Supporting Information

Copper Catalyzed Oxygen Assisted C(CNOH)-C(alkyl) Bond Cleavage: A Facile Conversion of Aryl/Aralkyl/Vinyl Ketones to Aromatic Acids

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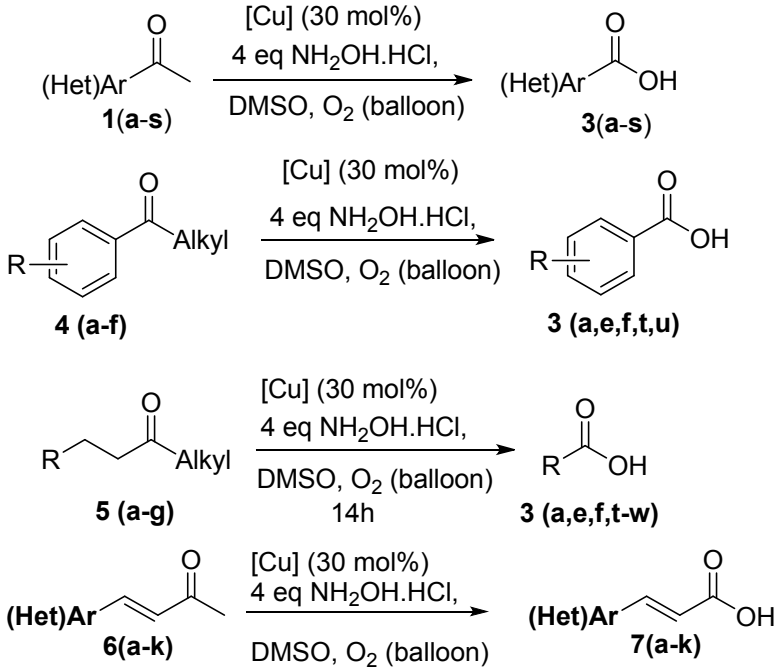
1.0. General Information:

All reactions were carried out in oven-dried glassware. IR spectra were recorded on FT-IR spectrometer (KBr) and reported in reciprocal centimetres (cm^{-1}). ^1H NMR spectra were recorded at 300 MHz and ^{13}C NMR at 75 MHz. For ^1H NMR, tetramethylsilane (TMS) was used as internal standard (δ = 0) and the values are reported as follows: chemical shift, integration, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, brs = broad singlet, dt = doublet of triplet), and the coupling constants in Hz. For ^{13}C NMR, $CDCl_3$ (δ = 77.23) was used as internal standard and spectra were obtained with complete proton decoupling. Melting points were measured on micro melting point apparatus. The precursors, (E)-4-arylbut-3-en-2-ones and 4-arylbutan-2-ones are prepared according to reported procedures. Commercially available acetophenones, hydroxylamine hydrochloride, CuI and DMSO were used without further purification.

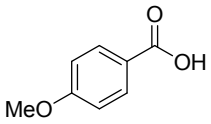
2.0. General procedure for the synthesis of Benzoic acids and Cinnamic acids:



A mixture of ketone [**(1, 4, 5, 6**] (1 mmol, 1 eq.), hydroxylamine hydrochloride (4 mmol, 4 eq.) and CuI (30 mol %) in dimethyl sulfoxide (10 mL) was stirred at 100 °C under oxygen atmosphere for an appropriate time. After completion of the reaction, as indicated by TLC, the mixture was diluted with water and extracted with EtOAc (3×20 mL). The extract was

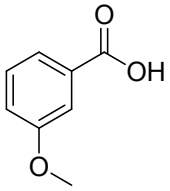
washed with brine, dried over Na_2SO_4 and evaporated, and the crude product was purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc) to obtain the product.

4-methoxybenzoic acid[1]



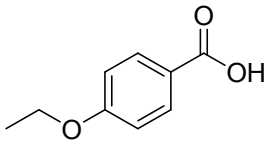
144 mg of **3a** was obtained from 150 mg (1 mmol) of **1a.** 95% yield; White solid; R_f = 0.4 (EtOAc/hexane = 3/7); m.p. 180-182 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 8.05 (d, J = 8.92 Hz, 2H), 6.95 (d, J = 8.89 Hz, 2H), 3.86 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$ + DMSO-d) δ: 167.5, 162.6, 131.1, 122.7, 112.9, 54.9; IR (KBr) ν: 3094, 1685.8, 1215.4, 757.7, 669.1 cm^{-1}; MS (EI) *m/z* 151 $[M-1]^+$.

