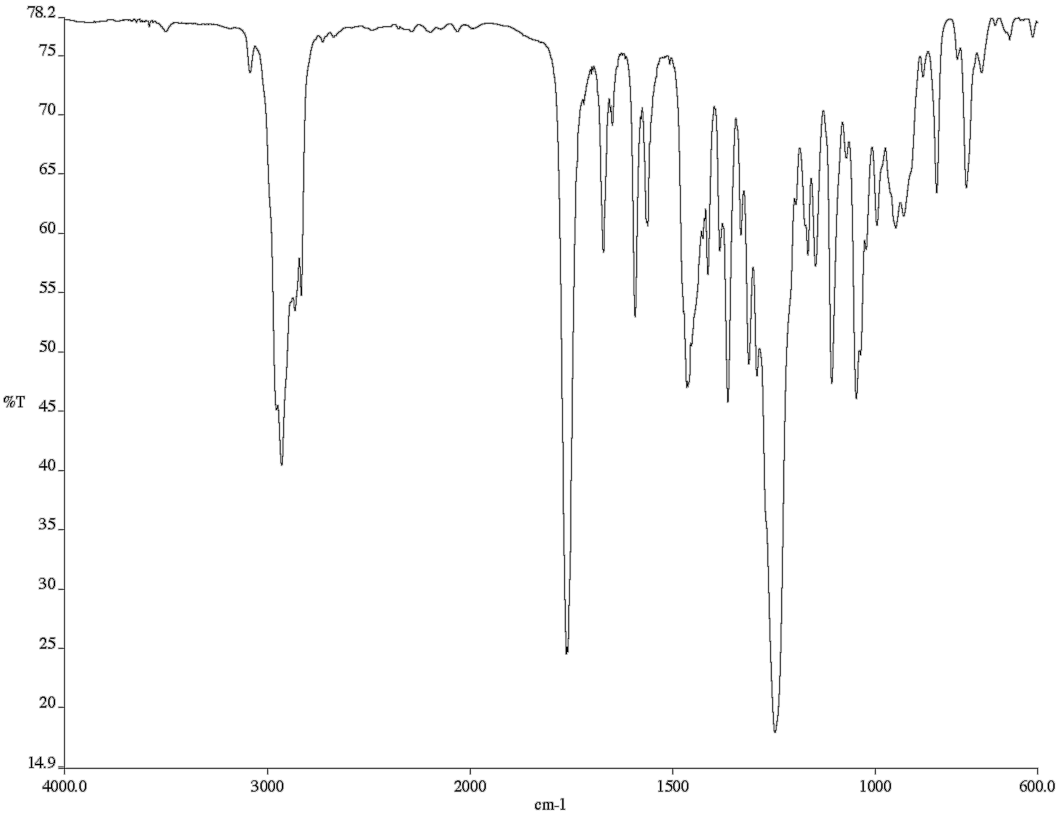
Infrared spectrum (Thin Film, NaCl) of compound **13**.



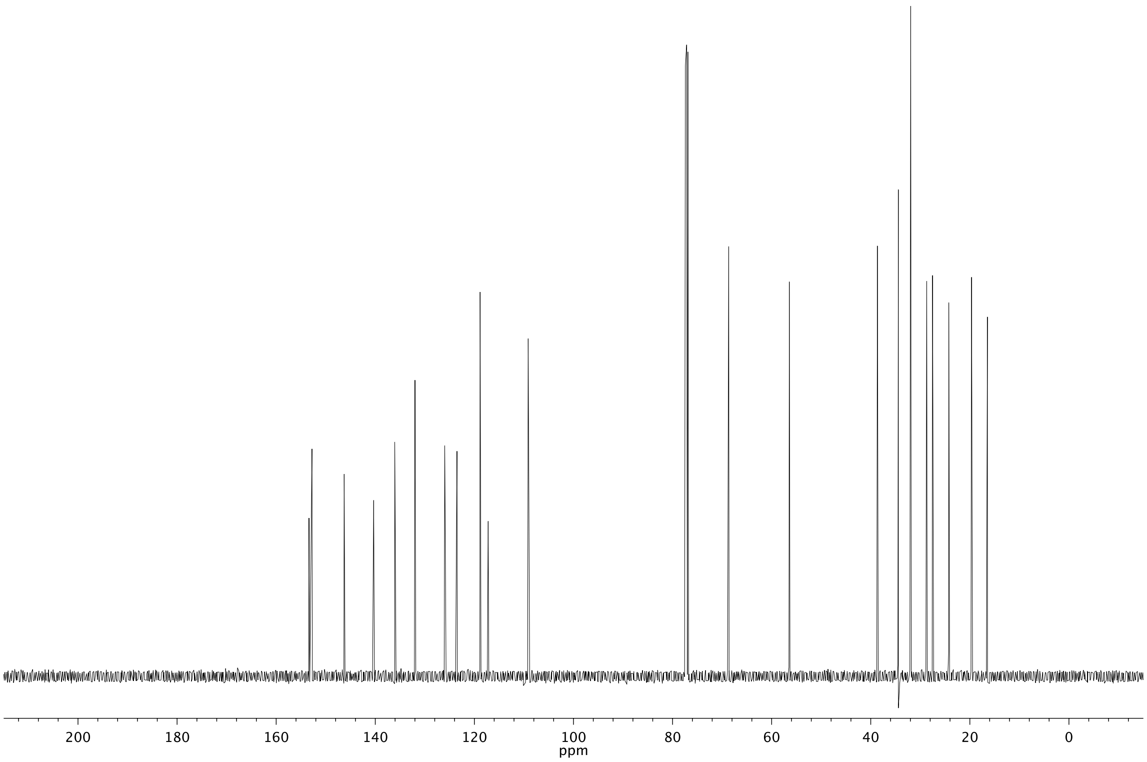
^{13}C NMR (126 MHz, CDCl$_3$) of compound **13**.



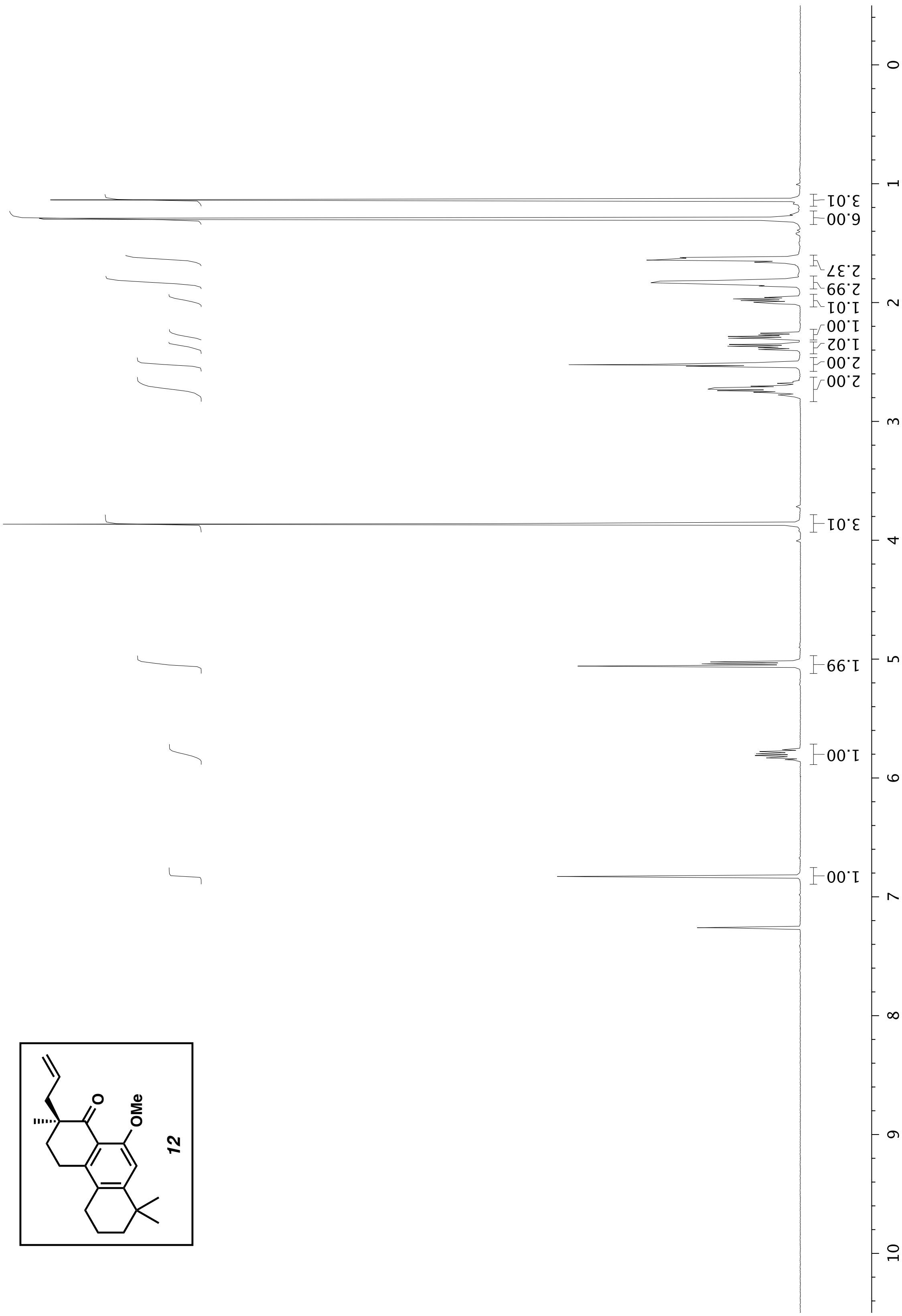
^{1}H NMR (500 MHz, CDCl$_3$) of compound **16**.



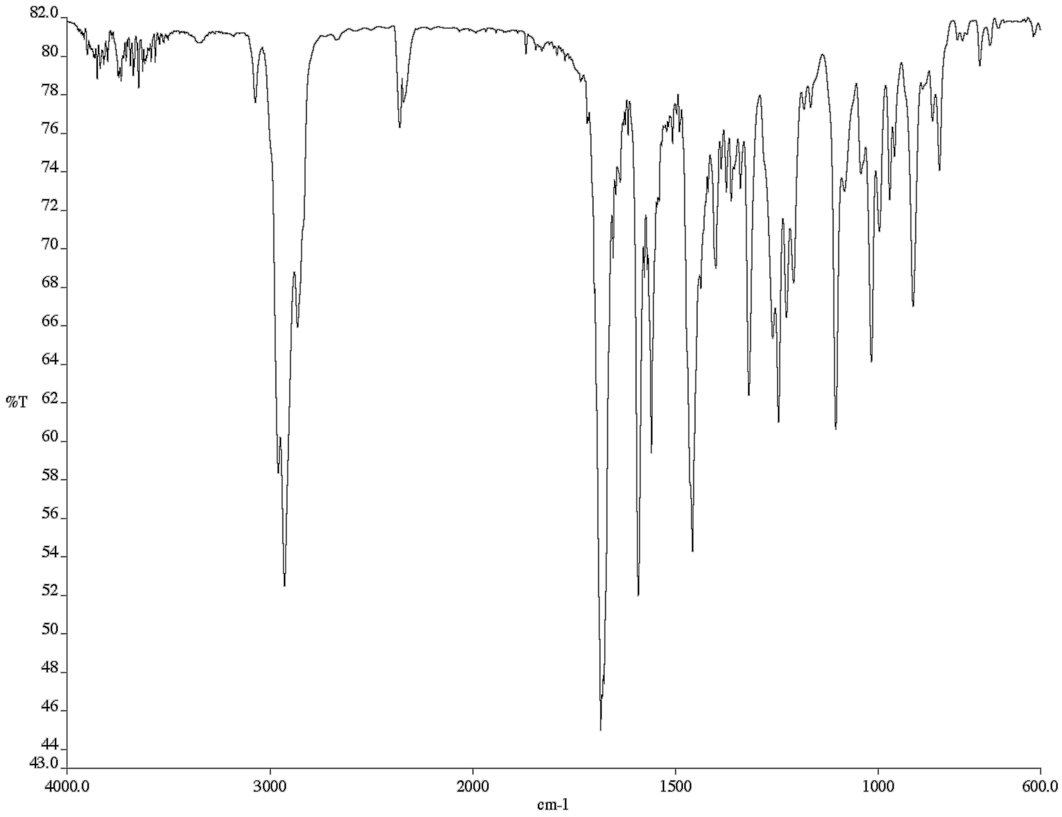
Infrared spectrum (Thin Film, NaCl) of compound **16**.



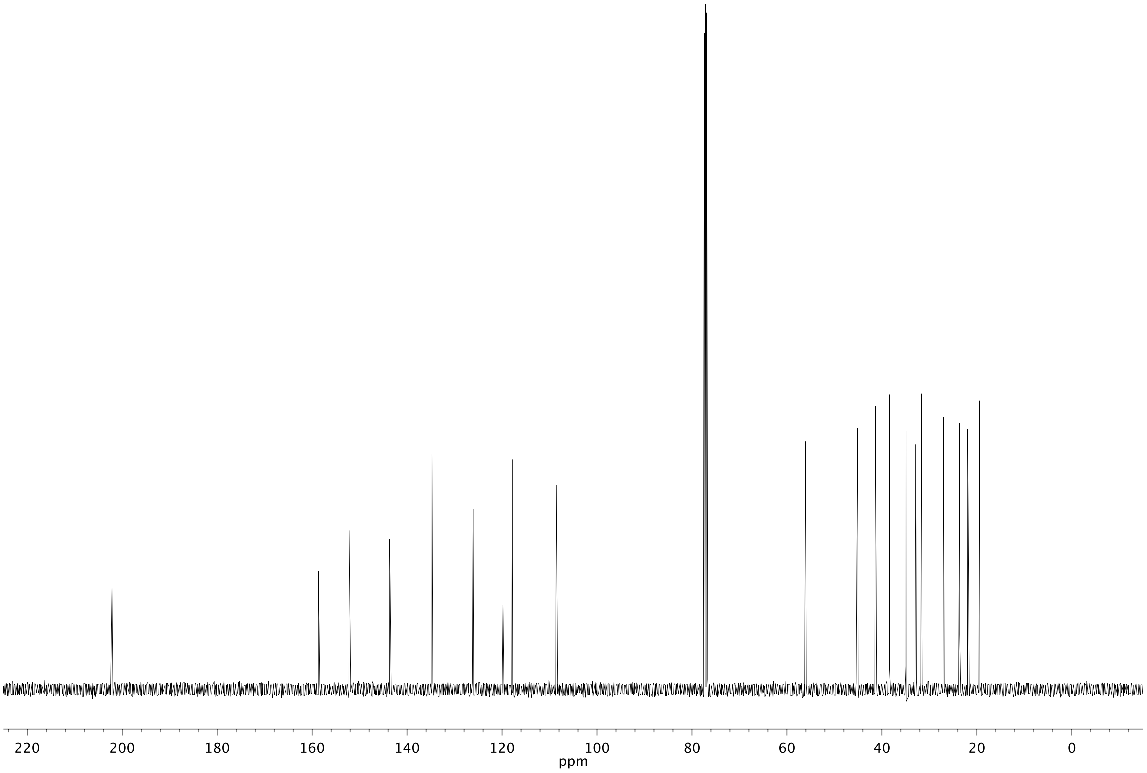
^{13}C NMR (126 MHz, CDCl$_3$) of compound **16**.



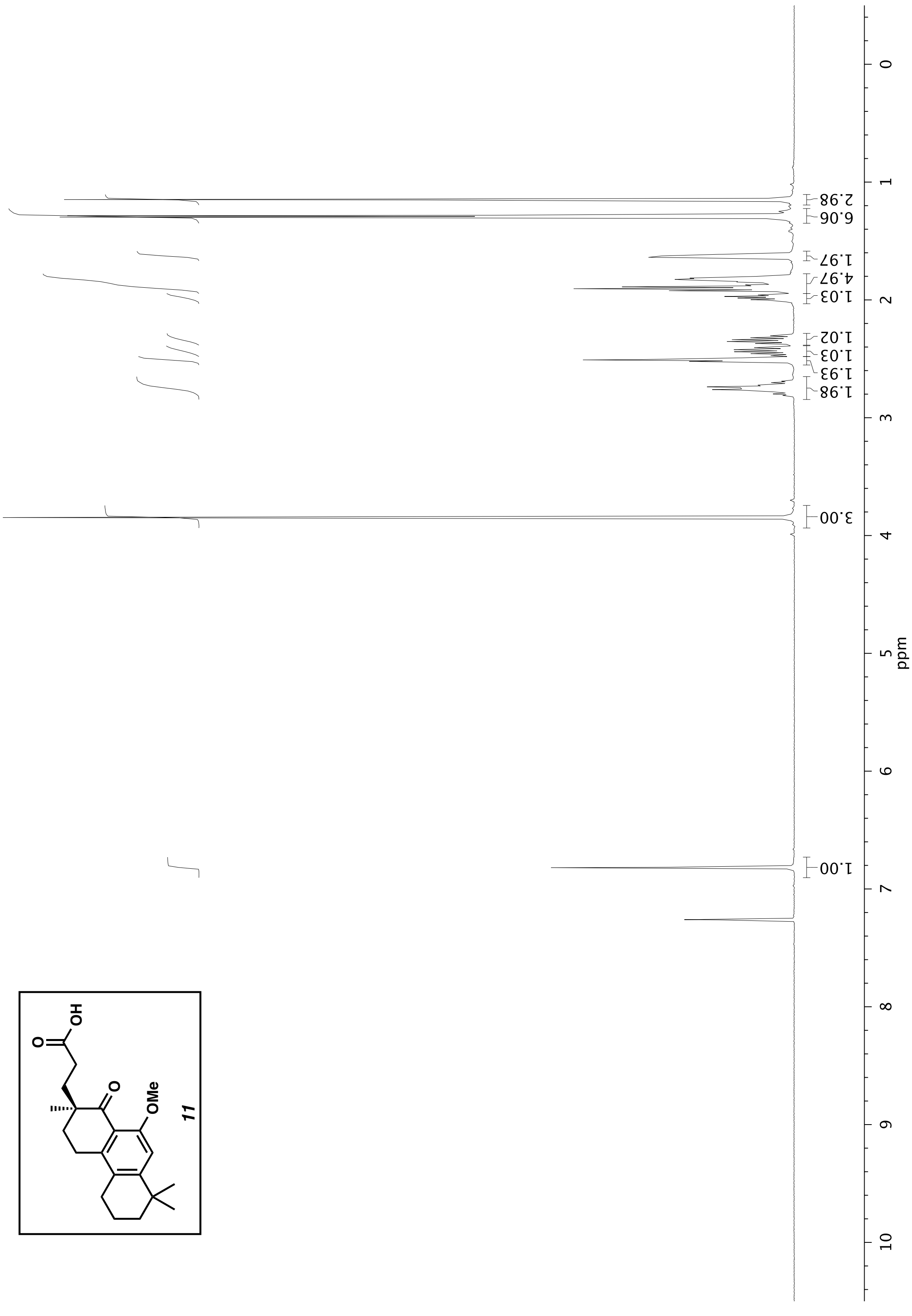
^{1}H NMR (500 MHz, CDCl$_3$) of compound **12**.