3-methoxybenzoic acid[1]



136.5 mg of **3b** was obtained from 150 mg (1 mmol) of **1b**. 90% yield; White solid; R_f = 0.4 (EtOAc/hexane = 3/7); m.p. 104-106 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.75-7.72 (m, 1H), 7.64-7.63 (m, 1H), 7.39 (t, J = 7.87 Hz, 1H), 7.18-7.15 (m, 1H), 3.87 (s, 3H); ^{13}C NMR (75 MHz, DMSO-d) δ: 167.0, 159.2, 132.1, 129.6, 121.5, 118.8, 113.8, 55.2; IR (KBr) ν: 3394.3, 3020.9, 1693.2, 1411.7, 1216.1, 760.0, 670.0 cm^{-1}; MS (EI) *m/z* 151 $[M-1]^+$.

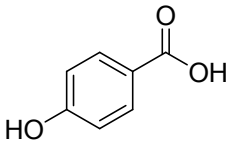
4-ethoxybenzoic acid[2]



154 mg of **3c** was obtained from 164 mg (1 mmol) of **1c**. 93% yield; White solid; R_f = 0.4 (EtOAc/hexane = 3/7); m.p. 195-197 ºC; ^{1}H NMR (300 MHz, $CDCl_3$ + DMSO-d) δ: 7.72-7.70 (m, 2H), 6.65-6.63 (m, 2H), 3.83 (q, J = 13.94, 6.99 Hz, 2H), 1.17 (t, J = 6.97 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$ + DMSO-d) δ: 167.2, 161.7, 130.8, 122.3, 113.1, 62.8, 13.9; IR

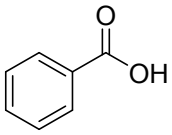
(KBr) ν: 3402.7, 3021.0, 1603.9, 1300.0, 1216.0, 1169.6, 761.5, 669.8 cm^{-1}; MS (EI) *m/z* 165 $[M-1]^+$.

4-hydroxybenzoic acid[3]



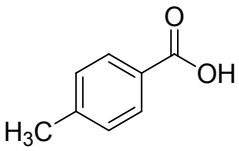
38.5 mg of **3d** was obtained from 136 mg (1 mmol) of **1d**. 28% yield; White solid; R_f = 0.2 (EtOAc/hexane = 9/1); m.p. 212-214 ºC; ^{1}H NMR (300 MHz, DMSO-d) δ: 10.23 (brs, 1H), 7.78 (d, *J* = 8.67 Hz, 2H), 6.81 (d, *J* = 8.63 Hz, 2H); ^{13}C NMR (75 MHz, DMSO-d) δ: 167.1, 161.5, 131.5, 121.5, 115.1; IR (KBr) ν: 3399.6, 3019.4, 1654.0, 1523.2, 1215.5, 757.5, 669.1 cm^{-1}; MS (EI) *m/z* 137 $[M-1]^+$.

Benzoic acid[1]



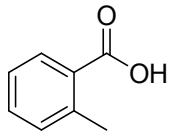
75.5 mg of **3e** was obtained from 120 mg (1 mmol) of **1e**. 62% yield; White solid; R_f = 0.4 (EtOAc/hexane = 3/7); m.p. 120-122 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 8.13 (dd, *J* = 8.11, 1.01 Hz, 2H), 7.64-7.61 (m, 1H), 7.49 (t, *J* = 7.84 Hz, 2H);^{13}C NMR (75 MHz, $CDCl_3$) δ: 172.3, 134.0, 130.4, 128.7; IR (KBr) ν: 3020.6, 1687.9, 1326.5, 1293.1, 934.8 , 708.9 cm^{-1}; MS (EI) *m/z* 121 $[M-1]^+$.

4-methylbenzoic acid[4]



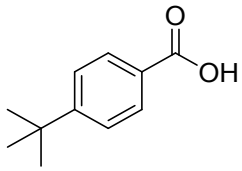
126 mg of **3f** was obtained from 134 mg (1 mmol) of **1f**. 93% yield; White solid; R_f = 0.5 (EtOAc/hexane = 3/7); m.p. 180-182 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 8.01 (d, *J* = 8.31 Hz, 2H), 7.27 (d, *J* = 7.94 Hz, 2H), 2.43 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 172.3, 144.8, 130.4, 129.4, 125.7, 21.9; IR (KBr) ν: 3019.5, 1692.6, 1215.5, 757.8, 669.1 cm^{-1}; MS (EI) *m/z* 135 $[M-1]^+$.

2-methylbenzoic acid[5]



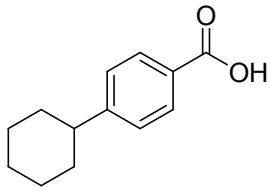
118 mg of **3g** was obtained from 134 mg (1 mmol) of **1g**. 87% yield; White solid; R_f = 0.5 (EtOAc/hexane = 3/7); m.p. 104-105 ºC; ^{1}H NMR (300 MHz, $CDCl_3$ + DMSO-d) δ: 7.85-7.83 (m, 1H), 7.31-7.28 (m, 1H), 7.15-7.11 (m, 1H), 2.52 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$ + DMSO-d) δ: 170.4, 140.1, 131.7, 131.5, 130.8, 130.0, 125.5, 21.7; IR (KBr) ν: 3019.5, 1692.6, 1215.5, 757.8, 669.1 cm^{-1}; MS (EI) *m/z* 135 [M-1]$^+$.

4-(*tert*-butyl) benzoic acid[5]



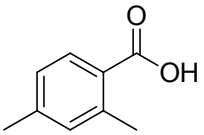
162 mg of **3h** was obtained from 176 mg (1 mmol) of **1h**. 91% yield; White solid; R_f = 0.5 (EtOAc/hexane = 3/7); m.p. 167-169 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 8.06 (d, *J* = 8.55 Hz, 2H), 7.50 (d, *J* = 8.58 Hz, 2H), 1.36 (s, 9H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 172.7, 157.8, 130.3, 126.8, 125.7, 35.4, 31.3; IR (KBr) ν: 3408.8, 3019.7, 1633.1, 1215.9, 1069.3, 769.5, 669.2 cm^{-1}; MS (EI) *m/z* 177 [M-1]$^+$.

4-cyclohexylbenzoic acid[6]



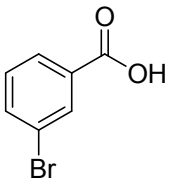
138.5 mg of **3i** was obtained from 202 mg (1 mmol) of **1i**. 68% yield; Light Gray solid; R_f = 0.5 (EtOAc/hexane = 3/7); m.p. 136-137 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 8.01 (d, *J* = 8.19 Hz, 2H), 7.28 (d, *J* = 8.17 Hz, 2H), 2.59-2.52 (m, 1H), 1.85-1.73 (m, 5H), 1.49-1.24 (m, 5H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 171.9, 154.6, 130.5, 127.2, 127.0, 45.0, 34.3, 26.9, 26.2; IR (KBr) ν: 3407.1, 3019.2, 1654.1, 1215.9, 768.8, 668.5 cm^{-1}.

2, 4-dimethylbenzoic acid[7]



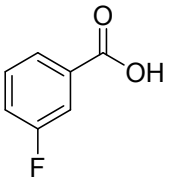
135 mg of **3j** was obtained from 148 mg (1 mmol) of **1j**. 90% yield; White solid; R_f = 0.5 (EtOAc/hexane = 3/7); m.p. 120-122 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.98-7.97 (m, 1H), 7.09-7.08 (m, 2H), 2.63 (s, 3H), 2.37 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 173.2, 143.8, 141.7, 132.9, 132.0, 126.8, 125.6, 22.3, 21.6; IR (KBr) ν: 3020.5, 1692.6, 1216.5, 757.5, 669.1 cm^{-1}; MS (EI) *m/z* 149 [M-1]$^+$.