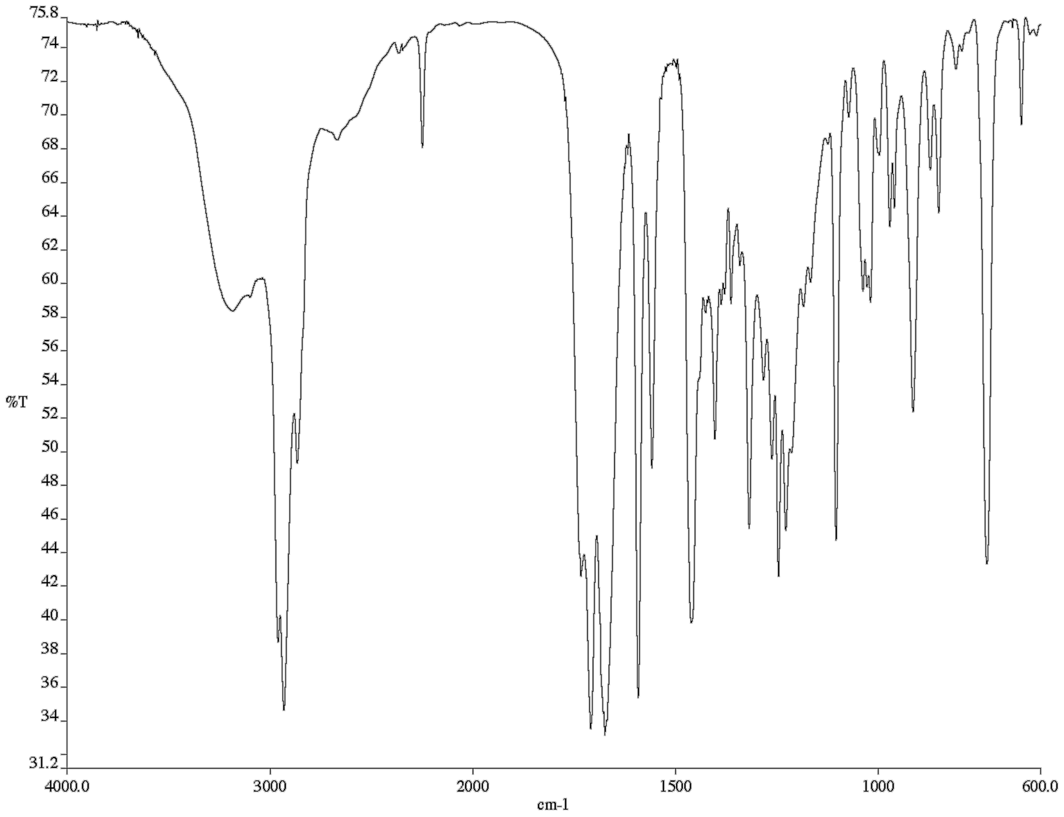
Infrared spectrum (Thin Film, NaCl) of compound **12**.



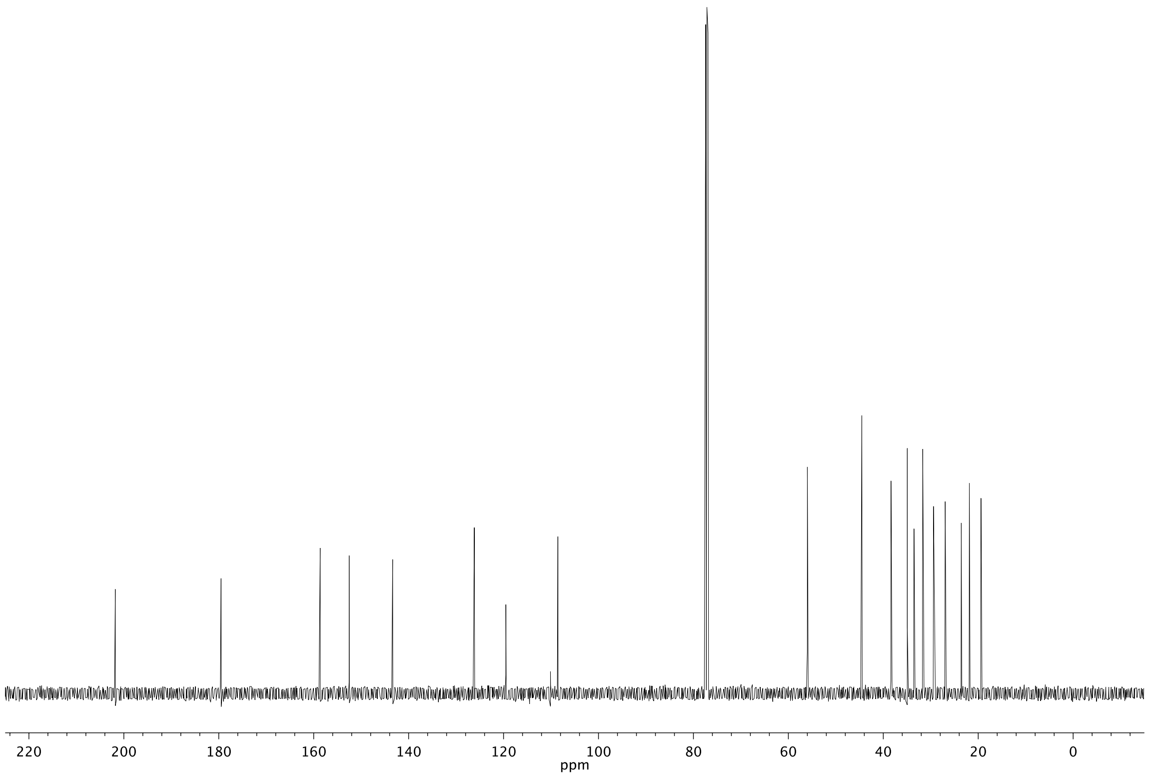
^{13}C NMR (126 MHz, CDCl$_3$) of compound **12**.



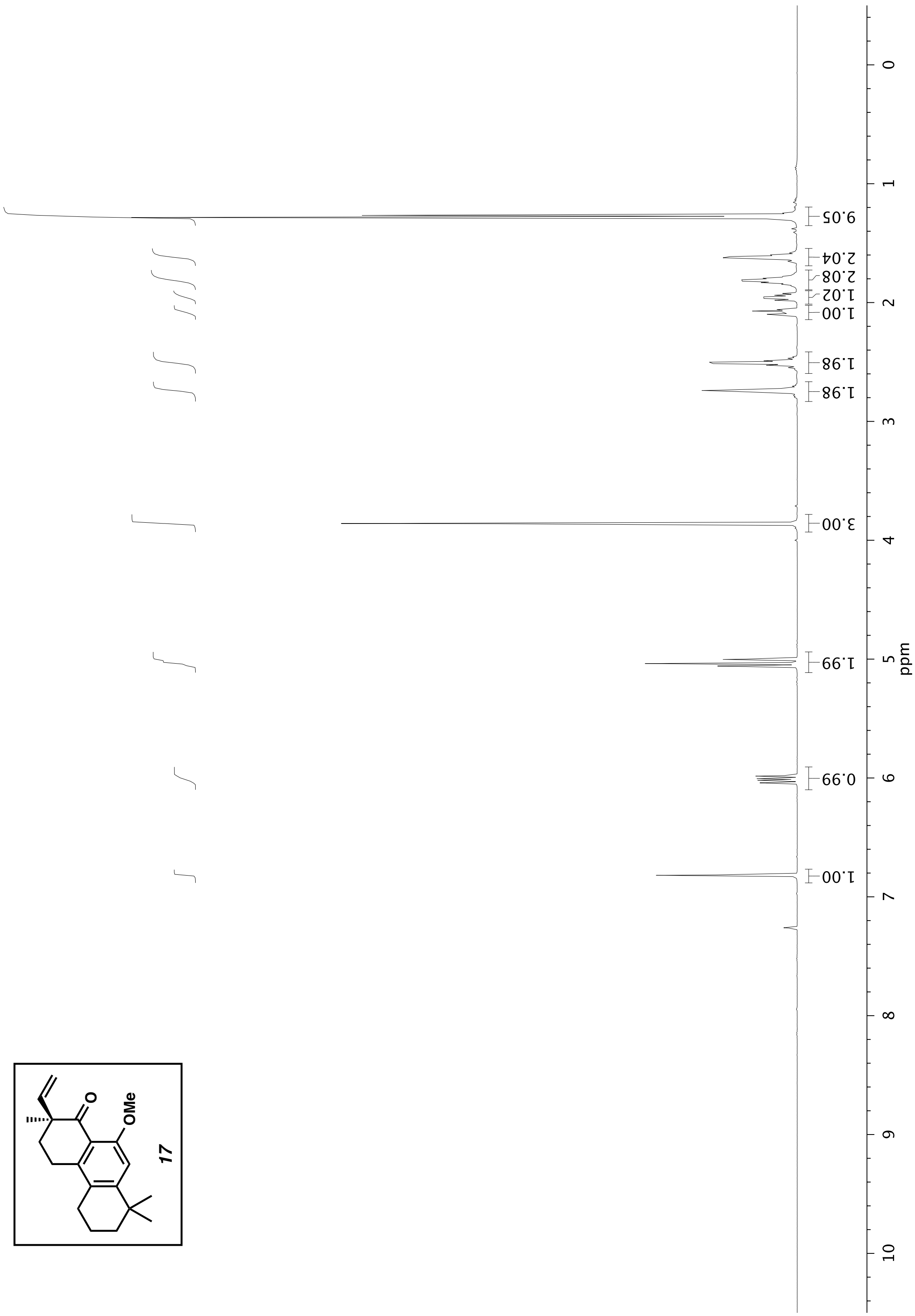
^{1}H NMR (500 MHz, CDCl$_3$) of compound **11**.



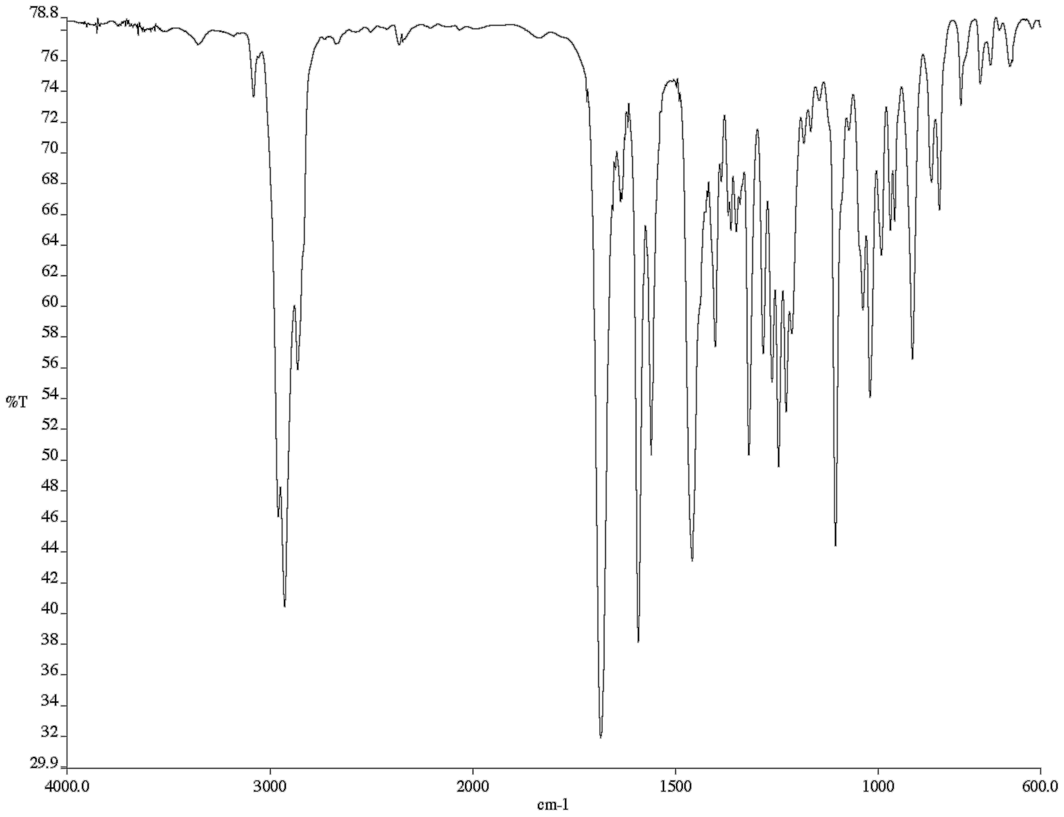
Infrared spectrum (Thin Film, NaCl) of compound **11**.



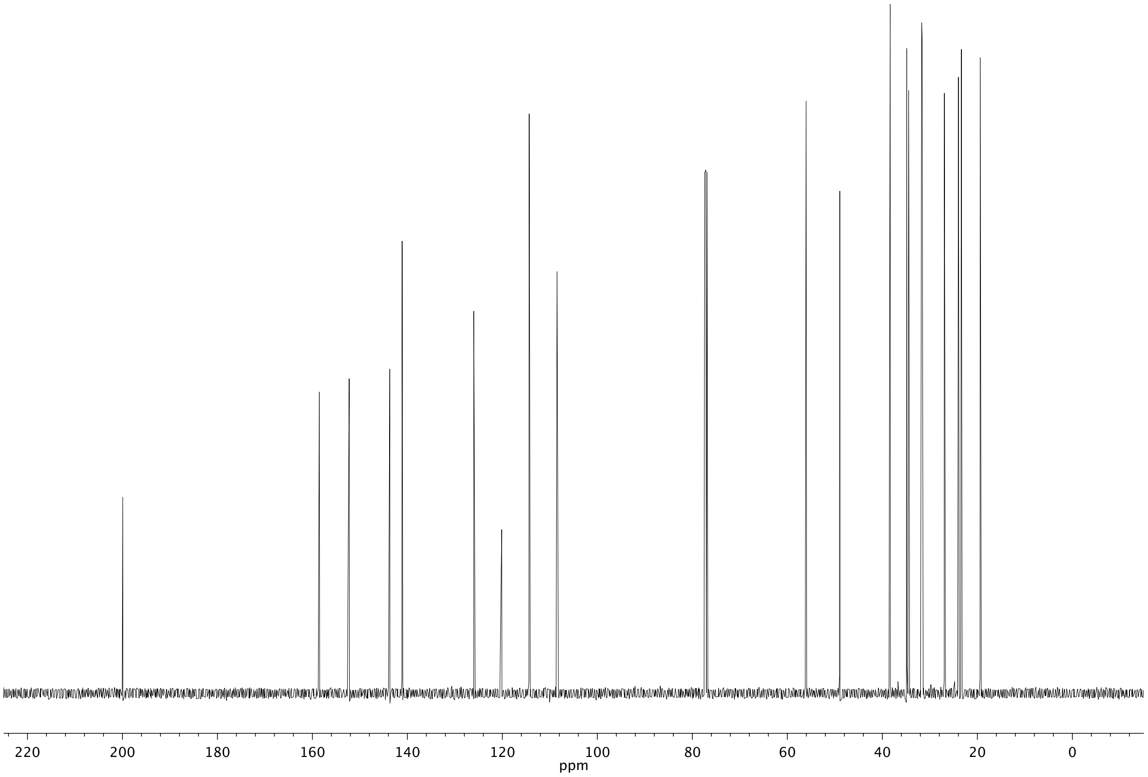
^{13}C NMR (126 MHz, CDCl$_3$) of compound **11**.



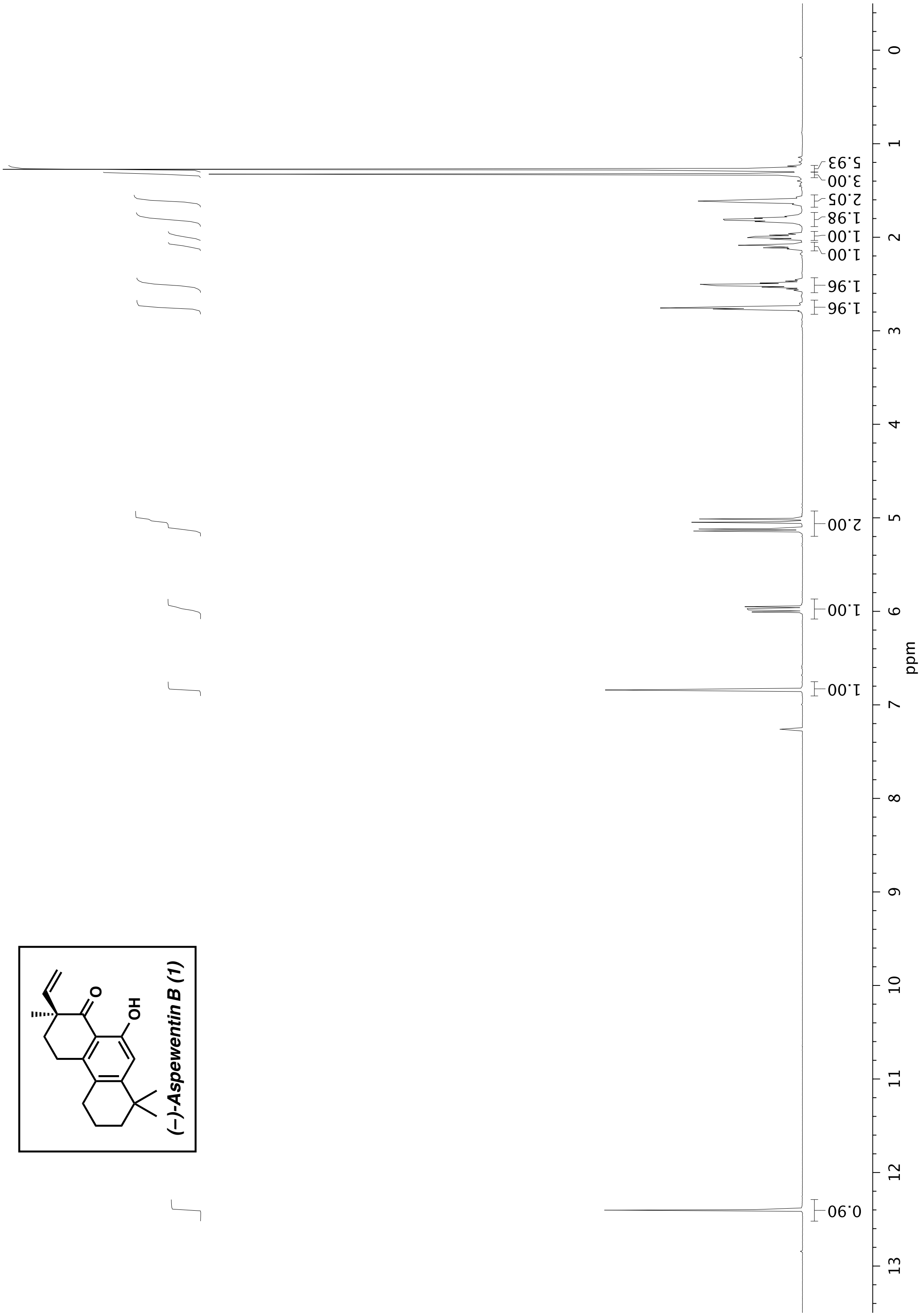
^{1}H NMR (500 MHz, CDCl$_3$) of compound **17**.



Infrared spectrum (Thin Film, NaCl) of compound **17**.

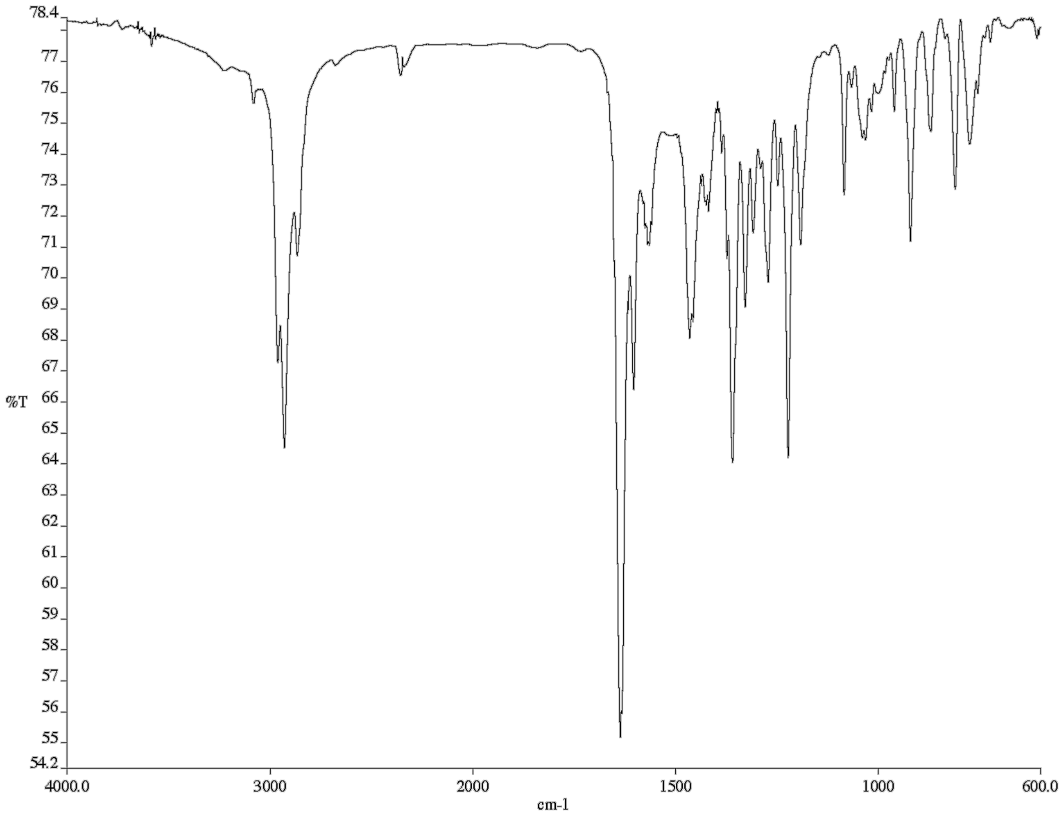


^{13}C NMR (126 MHz, CDCl$_3$) of compound **17**.

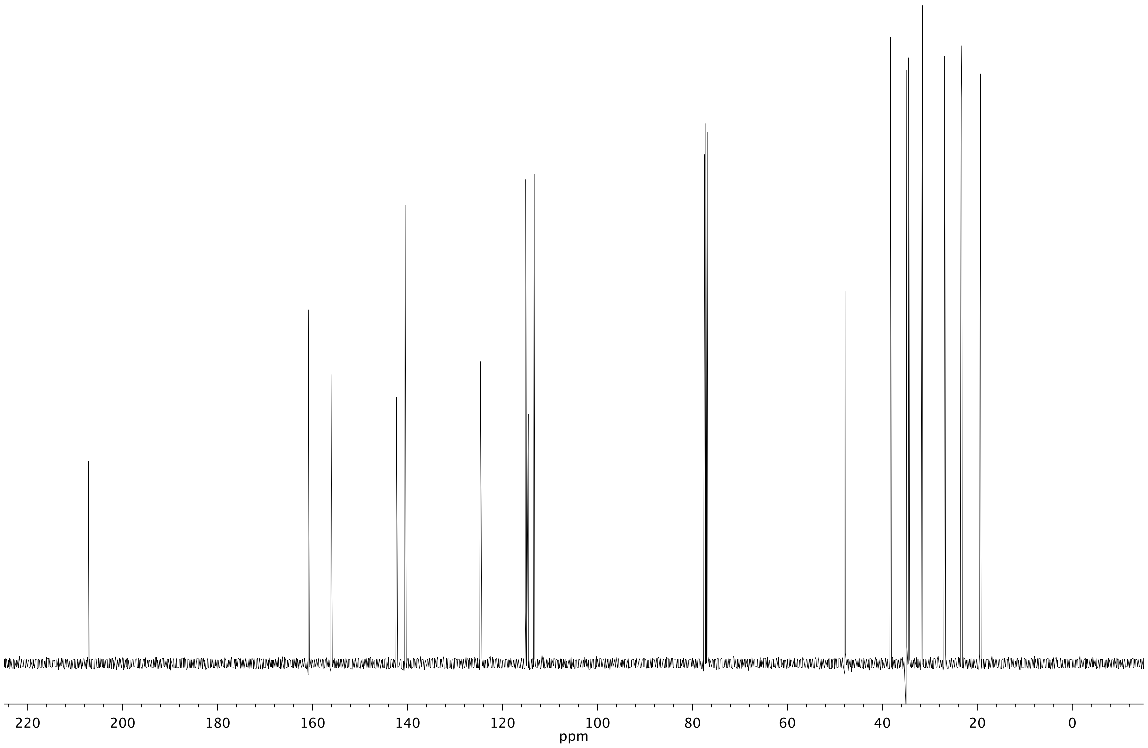


(−)-Aspewentin B (1)

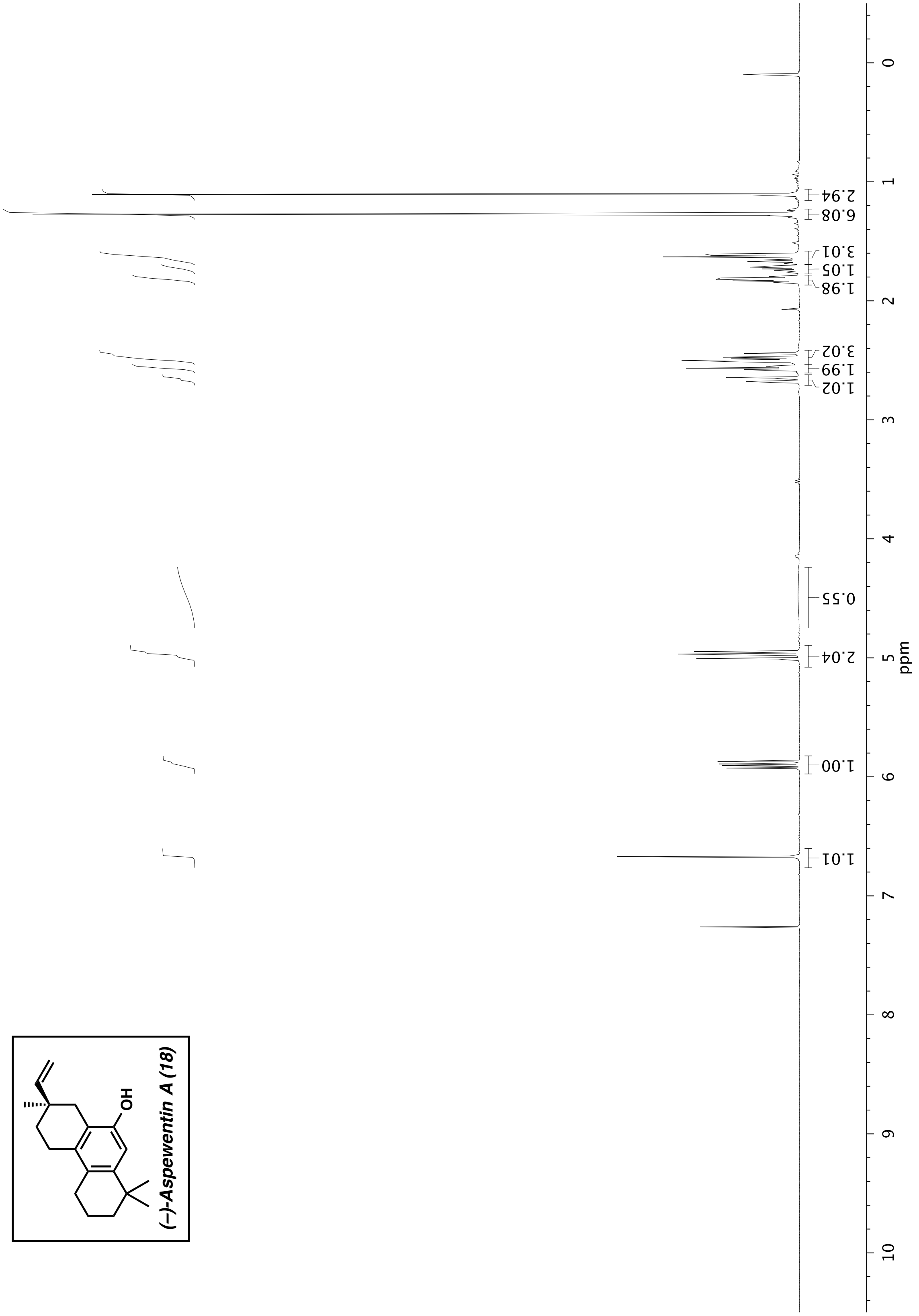
^{1}H NMR (500 MHz, $CDCl_3$) of compound **1**.



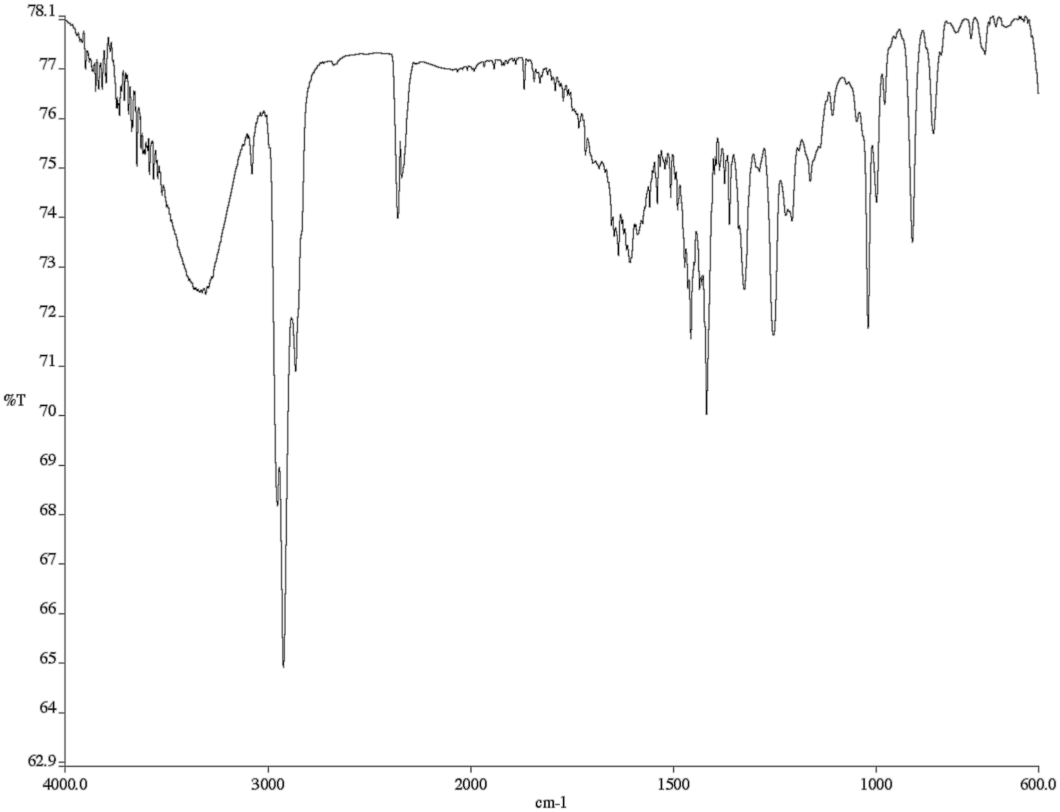
Infrared spectrum (Thin Film, NaCl) of compound **1**.



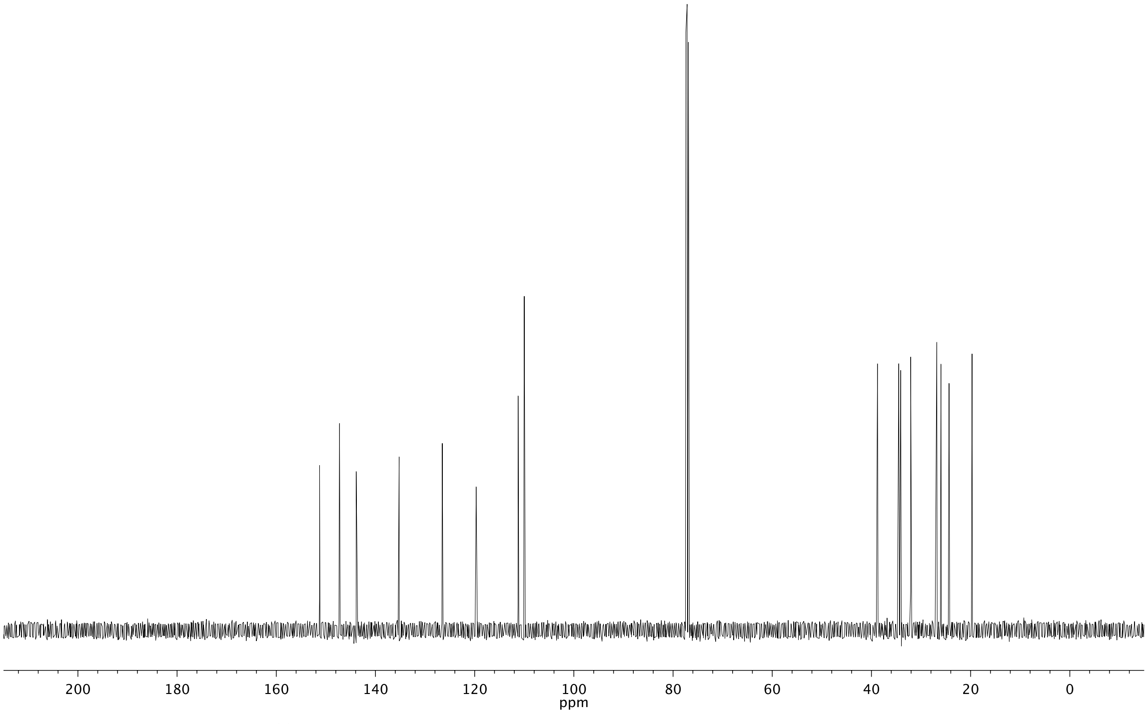
^{13}C NMR (126 MHz, CDCl$_3$) of compound **1**.



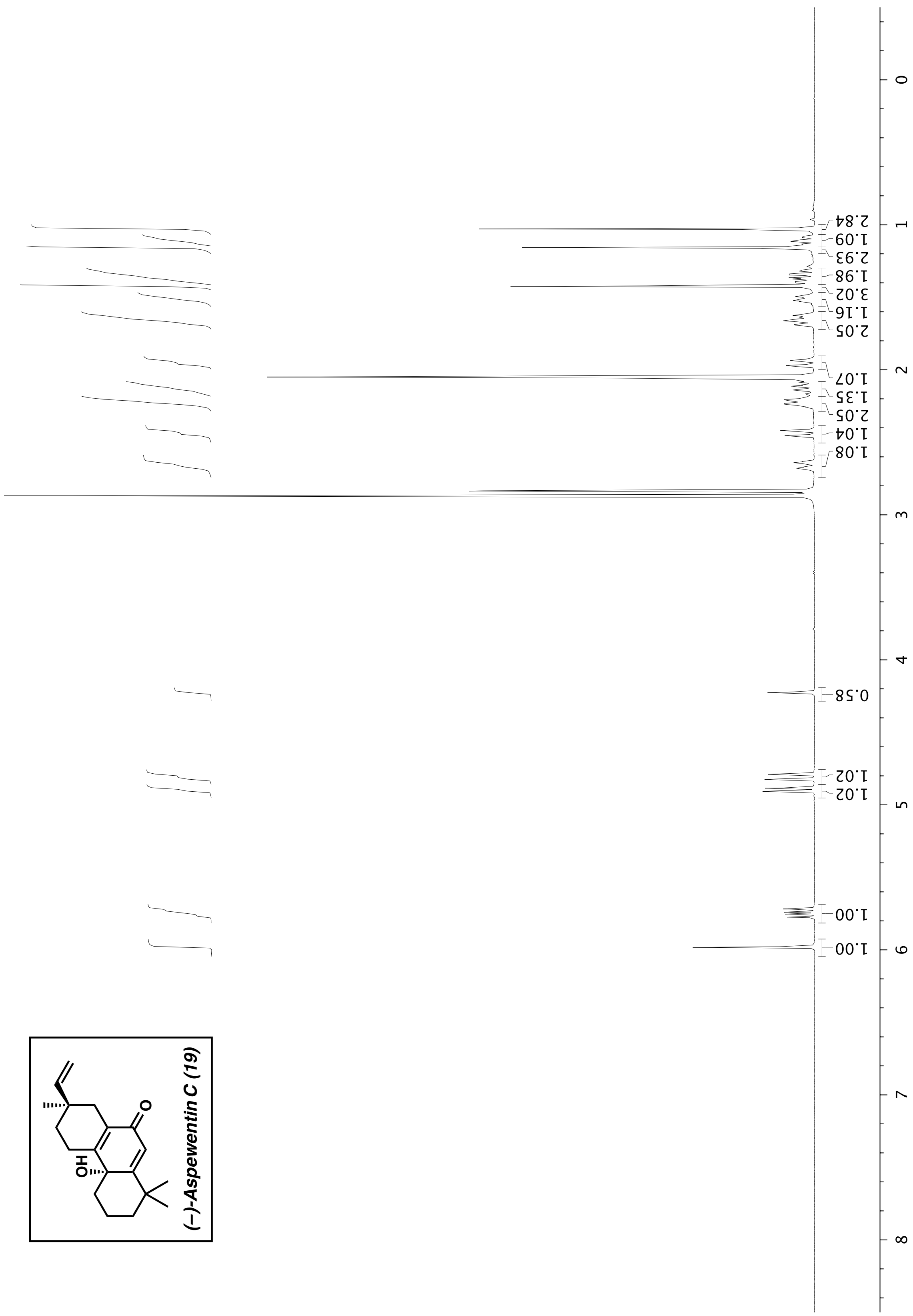
^{1}H NMR (500 MHz, CDCl$_3$) of compound **18**.