3-bromobenzoic acid[8]



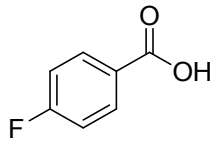
155 mg of **3k** was obtained from 197 mg (1 mmol) of **1k**. 78% yield; White solid; R_f = 0.5 (EtOAc/hexane = 3/7); m.p. 154-156 ºC; ^{1}H NMR (300 MHz, $CDCl_3$ + DMSO-d) δ: 7.89-7.88 (m, 1H), 7.71-7.68 (m, 1H), 7.41-7.38 (m, 1H). 7.08-7.04 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$ + DMSO-d) δ: 166.3, 134.9, 132.7, 132.1, 129.5, 127.8, 121.6; IR (KBr) ν: 3400.7, 3019.7, 1692.5, 1308.8, 1216.5, 760.3, 669.4 cm^{-1}; MS (EI) *m/z* 198 [M-1]$^+$.

3-fluorobenzoic acid[4]



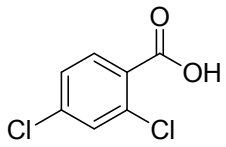
91 mg of **3l** was obtained from 138 mg (1 mmol) of **1l**. 65% yield; White solid; R_f = 0.5 (EtOAc/hexane = 3/7); m.p. 120-122 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 10.42 (brs, 1H), 7.94-7.91 (m, 1H), 7.82-7.78 (m, 1H), 7.49-7.44 (m, 1H), 7.35-7.30 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 171.4, 164.0, 161.5, 131.7, 131.6, 130.48, 130.41, 126.24, 126.22, 121.3, 121.1, 117.4, 117.2; IR (KBr) ν: 3397.2, 3021.3, 1694.1, 1413.7, 1216.0, 759.7 cm^{-1}; MS (EI) *m/z* 139 [M-1]$^+$.

4-fluorobenzoic acid[4]



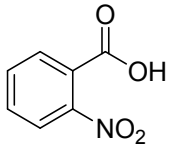
99.5 mg of **3m** was obtained from 138 mg (1 mmol) of **1m**. 71% yield; White solid; R_f = 0.5 (EtOAc/hexane = 3/7); m.p. 182-184 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 8.16-8.13 (m, 2H), 7.17-7.14 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 171.3, 168.2, 164.9, 133.1, 133.0, 125.7, 116.1, 115.8; IR (KBr) ν: 3408.3, 3019.5, 2400.1, 1601.6, 1420.2, 1215.4, 1069.0, 758.0, 669.0 cm^{-1}; MS (EI) *m/z* 139 [M-]$^+$.

2, 4-dichlorobenzoic acid[9]



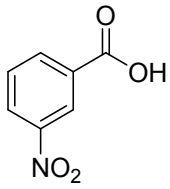
144 mg of **3n** was obtained from 188 mg (1 mmol) of **1n**. 60% yield; White solid; R_f = 0.5 (EtOAc/hexane = 3/7); m.p. 155-157 ºC; ^{1}H NMR (300 MHz, $CDCl_3$ + DMSO-d) δ: 9.05 (brs, 1H), 7.81-7.78 (m, 1H), 7.389-7.381 (m, 1H), 7.25-7.20 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$ + DMSO-d) δ: 166.1, 137.3, 134.3, 132.3, 130.3, 128.8, 126.5; IR (KBr) ν: 3399.4, 1698.7, 1588.1, 1384.2, 1216.3, 1051.9, 771.0, 668.5 cm^{-1}; MS (EI) *m/z* 189 [M-1]$^+$.

2-nitrobenzoic acid[10]



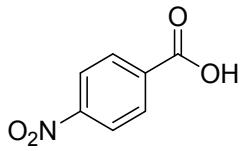
113.5 mg of **3o** was obtained from 165 mg (1 mmol) of **1o**. 68% yield; Light yellow solid; R_f = 0.45 (EtOAc/hexane = 3/7); m.p. 145-147 ºC; ^{1}H NMR (300 MHz, DMSO-d) δ: 13.85 (brs, 1H), 7.98-7.96 (m, 1H), 7.87-7.85 (m, 1H), 7.81-7.74 (m, 2H); ^{13}C NMR (75 MHz, DMSO-d) δ: 165.9, 148.4, 133.1, 132.4, 129.8, 127.2, 123.7; IR (KBr) ν: 3021.2, 1676.4, 1382.1, 1216.1, 765.5 cm^{-1}; MS (EI) *m/z* 166 [M-1]$^+$.