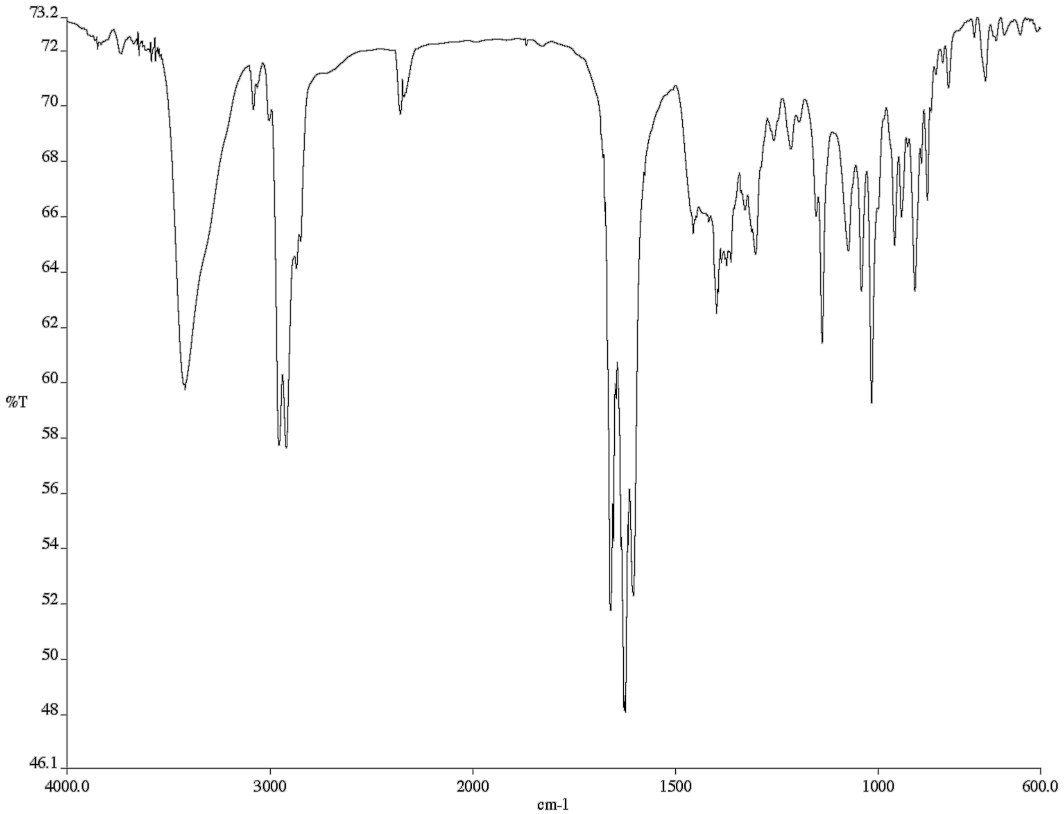
Infrared spectrum (Thin Film, NaCl) of compound **18**.



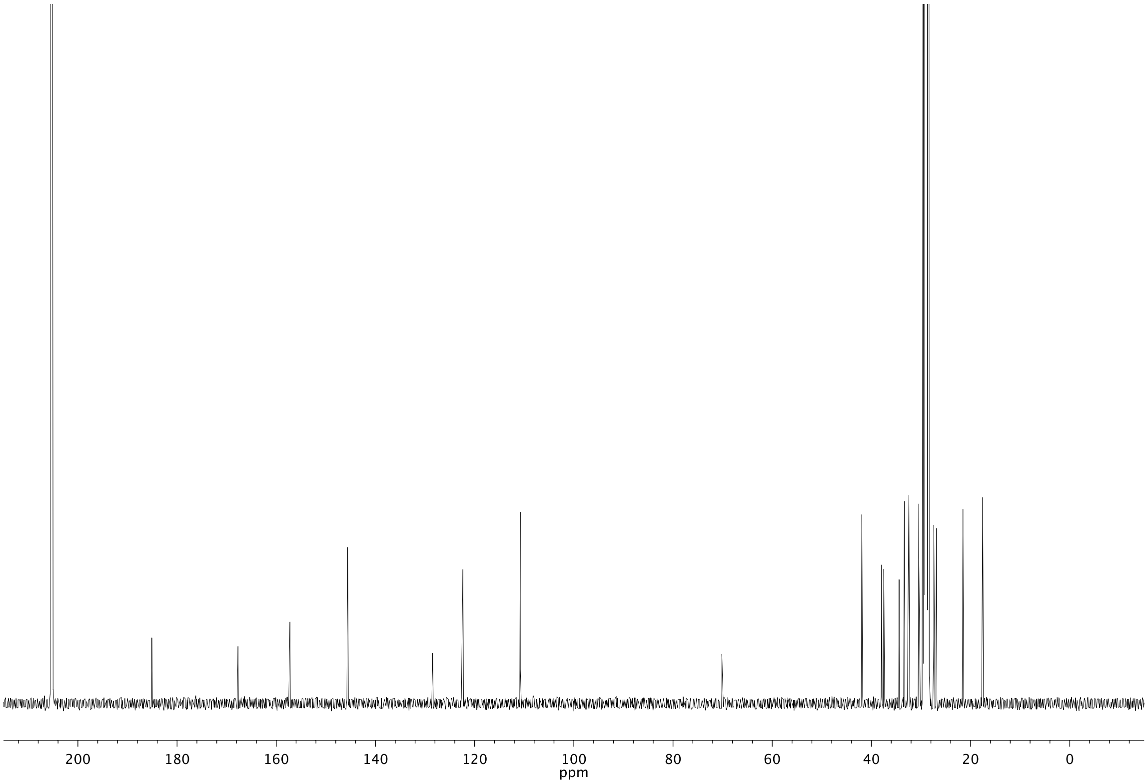
^{13}C NMR (126 MHz, CDCl$_3$) of compound **18**.



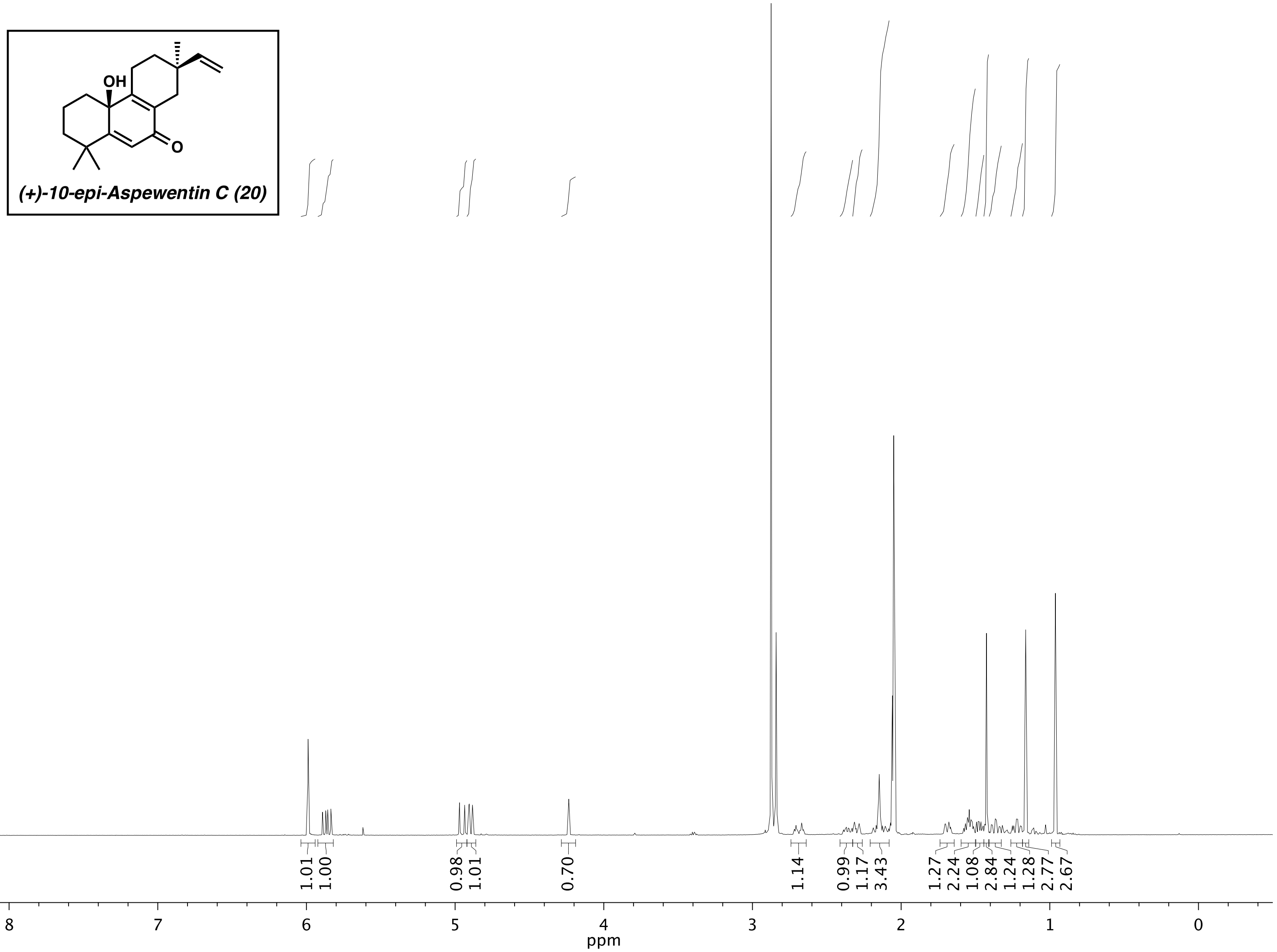
^{1}H NMR (500 MHz, Acetone-d_6) of compound **19**.



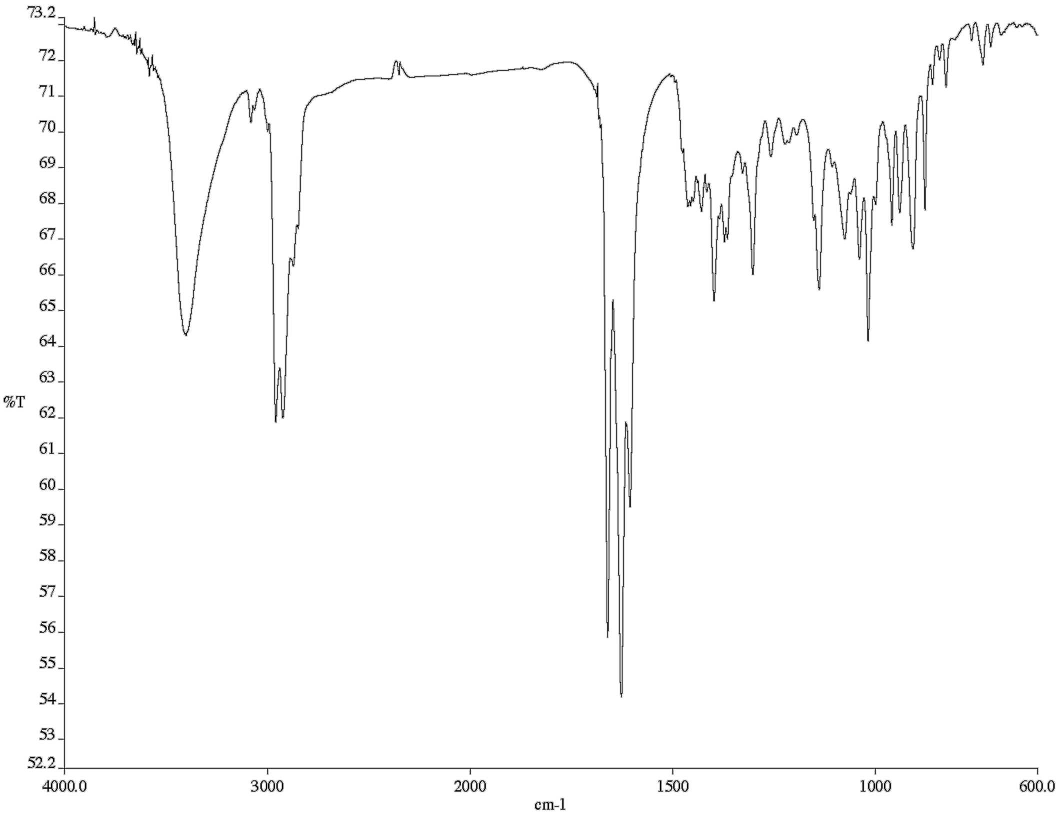
Infrared spectrum (Thin Film, NaCl) of compound **19**.



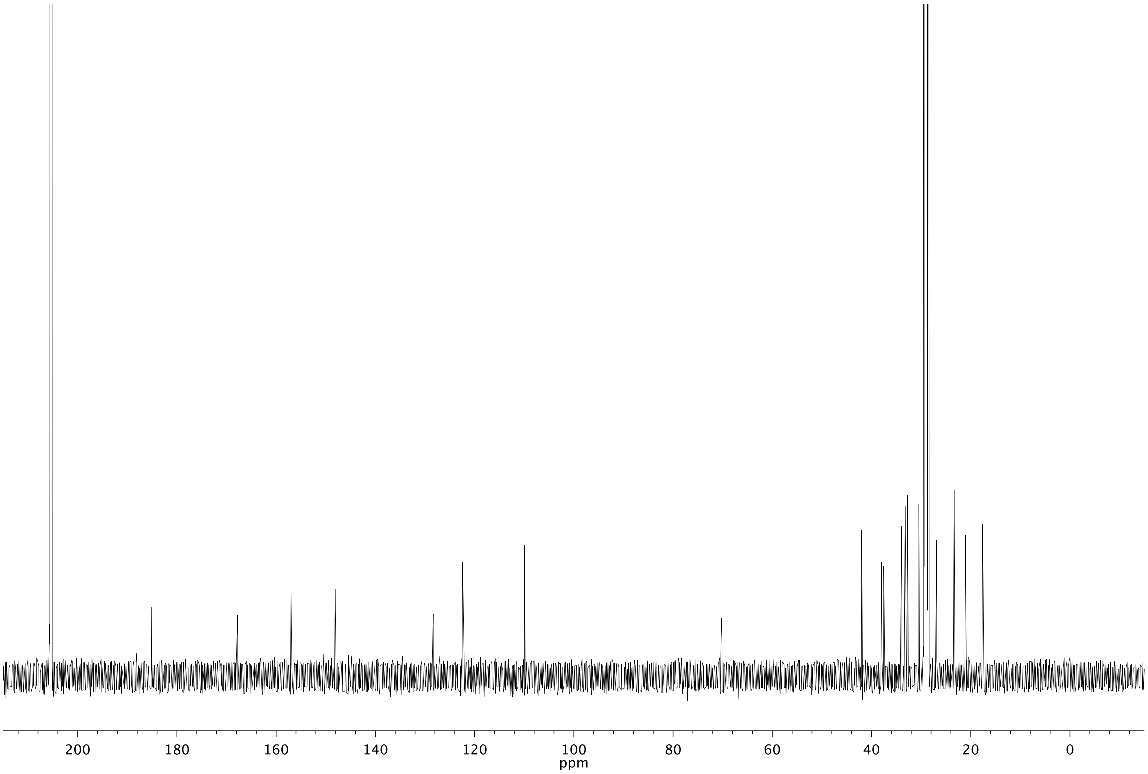
^{13}C NMR (101 MHz, Acetone-d_6) of compound **19**.



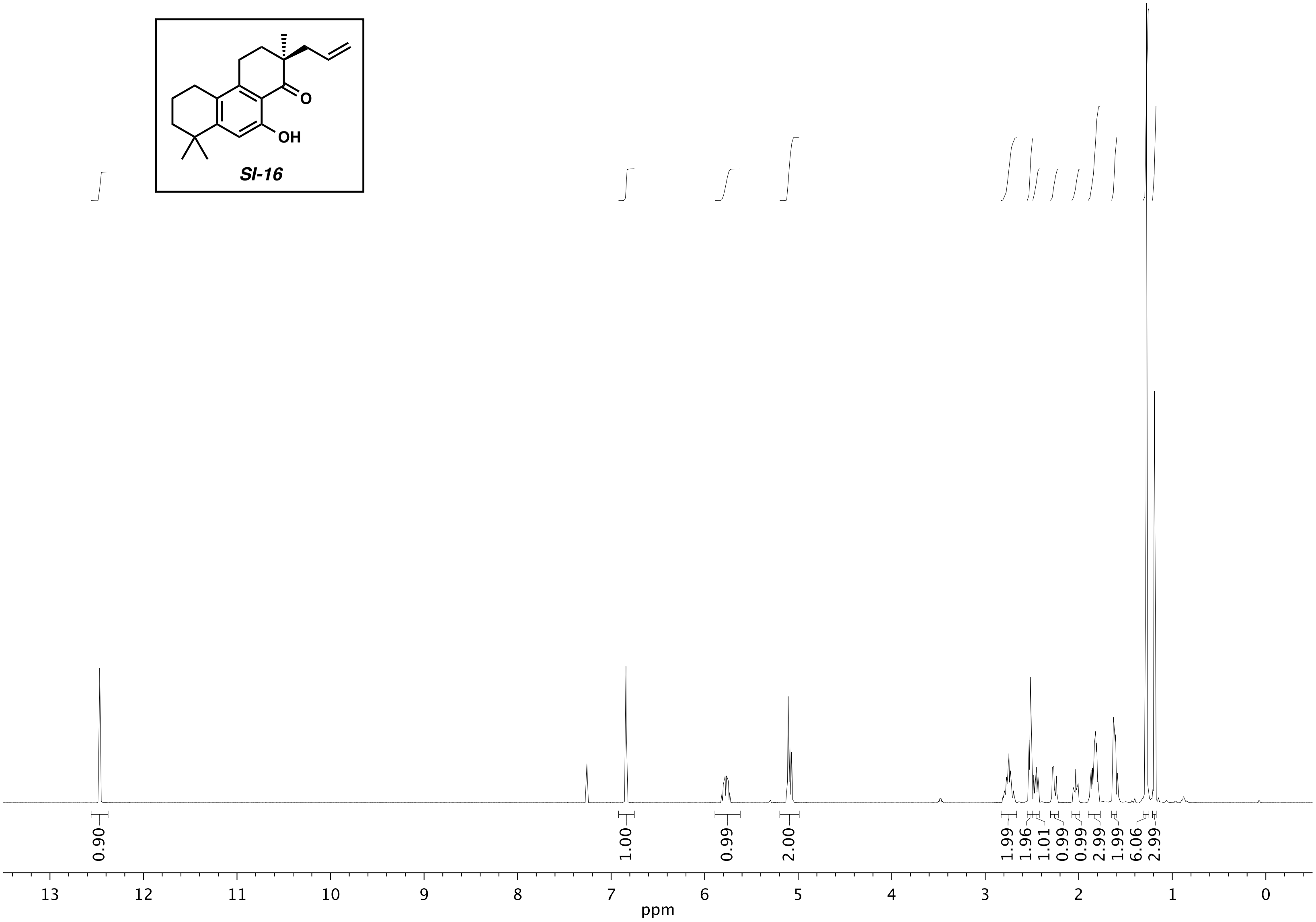
^{1}H NMR (500 MHz, Acetone-d_6) of compound **20**.