3-nitrobenzoic acid[5]



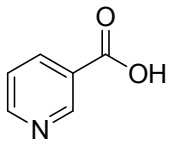
117 mg of **3p** was obtained from 165 mg (1 mmol) of **1p**. 70% yield; Lightyellow solid; R_f = 0.45 (EtOAc/hexane = 3/7); m.p. 138-140 ºC; ^{1}H NMR (300 MHz, DMSO-d) δ: 8.59 (brs, 1H), 8.46-8.43 (m, 1H), 8.34-8.29 (m, 1H), 7.79 (t, *J* = 7.89 Hz, 1H); ^{13}C NMR (75 MHz, DMSO-d) δ: 165.5, 147.8, 135.3, 130.5, 127.3, 123.6; IR (KBr) ν: 3021.7, 1705.9, 1352.1, 1288.4, 1215.7, 759.9, 669.5 cm^{-1}; MS (EI) *m/z* 166 [M-1]$^+$.

4-nitrobenzoic acid[4]



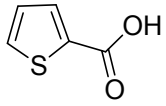
120 mg of **3q** was obtained from 165 mg (1 mmol) of **1q**. 72% yield; Light yellow solid; R_f = 0.45 (EtOAc/hexane = 3/7); m.p. 232-234 ºC; ^{1}H NMR (300 MHz, DMSO-d) δ: 8.72 (d, *J* = 8.80 Hz, 2H), 8.57 (d, *J* = 8.80 Hz, 2H); ^{13}C NMR (75 MHz, DMSO-d) δ: 165.8, 150.0, 136.3, 130.6, 123.7; IR (KBr) ν: 3019.6, 1654.5, 1384.6, 1215.5, 1069.8, 757.3, 669.1 cm^{-1}; MS (EI) *m/z* 166 [M-1]$^+$.

Nicotinic acid[11]



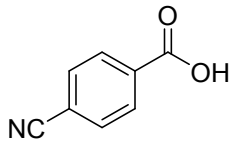
83.5 mg of **3r** was obtained from 121 mg (1 mmol) of **1r**. 68% yield; White solid; R_f = 0.3 (EtOAc/hexane = 1/1); m.p. 230-234 ºC; ^{1}H NMR (300 MHz, DMSO-d) δ: 13.41 (brs, 1H), 9.08-9.07 (m, 1H), 8.785 (dd, *J* = 4.80, 1.56 Hz, 1H), 8.265 (dt, *J* = 7.93, 1.97 Hz, 1H), 7.56-7.52 (m, 1H); ^{13}C NMR (75 MHz, DMSO-d) δ: 166.2, 153.2, 150.2, 136.9, 126.5, 123.7; IR (KBr) ν: 3401.3, 3019.3, 2400.0, 1654.1, 1215.4, 757.2, 669.0 cm^{-1}; MS (EI) *m/z* 122 [M-1]$^+$.

Thiophene-2-carboxylic acid[1]



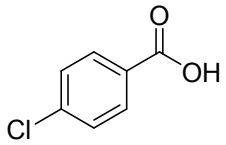
115 mg of **3s** was obtained from 126 mg (1 mmol) of **1s**. 90% yield; White solid; R_f = 0.5 (EtOAc/hexane = 3/7); m.p. 122-125 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.87 (dd, *J* = 3.75, 1.23 Hz, 1H), 7.63 (dd, *J* = 4.95, 1.22 Hz, 1H), 7.13-7.12 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 167.7, 135.2, 134.2, 133.0, 128.2; IR (KBr) ν: 3019.6, 1654.5, 1384.6, 1215.5, 1069.8, 757.3, 669.1 cm^{-1} ; MS (EI) *m/z* 128 [M^+].

4-cyanobenzoic acid[12]



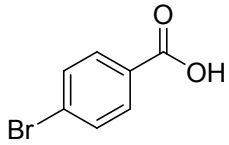
70 mg of **3t** was obtained from 148 mg (1 mmol) of **1t**. 48% yield; White solid; R_f = 0.5 (EtOAc/hexane = 3/7); m.p. 215-127 ºC; ^{1}H NMR (300 MHz, DMSO-d) δ: 8.09-8.07 (m, 2H), 7.99-7.96 (m, 1H); ^{13}C NMR (75 MHz, DMSO-d) δ: 166.0, 134.8, 132.6, 129.9, 118.1, 115.0; IR (KBr) ν: 3401.1, 1711.1, 1423.3, 1215.8, 769.6, 670.0 cm^{-1}; MS (EI) *m/z* 148 [M^+].

4-chlorobenzoic acid[1]



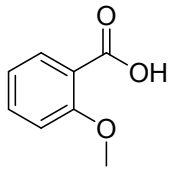
112 mg of **3u** was obtained from 154 mg (1 mmol) of **4d**. 72% yield; White solid; R_f = 0.5 (EtOAc/hexane = 3/7); m.p. 235-237 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.75-7.72 (m, 2H), 7.42-7.39 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 168.4, 138.5, 131.9, 129.1, 129.0; IR (KBr) ν: 3400.5, 3019.5, 1647.0, 1215.4, 757.9, 669.1 cm^{-1}; MS (EI) *m/z* 155 [M-1]$^+$.

4-bromobenzoic acid[1]



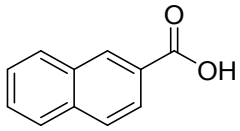
159 mg of **3v** was obtained from 197 mg (1 mmol) of **4e**. 80% yield; White solid; R_f = 0.5 (EtOAc/hexane = 3/7); m.p. 248-250 ºC; ^{1}H NMR (300 MHz, DMSO-d) δ: 13.17 (brs, 1H), 7.87-7.85 (m, 2H), 7.71-7.69 (m, 2H); ^{13}C NMR (75 MHz, DMSO-d) δ: 166.5, 131.6, 131.2, 130.0, 126.8; IR (KBr) ν: 3395.8, 3021.1, 1676.2, 1425.1, 1296.8, 1215.6, 761.7 cm^{-1}; MS (EI) *m/z* 198 [M-1]$^+$.

2-methoxybenzoic acid[1]



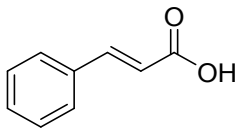
136.5 mg of **3w** was obtained from 150 mg (1 mmol) of **5b**. 90% yield; White solid; R_f = 0.4 (EtOAc/hexane = 3/7); m.p. 100-102 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.74-7.72 (m, 1H), 7.64-7.63 (m, 1H), 7.39 (t, *J* = 7.83 Hz, 1H), 7.18-7.15 (m, 1H), 3.87 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 172.5, 159.8, 130.8, 129.7, 122.9, 120.7, 114.6, 55.6; IR (KBr) ν: 3020.6, 1692.9, 1287.9, 1216.5, 759.7, 670.0 cm^{-1}; MS (EI) *m/z* 151 [M-1]$^+$.

2-naphthoic acid[5]



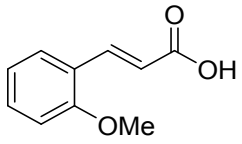
85.5 mg of **3x** was obtained from 198 mg (1 mmol) of **5f**. 49.7% yield; White solid; R_f = 0.3 (EtOAc/hexane = 3/7); m.p. 183-185 °C; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 8.72 (s, 1H), 8.12 (dd, *J* = 8.64, 1.60 Hz, 1H), 8.00 (d, *J* = 8.09 Hz, 1H), 7.92 (t, *J* = 8.64 Hz, 2H), 7.65-7.62 (m,1H), 7.59-7.56 (m,1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 171.5, 136.1, 132.6, 132.3, 129.7, 128.8, 128.5, 128.0, 127.0, 125.6; IR (KBr) ν: 3066.3, 1686.2, 1216.4, 769.6, 669.6 cm^{-1}; MS (EI) *m/z* 171 [M-1]$^+$.

cinnamic acid[1]



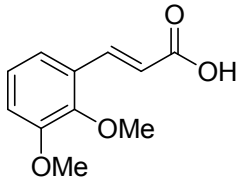
7a was obtained from 146 mg (1 mmol) of **6a**. 58% yield; White solid; R_f = 0.3 (EtOAc/hexane = 3/7); m.p. 129-130 ºC; ^{1}H NMR (300 MHz, DMSO-d) δ: 7.70-7.66 (m, 2H), 7.59 (d, *J* = 16.06 Hz, 1H), 7.42 - 7.40 (m, 3H), 6.53 (d, *J* = 15.93 Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 172.7, 147.3, 134.2, 130.9, 129.1, 128.5, 117.5; IR (KBr) ν: 3396.7, 3022.0, 1684.6, 1216.4, 765.3, 672.7 cm^{-1}; MS (EI) *m/z* 147 [M-1]$^+$.