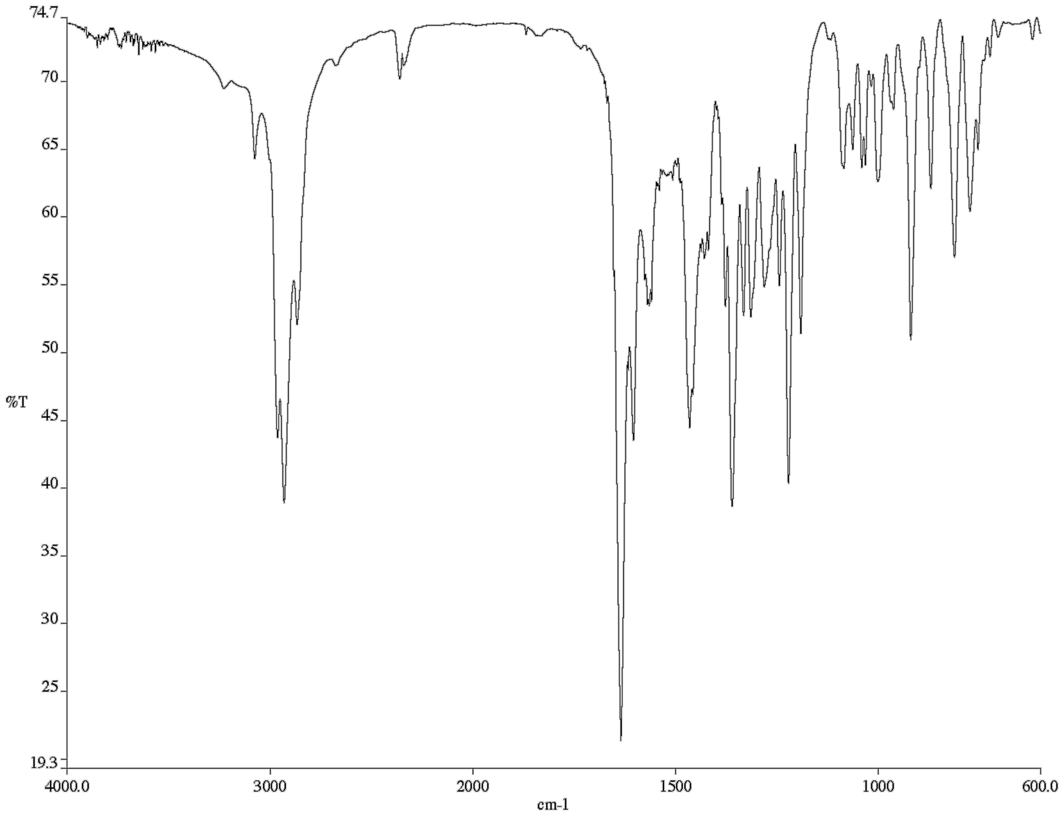
Infrared spectrum (Thin Film, NaCl) of compound **20**.



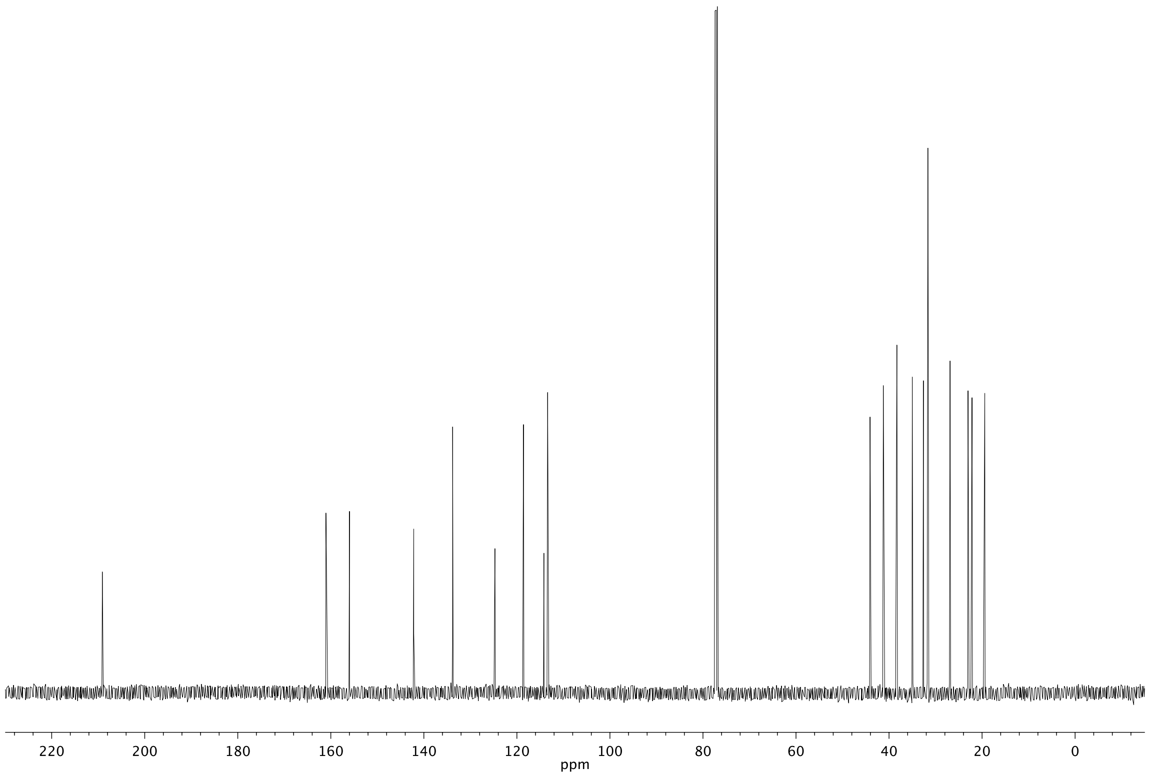
^{13}C NMR (126 MHz, Acetone-d_6) of compound **20**.



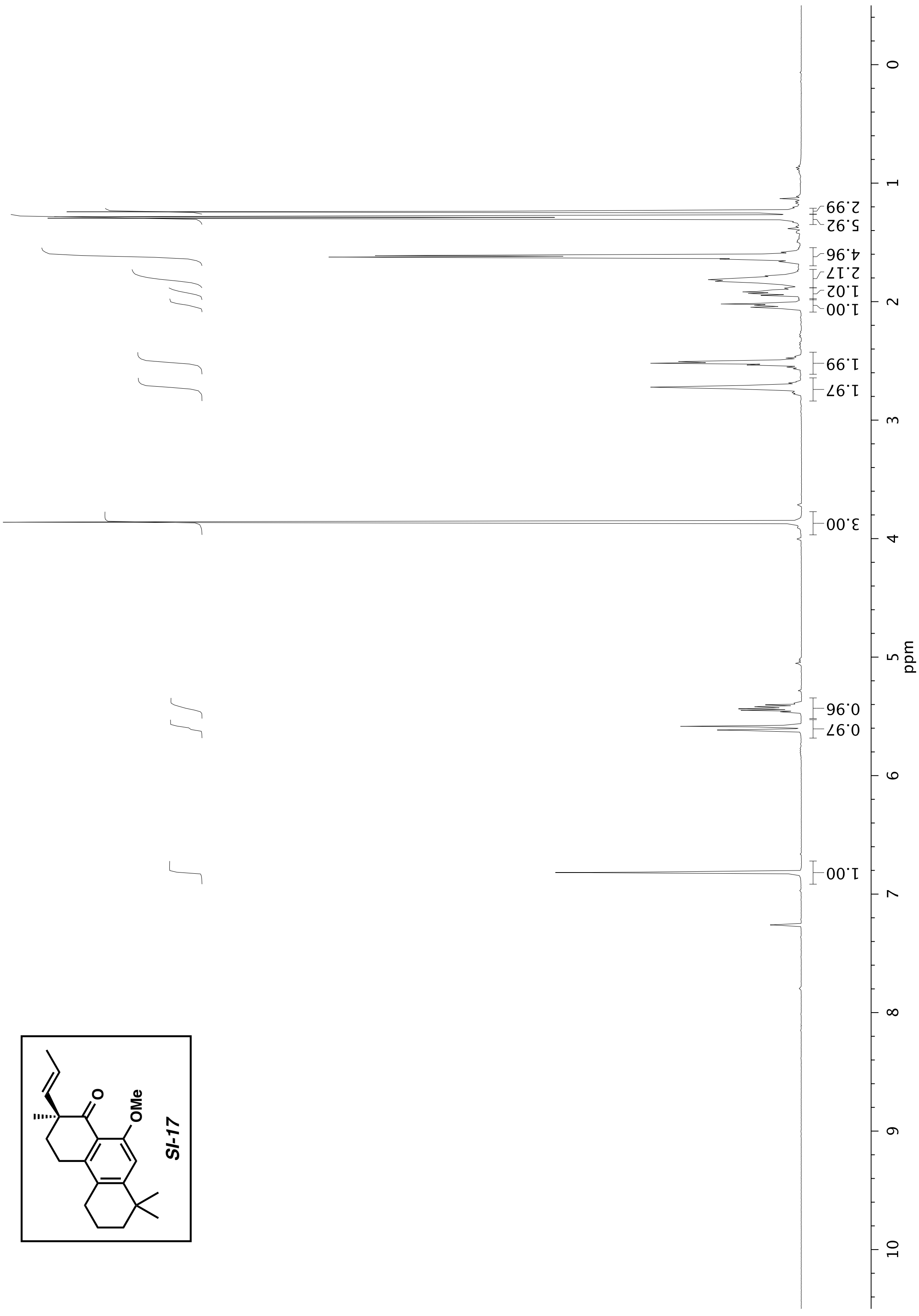
^{1}H NMR (500 MHz, CDCl$_3$) of compound **SI-16**.



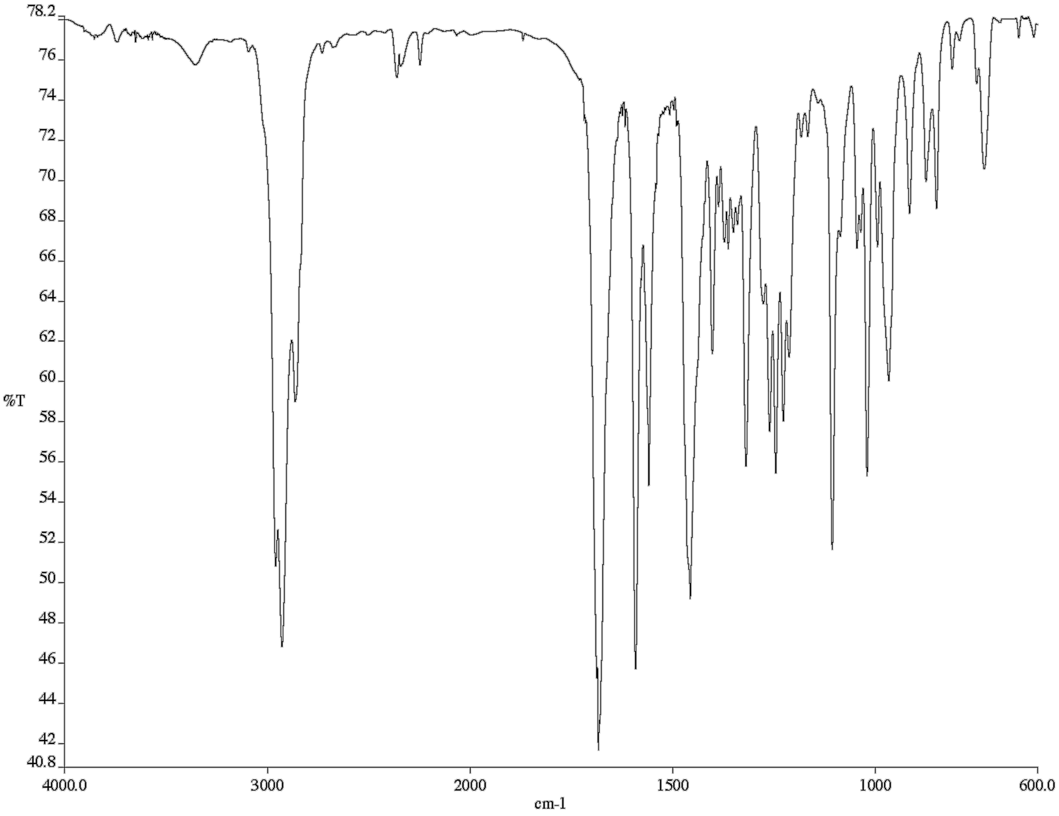
Infrared spectrum (Thin Film, NaCl) of compound **SI-16**.



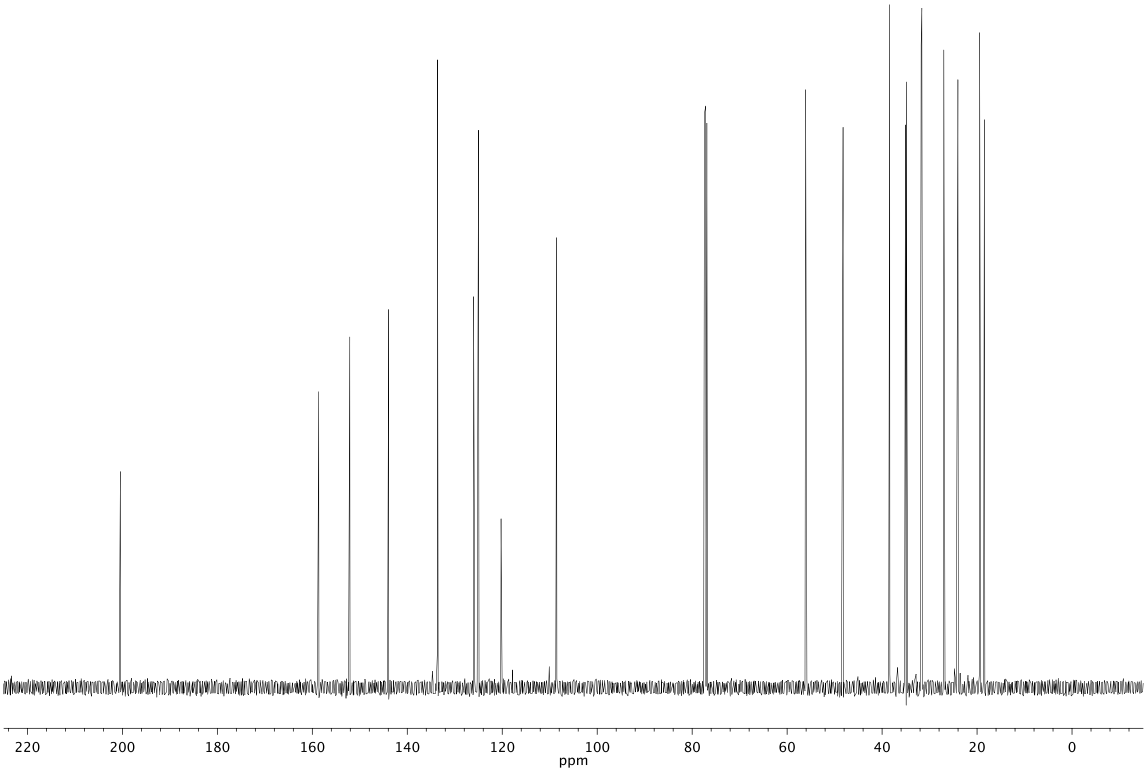
^{13}C NMR (126 MHz, $CDCl_3$) of compound **SI-16**.



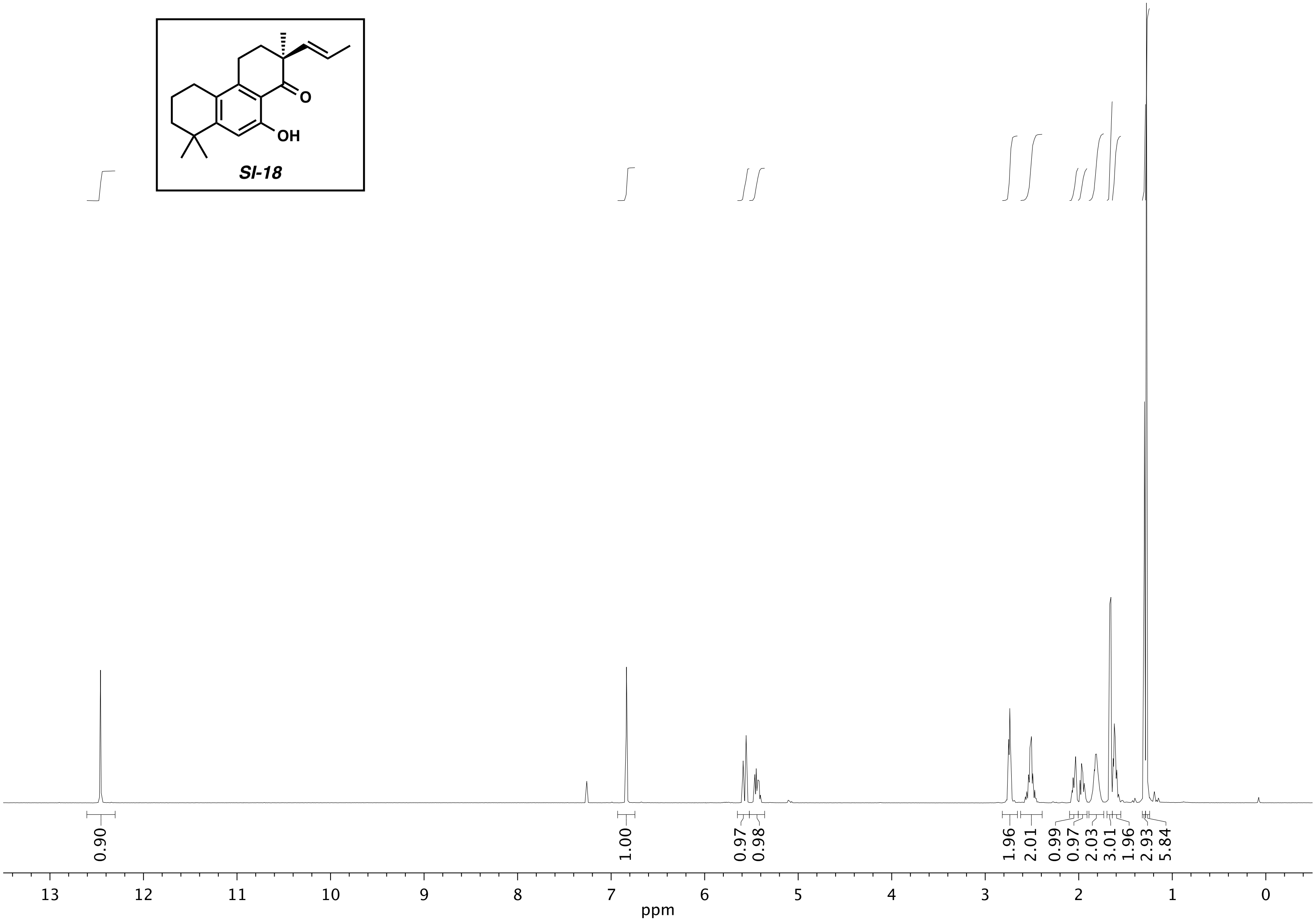
^{1}H NMR (500 MHz, CDCl$_3$) of compound **SI-17**.



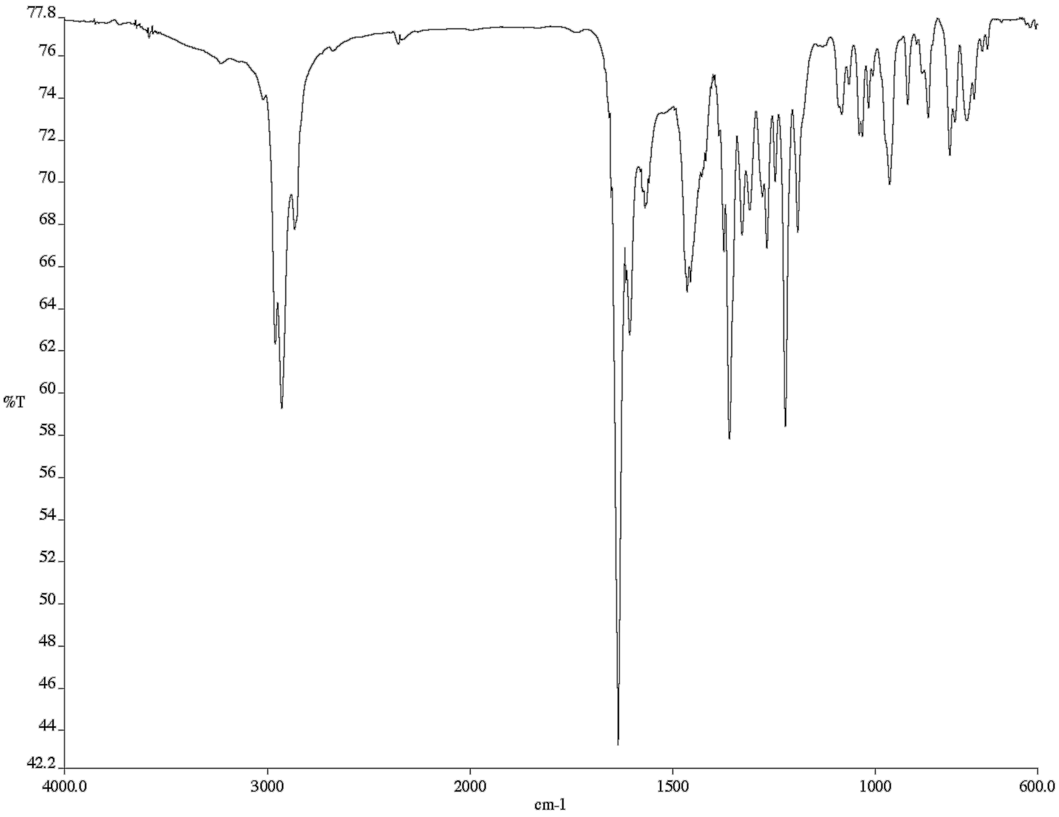
Infrared spectrum (Thin Film, NaCl) of compound **SI-17**.



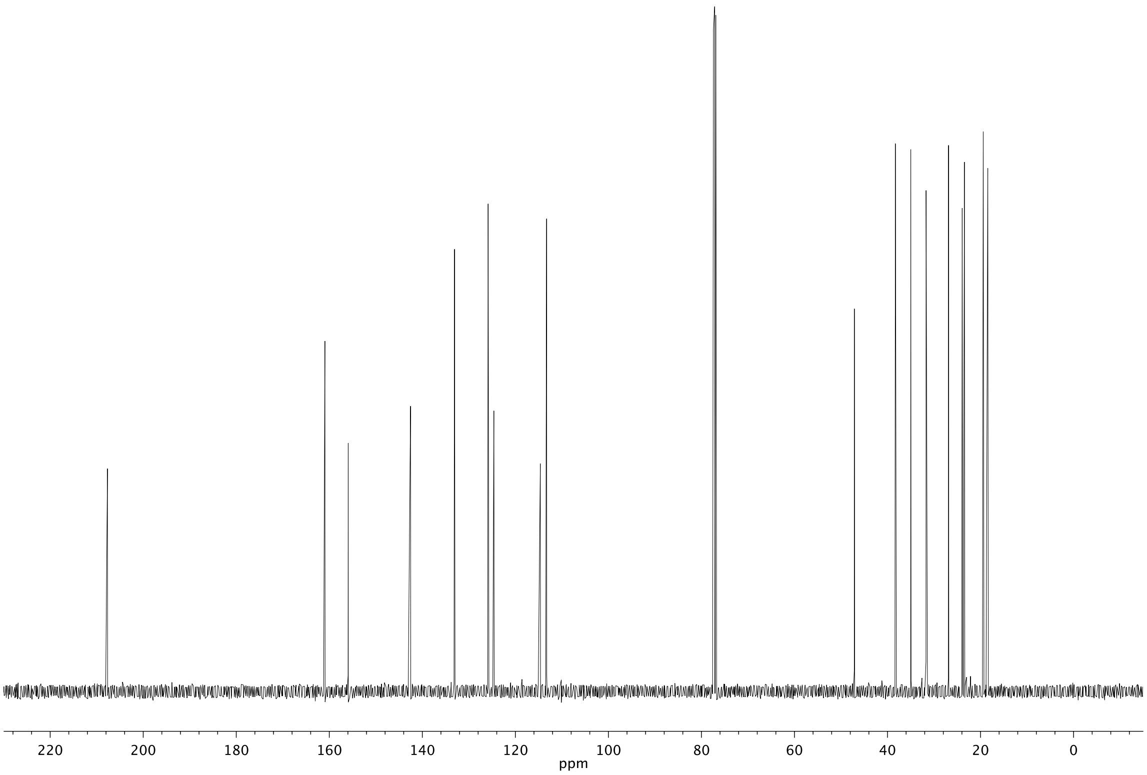
^{13}C NMR (126 MHz, CDCl$_3$) of compound **SI-17**.



^{1}H NMR (500 MHz, $CDCl_3$) of compound **SI-18**.



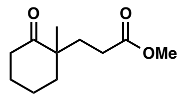
Infrared spectrum (Thin Film, NaCl) of compound **SI-18**.



^{13}C NMR (126 MHz, $CDCl_3$) of compound **SI-18**.

Representative Chiral HPLC, SFC, and GC Traces

```
Data File C:\CHEM32\1\DATA\YL11\YL-XI-223A_OD_10IPA15-220.D
Sample Name: YL-XI-223A_OD
    ====================================================================
    Acq. Operator   : YL                                 Seq. Line :    7
    Acq. Instrument : HPLC 1                              Location : Vial 31
    Injection Date  : 11/22/2014 8:50:26 PM                    Inj :    1
                                                        Inj Volume : 5.0 µl
    Different Inj Volume from Sequence !      Actual Inj Volume : 10.0 µl
    Acq. Method     : C:\CHEM32\1\METHODS\10IPA15_220.M
    Last changed    : 11/22/2014 8:42:16 PM by MW
    Analysis Method : C:\CHEM32\1\METHODS\10IPA20_254_0_5MLMIN.M
    Last changed    : 1/26/2015 5:59:15 PM by SJH
                      (modified after loading)
    Method Info     : 10% IPA    20 min   254 nm   0.5 mL/min
```



(±)-SI-3

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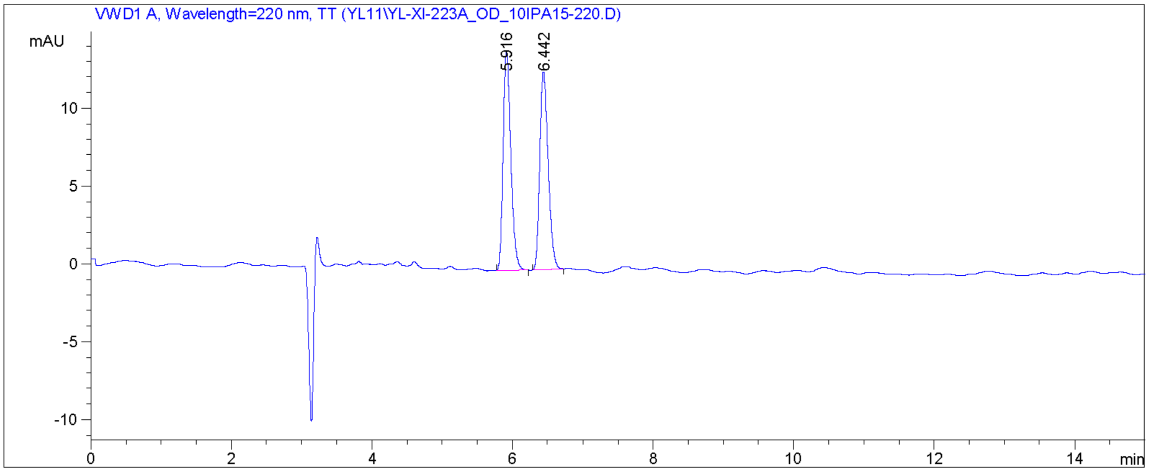
    ====================================================================
```



```
    ====================================================================
                             Area Percent Report
    ====================================================================

    Sorted By             :      Signal
    Multiplier:                  :      1.0000
    Dilution:                    :      1.0000
    Do not use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=220 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1   5.916 BB    0.1171  107.35893   14.12435  50.4407
       2   6.442 BB    0.1282  105.48306   12.69412  49.5593

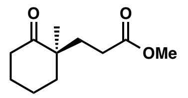
    Totals :                   212.84200   26.81847


    ====================================================================
                             Summed Peaks Report
    ====================================================================

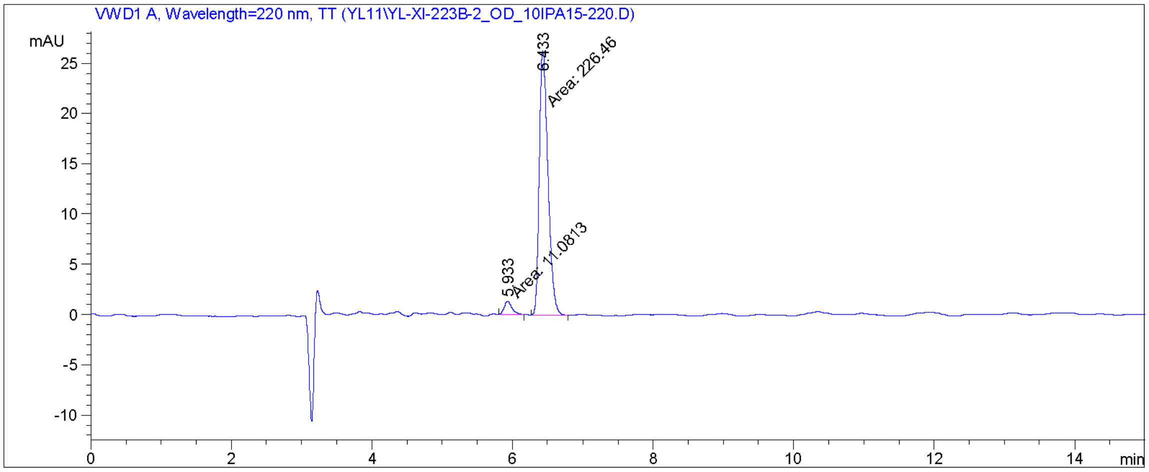
HPLC 1 1/26/2015 5:59:35 PM SJH                                Page    1 of 2
```

```
Data File C:\CHEM32\1\DATA\YL11\YL-XI-223B-2_OD_10IPA15-220.D
Sample Name: YL-XI-223B-2_OD
    =====================================================================
    Acq. Operator   : YL                                Seq. Line :    4
    Acq. Instrument : HPLC 1                             Location : Vial 33
    Injection Date  : 11/25/2014 10:50:17 PM                  Inj :    1
                                                       Inj Volume : 5.0 µl
    Different Inj Volume from Sequence !      Actual Inj Volume : 10.0 µl
    Acq. Method     : C:\CHEM32\1\METHODS\10IPA15_220.M
    Last changed    : 11/22/2014 8:42:16 PM by MW
    Analysis Method : C:\CHEM32\1\METHODS\10IPA20_254_0_5MLMIN.M
    Last changed    : 1/26/2015 5:59:15 PM by SJH
                      (modified after loading)
    Method Info     : 10% IPA    20 min    254 nm   0.5 mL/min

    =====================================================================
```



SI-3



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    =====================================================================
                             Area Percent Report
    =====================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Do not use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=220 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]       %
    ----|-------|----|-------|----------|----------|--------|
       1   5.933 MM    0.1368   11.08131    1.35039   4.6650
       2   6.433 MM    0.1432  226.45950   26.36230  95.3350

    Totals :                   237.54081   27.71269


    =====================================================================
                             Summed Peaks Report
    =====================================================================
```

```
Data File C:\HPCHEM\2\DATA\YIYANG\9223-2.D                              Sample Name: YL-IX-223

    =====================================================================
    Injection Date  : 3/26/2014 12:42:30 AM          Seq. Line :    1
    Sample Name     : YL-IX-223                       Location : Vial 2
    Acq. Operator   : Yiyang                               Inj :    1
    Acq. Instrument : GC4                           Inj Volume : 1 µl
    Acq. Method     : C:\HPCHEM\2\METHODS\Y60130.M
    Last changed    : 3/26/2014 12:37:31 AM by mk
    Analysis Method : C:\HPCHEM\2\METHODS\YY180-3.M
    Last changed    : 5/5/2015 11:14:31 AM by KEK
                      (modified after loading)
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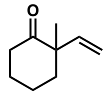
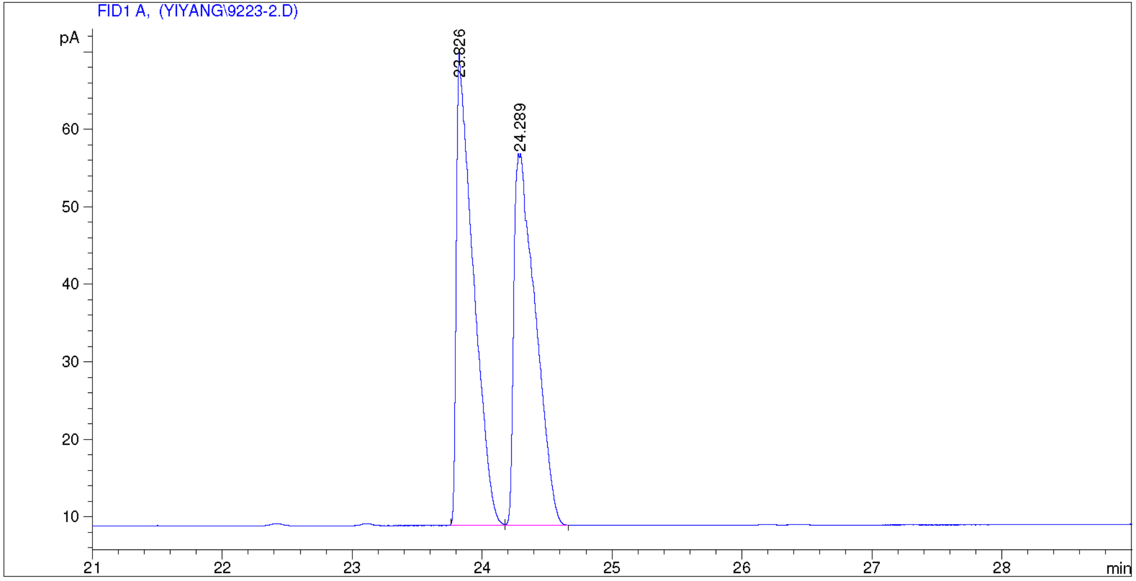


(±)-7



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    =====================================================================
                             Area Percent Report
    =====================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: FID1 A,

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [pA*s]      [pA]        %
    ----|-------|----|-------|----------|----------|--------|
       1  23.826 BV    0.1155  550.97797   60.94256 49.94253
       2  24.289 VB    0.1591  552.24609   47.68414 50.05747

    Totals :                   1103.22406  108.62670

     Results obtained with enhanced integrator!
    =====================================================================
                              *** End of Report ***
```
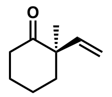
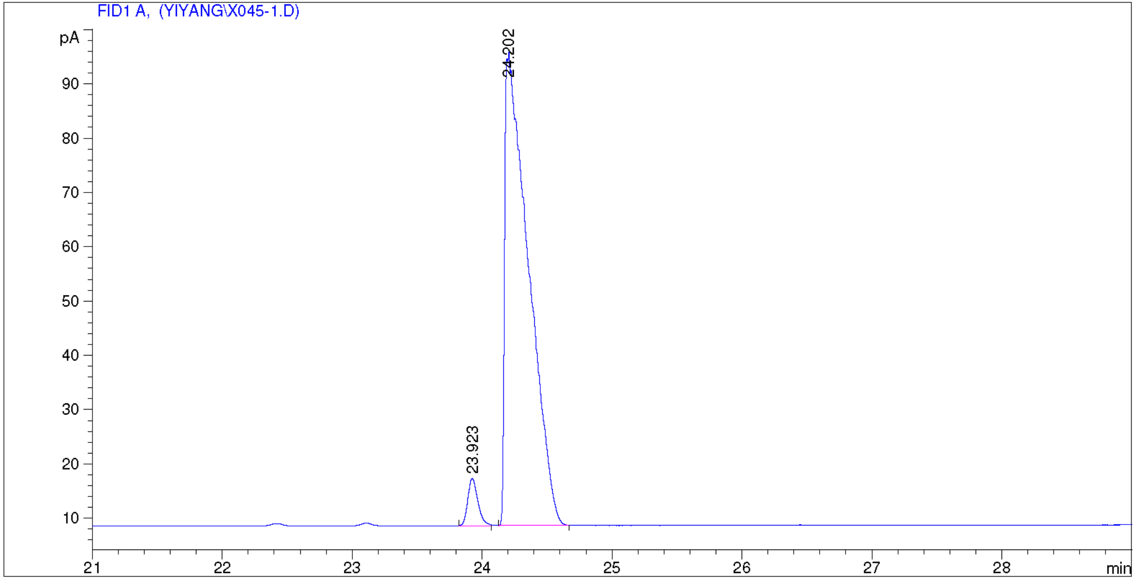

```
Data File C:\HPCHEM\2\DATA\YIYANG\X045-1.D                                  Sample Name: YL-X-045

    =====================================================================
    Injection Date  : 3/26/2014 1:32:40 AM           Seq. Line :    2
    Sample Name     : YL-X-045                         Location : Vial 3
    Acq. Operator   : Yiyang                                Inj :    1
    Acq. Instrument : GC4                            Inj Volume : 1 µl
    Acq. Method     : C:\HPCHEM\2\METHODS\Y60130.M
    Last changed    : 3/26/2014 12:37:31 AM by mk
    Analysis Method : C:\HPCHEM\2\METHODS\YY180-3.M
    Last changed    : 5/5/2015 11:14:31 AM by KEK
                      (modified after loading)
```

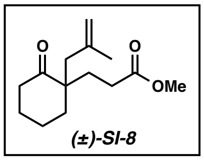


ent-7

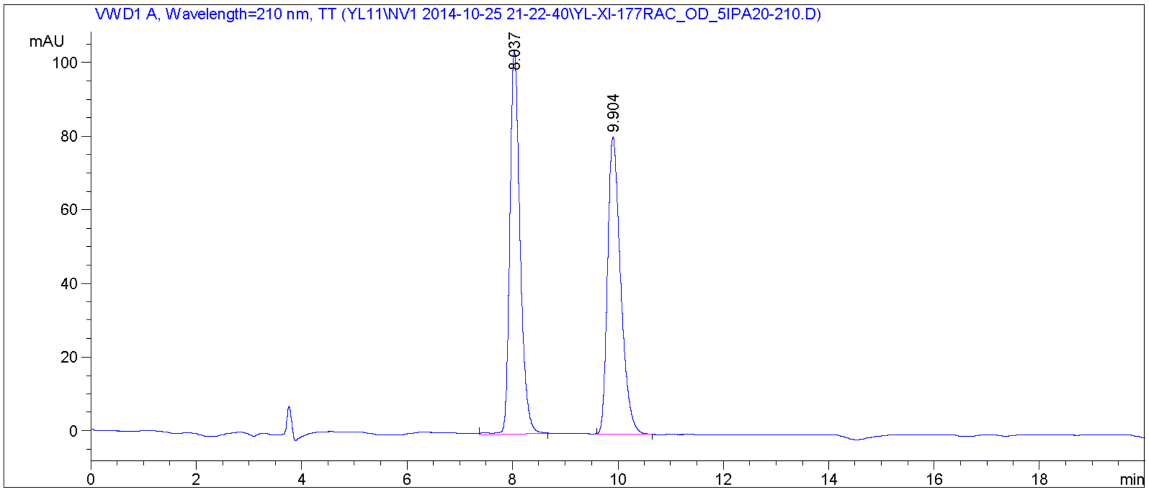


```
    =====================================================================
                             Area Percent Report
    =====================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: FID1 A,

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [pA*s]      [pA]        %
    ----|-------|----|-------|----------|----------|--------|
       1  23.923 BB    0.0826   46.69868    8.69731  4.06955
       2  24.202 BB    0.1601 1100.81531   86.70228 95.93045

    Totals :                  1147.51399   95.39959

     Results obtained with enhanced integrator!
    =====================================================================
                              *** End of Report ***



GC4 5/5/2015 11:14:47 AM KEK                                                Page 1 of 1
```

```
Data File C:\CHEM32\2\DATA\YL11\NV1 2014-10-25 21-22-40\YL-XI-177RAC_OD_5IPA20-210.D
Sample Name: YL-XI-177rac-OD
    =====================================================================
    Acq. Operator   : YL                               Seq. Line :  14
    Acq. Instrument : HPLC 2                            Location : Vial 1
    Injection Date  : 10/25/2014 11:42:10 PM                 Inj :   1
                                                      Inj Volume : 5.0 µl
    Acq. Method     : C:\CHEM32\2\DATA\YL11\NV1 2014-10-25 21-22-40\5IPA20_210.M
    Last changed    : 10/25/2014 9:19:06 PM by MW
    Analysis Method : C:\CHEM32\2\METHODS\2IPA20_210.M
    Last changed    : 10/25/2014 10:23:26 PM by MW
    Method Info     : 2% IPA   20 min   210 nm   1 mL/min

    =====================================================================
```



(±)-SI-8



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    =====================================================================
                             Area Percent Report
    =====================================================================

    Sorted By             :      Signal
    Multiplier:                    :      1.0000
    Dilution:                      :      1.0000
    Do not use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=210 nm, TT

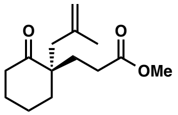
    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU    *s   [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1   8.037 BB    0.2061 1410.35120  104.13170  50.3374
       2   9.904 BB    0.2629 1391.44690   80.74227  49.6626

    Totals :                  2801.79810  184.87397

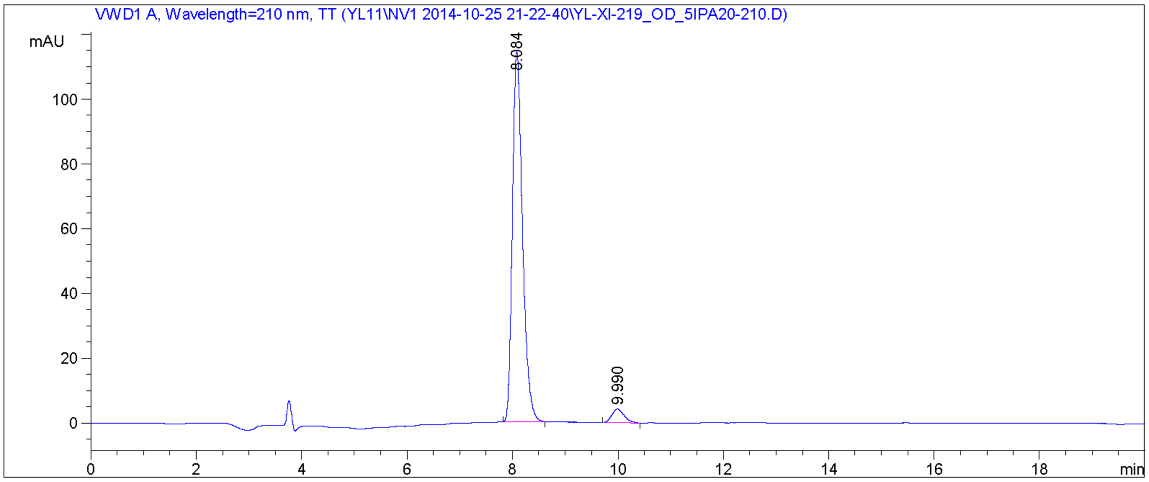

    =====================================================================
                             Summed Peaks Report
    =====================================================================
```

```
Data File C:\CHEM32\2\DATA\YL11\NV1 2014-10-25 21-22-40\YL-XI-219_OD_5IPA20-210.D
Sample Name: YL-XI-219-OD
    =====================================================================
    Acq. Operator    : YL                                Seq. Line :  16
    Acq. Instrument  : HPLC 2                             Location : Vial 2
    Injection Date   : 10/26/2014 12:14:06 AM                  Inj :   1
                                                        Inj Volume : 5.0 µl
    Acq. Method      : C:\CHEM32\2\DATA\YL11\NV1 2014-10-25 21-22-40\5IPA20_210.M
    Last changed     : 10/25/2014 9:19:06 PM by MW
    Analysis Method  : C:\CHEM32\2\METHODS\2IPA20_210.M
    Last changed     : 10/26/2014 12:42:41 AM by MW
                       (modified after loading)
    Method Info      : 2% IPA    20 min   210 nm   1 mL/min

    =====================================================================
```



SI-8



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    =====================================================================
                             Area Percent Report
    =====================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Do not use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=210 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU    *s   [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1   8.084 BB    0.2034 1525.98401  114.61406  95.7321
       2   9.990 BB    0.2448   68.03126    4.20617   4.2679

    Totals :                  1594.01527  118.82023


    =====================================================================
                             Summed Peaks Report
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```
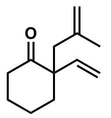
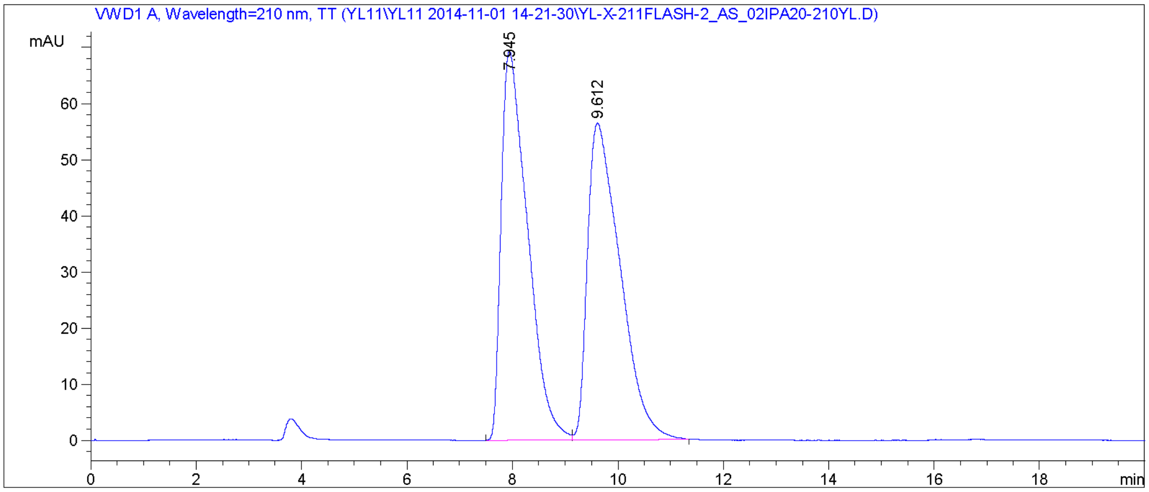

```
Data File C:\CHEM32\...TA\YL11\YL11 2014-11-01 14-21-30\YL-X-211FLASH-2_AS_02IPA20-210YL.D
Sample Name: YL-X-211flash-AS
    =====================================================================
    Acq. Operator   : YL                               Seq. Line :    7
    Acq. Instrument : HPLC 2                            Location : Vial 23
    Injection Date  : 11/1/2014 4:08:18 PM                   Inj :    1
                                                      Inj Volume : 5.0 µl
    Acq. Method     : C:\CHEM32\2\DATA\YL11\YL11 2014-11-01 14-21-30\02IPA20_210YL.M
    Last changed    : 11/1/2014 10:34:26 AM by MW
    Analysis Method : C:\CHEM32\2\METHODS\02IPA20_210YL.M
    Last changed    : 11/1/2014 10:34:26 AM by MW
    Method Info     : 0.2% IPA    20 min    210 nm    1 mL/min    YL

    =====================================================================
```

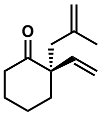


(±)-9e

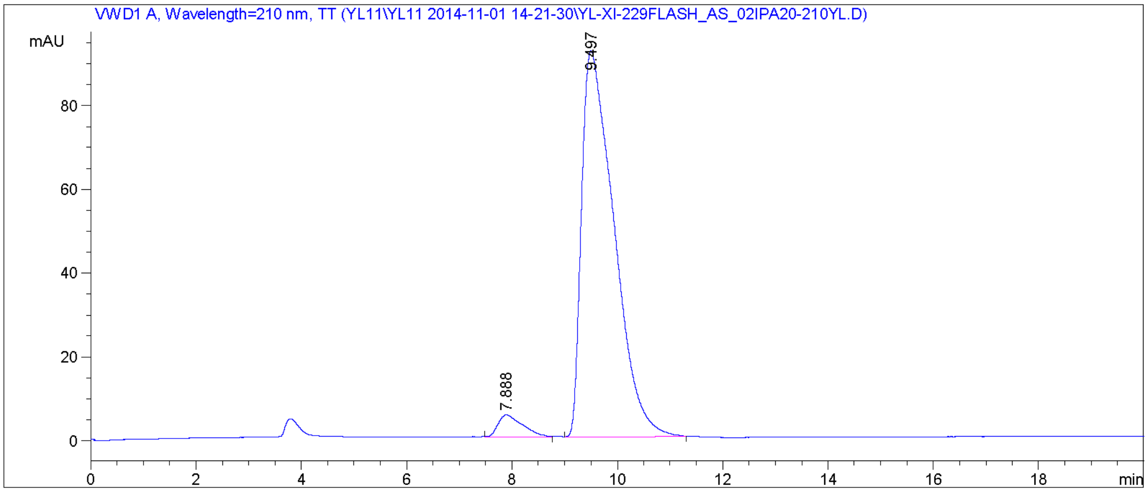


```
    =====================================================================
                             Area Percent Report
    =====================================================================

    Sorted By             :      Signal
    Multiplier:                    :      1.0000
    Dilution:                      :      1.0000
    Do not use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=210 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU    *s   [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1   7.945 BV    0.4982 2409.75024   69.29615  49.8495
       2   9.612 VB    0.6070 2424.29688   56.40124  50.1505

    Totals :                  4834.04712  125.69739


    =====================================================================
                             Summed Peaks Report
    =====================================================================
```

```
Data File C:\CHEM32\2\DATA\YL11\YL11 2014-11-01 14-21-30\YL-XI-229FLASH_AS_02IPA20-210YL.D
Sample Name: YL-XI-229flash-AS
    =====================================================================
    Acq. Operator   : YL                              Seq. Line :    5
    Acq. Instrument : HPLC 2                           Location : Vial 25
    Injection Date  : 11/1/2014 3:25:55 PM                  Inj :    1
                                                     Inj Volume : 5.0 µl
    Acq. Method     : C:\CHEM32\2\DATA\YL11\YL11 2014-11-01 14-21-30\02IPA20_210YL.M
    Last changed    : 11/1/2014 10:34:26 AM by MW
    Analysis Method : C:\CHEM32\2\METHODS\02IPA20_210YL.M
    Last changed    : 11/1/2014 10:34:26 AM by MW
    Method Info     : 0.2% IPA    20 min   210 nm   1 mL/min   YL

    =====================================================================
```

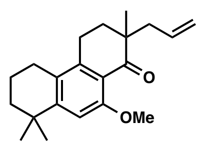


9e

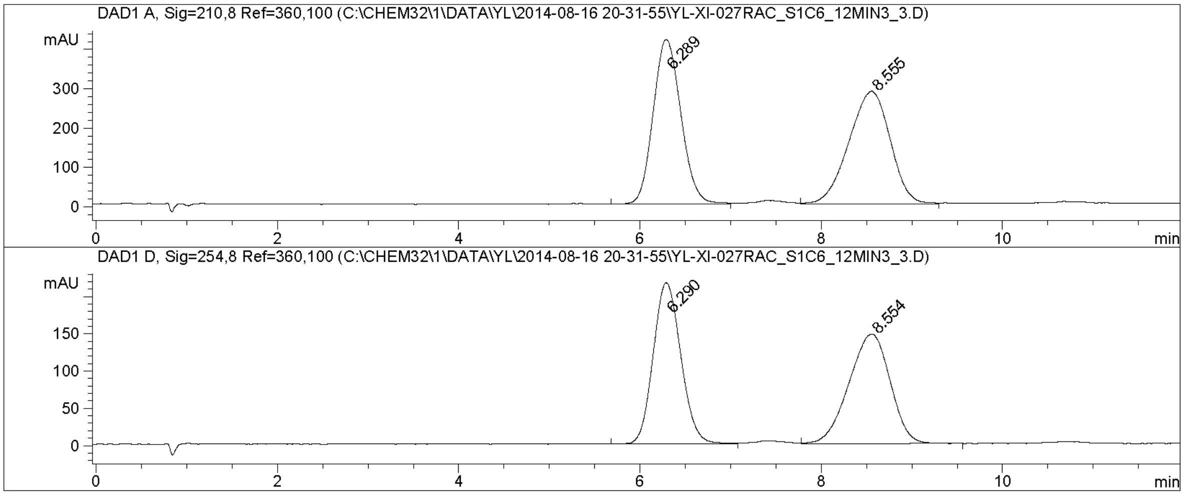


```
    =====================================================================
                         Area Percent Report
    =====================================================================

    Sorted By             :      Signal
    Multiplier:                  :      1.0000
    Dilution:                    :      1.0000
    Do not use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=210 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU    *s   [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1   7.888 VB    0.4110  171.55486    5.25078   4.1799
       2   9.497 VB    0.5945 3932.72949   92.05544  95.8201

    Totals :                  4104.28435   97.30622


    =====================================================================
                         Summed Peaks Report
    =====================================================================
```

```
Data File C:\CHEM32\1\DATA\YL\2014-08-16 20-31-55\YL-XI-027RAC_S1C6_12MIN3_3.D
Sample Name: YL-XI-027rac

    =====================================================================
    Acq. Operator   : YL                              Seq. Line :   6
    Acq. Instrument : Instrument 1                     Location : P4-E-09
    Injection Date  : 8/16/2014 8:58:18 PM                  Inj :   1
                                                     Inj Volume : 5 µl
    Different Inj Volume from Sequence !     Actual Inj Volume : 15 µl
    Acq. Method     : C:\Chem32\1\DATA\YL\2014-08-16 20-31-55\S1C6 12MIN3_3.M
    Last changed    : 7/29/2014 8:33:48 PM by YL
    Analysis Method : C:\CHEM32\1\DATA\YL\2014-08-16 20-31-55\S1C6 12MIN3_3.M
    Last changed    : 5/6/2015 9:24:18 PM by NO
    Method Info     : S1C6 12min3.M: 3% MeOH, OB-H 3.0 mL/min, 12 min
```

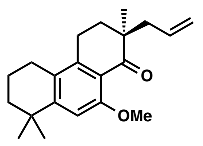


(±)-12

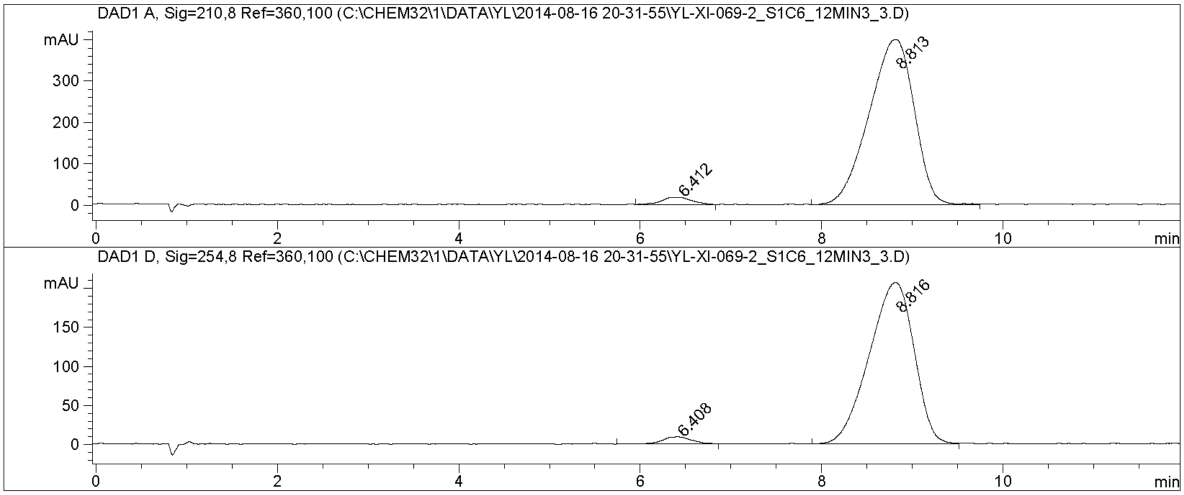


```
    =====================================================================
                             Area Percent Report
    =====================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=210,8 Ref=360,100

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1   6.289 VV    0.3367 8921.93066  418.53763  49.5245
       2   8.555 VV    0.4939 9093.24316  286.80594  50.4755

    Totals :                  1.80152e4   705.34357


    Signal 2: DAD1 D, Sig=254,8 Ref=360,100

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1   6.290 VB    0.3312 4587.55371  216.52286  49.7796
       2   8.554 VB    0.4948 4628.16895  147.20467  50.2204
```

```
Data File C:\CHEM32\1\DATA\YL\2014-08-16 20-31-55\YL-XI-069-2_S1C6_12MIN3_3.D
Sample Name: YL-XI-069-2

    =====================================================================
    Acq. Operator   : YL                              Seq. Line :    9
    Acq. Instrument : Instrument 1                     Location : P4-F-04
    Injection Date  : 8/16/2014 9:17:04 PM                  Inj :    1
                                                     Inj Volume : 5 µl
    Different Inj Volume from Sequence !     Actual Inj Volume : 15 µl
    Acq. Method     : C:\Chem32\1\DATA\YL\2014-08-16 20-31-55\S1C6 12MIN3_3.M
    Last changed    : 7/29/2014 8:33:48 PM by YL
    Analysis Method : C:\CHEM32\1\DATA\YL\2014-08-16 20-31-55\S1C6 12MIN3_3.M
    Last changed    : 5/6/2015 8:56:51 PM by NO
    Method Info     : S1C6 12min3.M: 3% MeOH, OB-H 3.0 mL/min, 12 min
```

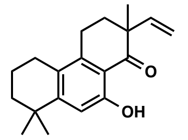


12

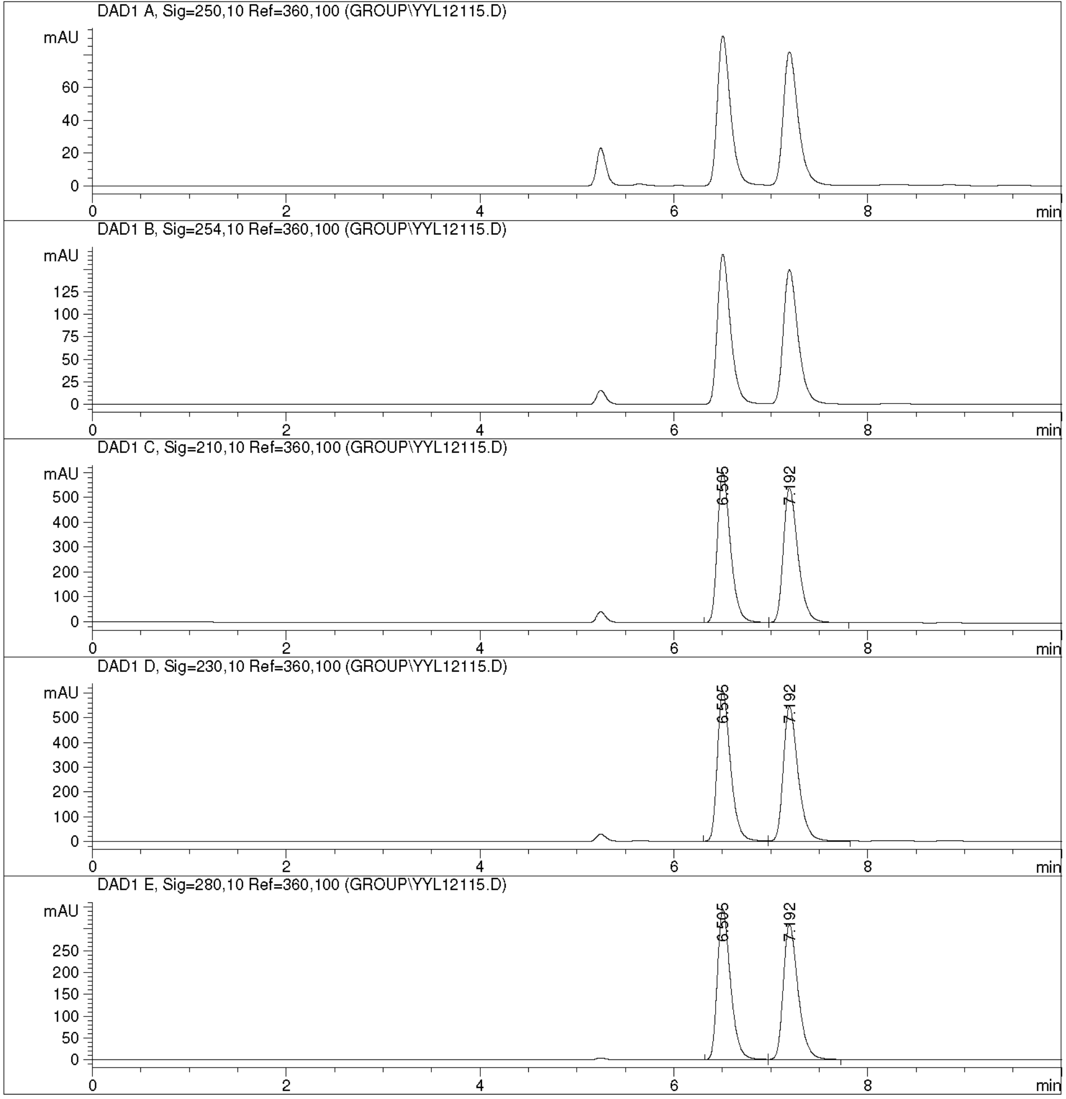


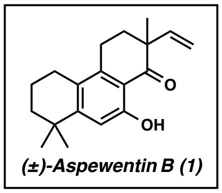
```
    =====================================================================
                             Area Percent Report
    =====================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=210,8 Ref=360,100

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1   6.412 VV    0.3230  451.53680   18.88447   3.1481
       2   8.813 VB    0.5292 1.38918e4   399.92935  96.8519

    Totals :                  1.43433e4   418.81382


    Signal 2: DAD1 D, Sig=254,8 Ref=360,100

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]        %
    ----|-------|----|-------|----------|----------|--------|
       1   6.408 BV    0.3020  212.67902    9.32794   2.9161
       2   8.816 VV    0.5327 7080.52051  206.14867  97.0839
```

```
Data File C:\HPCHEM\1\DATA\GROUP\YYL12115.D                                    Sample Name: YYL-XII-115

    =====================================================================
    Injection Date  : 5/3/2015 3:37:50 PM            Seq. Line :   2
    Sample Name     : YYL-XII-115                     Location : Vial 21
    Acq. Operator   : XM                                   Inj :   1
    Acq. Instrument : Instrument 1                  Inj Volume : 15 µl
    Different Inj Volume from Sequence !     Actual Inj Volume : 2 µl
    Acq. Method     : C:\HPCHEM\1\METHODS\AD-00530.M
    Last changed    : 5/3/2015 3:55:41 PM by XM
                      (modified after loading)
    Analysis Method : C:\HPCHEM\1\METHODS\AD-10-20.M
    Last changed    : 5/3/2015 5:22:59 PM by XM
                      (modified after loading)
```



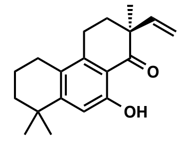
(±)-Aspewentin B (1)



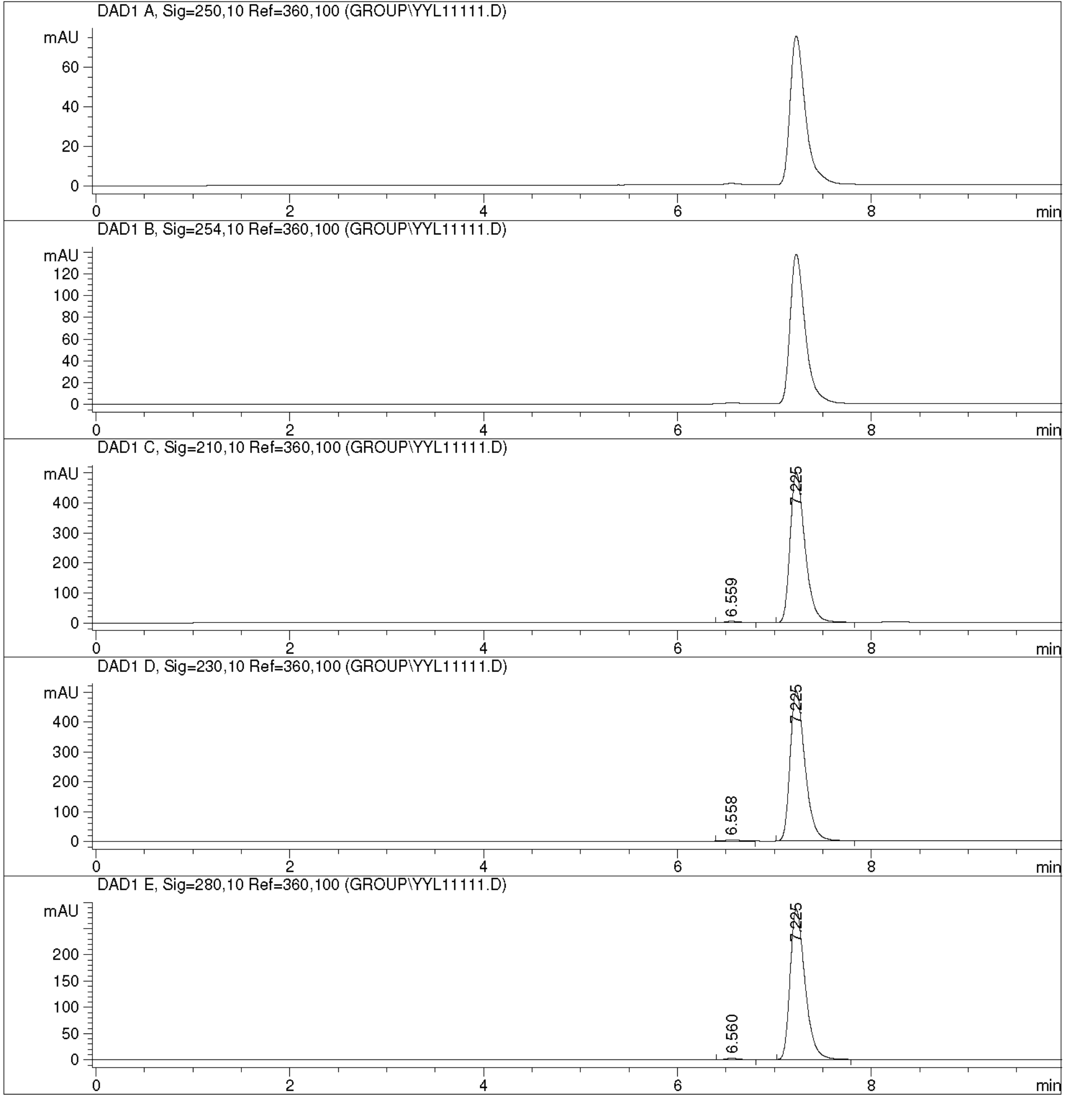


```
Data File C:\HPCHEM\1\DATA\GROUP\YYL12115.D                          Sample Name: YYL-XII-115

  =====================================================================
                         Area Percent Report
  =====================================================================

  Sorted By             :      Signal
  Multiplier            :      1.0000
  Dilution              :      1.0000
  Use Multiplier & Dilution Factor with ISTDs


  Signal 1: DAD1 A, Sig=250,10 Ref=360,100


  Signal 2: DAD1 B, Sig=254,10 Ref=360,100


  Signal 3: DAD1 C, Sig=210,10 Ref=360,100

  Peak RetTime Type  Width     Area      Height     Area
    #   [min]        [min]   [mAU*s]     [mAU]        %
  ----|-------|----|-------|----------|----------|--------|
     1   6.505 BV    0.1434 5666.01025  604.05304  49.8960
     2   7.192 VB    0.1608 5689.62744  540.63428  50.1040

  Totals :                  1.13556e4  1144.68732

   Results obtained with enhanced integrator!

  Signal 4: DAD1 D, Sig=230,10 Ref=360,100

  Peak RetTime Type  Width     Area      Height     Area
    #   [min]        [min]   [mAU*s]     [mAU]        %
  ----|-------|----|-------|----------|----------|--------|
     1   6.505 BV    0.1437 5709.97949  607.32703  49.8757
     2   7.192 VB    0.1612 5738.43896  543.26447  50.1243

  Totals :                  1.14484e4  1150.59149

   Results obtained with enhanced integrator!

  Signal 5: DAD1 E, Sig=280,10 Ref=360,100

  Peak RetTime Type  Width     Area      Height     Area
    #   [min]        [min]   [mAU*s]     [mAU]        %
  ----|-------|----|-------|----------|----------|--------|
     1   6.505 BV    0.1464 3253.07544  343.87250  49.7970
     2   7.192 VB    0.1618 3279.59814  309.11072  50.2030

  Totals :                  6532.67358  652.98322

   Results obtained with enhanced integrator!
  =====================================================================
                          *** End of Report ***
```

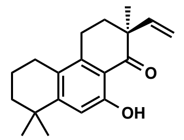
```
Data File C:\HPCHEM\1\DATA\GROUP\YYL11111.D                                   Sample Name: YYL-XI-111

    =====================================================================
    Injection Date  : 5/3/2015 3:57:17 PM           Seq. Line :   3
    Sample Name     : YYL-XI-111                      Location : Vial 22
    Acq. Operator   : XM                                   Inj :   1
    Acq. Instrument : Instrument 1                  Inj Volume : 15 µl
    Different Inj Volume from Sequence !     Actual Inj Volume : 2 µl
    Acq. Method     : C:\HPCHEM\1\METHODS\AD-00530.M
    Last changed    : 5/3/2015 3:57:06 PM by XM
                      (modified after loading)
    Analysis Method : C:\HPCHEM\1\METHODS\AD-10-20.M
    Last changed    : 5/3/2015 5:21:36 PM by XM
                      (modified after loading)
```



(–)-Aspewentin B (1)



```
Data File C:\HPCHEM\1\DATA\GROUP\YYL11111.D                           Sample Name: YYL-XI-111

  =====================================================================
                           Area Percent Report
  =====================================================================

  Sorted By             :      Signal
  Multiplier            :      1.0000
  Dilution              :      1.0000
  Use Multiplier & Dilution Factor with ISTDs


  Signal 1: DAD1 A, Sig=250,10 Ref=360,100


  Signal 2: DAD1 B, Sig=254,10 Ref=360,100


  Signal 3: DAD1 C, Sig=210,10 Ref=360,100

  Peak RetTime Type  Width     Area      Height     Area
    #   [min]        [min]   [mAU*s]     [mAU]        %
  ----|-------|----|-------|----------|----------|--------|
     1   6.559 BB    0.1458   44.17721    4.61094   0.8303
     2   7.225 BB    0.1634 5276.64453  498.90460  99.1697

  Totals :                  5320.82174  503.51554

   Results obtained with enhanced integrator!

  Signal 4: DAD1 D, Sig=230,10 Ref=360,100

  Peak RetTime Type  Width     Area      Height     Area
    #   [min]        [min]   [mAU*s]     [mAU]        %
  ----|-------|----|-------|----------|----------|--------|
     1   6.558 BB    0.1430   44.21828    4.64623   0.8260
     2   7.225 PB    0.1635 5309.22021  501.35626  99.1740

  Totals :                  5353.43849  506.00250

   Results obtained with enhanced integrator!

  Signal 5: DAD1 E, Sig=280,10 Ref=360,100

  Peak RetTime Type  Width     Area      Height     Area
    #   [min]        [min]   [mAU*s]     [mAU]        %
  ----|-------|----|-------|----------|----------|--------|
     1   6.560 BB    0.1407   24.88921    2.67128   0.8102
     2   7.225 BB    0.1645 3047.15698  285.48328  99.1898

  Totals :                  3072.04619  288.15456

   Results obtained with enhanced integrator!
  =====================================================================
                           *** End of Report ***
```



(–)-Aspewentin B (1)