(E)-3-(2-methoxyphenyl) acrylic acid[13]



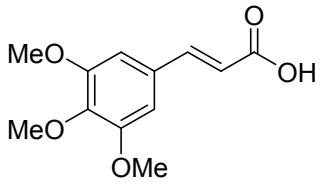
85 mg of **7b** was obtained from 176 mg (1 mmol) of **6b**. 48% yield; White solid; R_f = 0.5 (EtOAc/hexane = 3/7); m.p. 178-180 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 8.11 (d, *J* = 16.10 Hz, 1H), 7.55-7.53 (m, 1H), 7.41-7.35 (m, 1H), 7.01-6.92 (m, 2H), 6.56 (d, *J* = 16.18 Hz, 1H), 3.91 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 167.9, 157.4, 138.7, 131.0, 127.9, 120.2, 118.8, 110.8, 55.07; IR (KBr) ν: 3388.0, 1620.9, 1400.9, 1249.3, 1218.6, 1069.0, 771.5 cm^{-1}; MS (EI) *m/z* 177 [M-1]$^+$.

(E)-3-(2, 3-dimethoxyphenyl) acrylic acid[14]



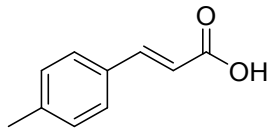
106 mg of **7c** was obtained from 206 mg (1 mmol) of **6c**. 51% yield; White solid; R_f = 0.3 (EtOAc/hexane = 3/7); m.p. 178-180 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 8.11 (d, *J* = 15.88 Hz, 1H), 7.20-7.18 (dd, *J* = 7.91, 1.19 Hz, 1H), 7.08 (t, *J* = 8.09 Hz, 1H),6.98-6.96 (dd, *J* = 8.11, 1.24 Hz, 1H), 6.51 (d, *J* = 16.10 Hz, 1H), 3.89 (s, 3H), 3.88 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 172.2, 153.3, 148.9, 141.9, 128.4, 124.4, 118.7, 114.6, 61.6, 56.1; IR (KBr) ν: 3400.0, 1626.3, 1410.6, 1253.3, 1216.9, 1069.9, 776.5 cm^{-1}; MS (EI) *m/z* 207 [M-1]$^+$.

(E)-3-(3, 4, 5-trimethoxyphenyl) acrylic acid[15]



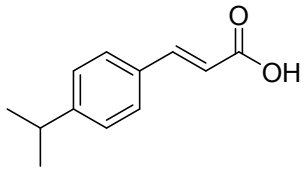
154.5 mg of **7d** was obtained from 236 mg (1 mmol) of **6d**. 65% yield; Light yellow solid; R_f = 0.3 (EtOAc/hexane = 3/7); m.p. 168-170 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.71 (d, *J* = 15.70 Hz, 1H), 6.79 (s, 2H), 6.37 (d, *J* = 15.74 Hz, 1H), 3.91 (s, 9H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 172.4, 153.6, 147.2, 140.7, 129.6, 116.6, 105.7, 61.1, 56.3; IR (KBr) ν: 3401.5, 3019.3, 1631.3, 1283.0, 1216.2, 1068.9, 770.4, 669.1 cm^{-1}; MS (EI) *m/z* 239 [M+].

(E)-3-(p-tolyl) acrylic acid[16]



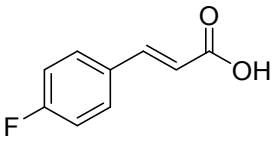
98.5 mg of **7e** was obtained from 160 mg (1 mmol) of **6e**. 61% yield; White solid; R_f = 0.3 (EtOAc/hexane = 3/7); m.p. 192-194 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.77 (d, *J* = 15.94 Hz, 1H), 7.45 (d, *J* = 7.97 Hz, 2H), 7.21 (d, *J* = 7.97 Hz, 2H), 6.41 (d, *J* = 16.00 Hz, 1H), 2.39 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ:172.6, 147.3, 141.5, 131.5, 129.9, 128.6, 116.3, 21.7; IR (KBr) ν: 3387.5, 2920.1, 1628.7, 1286.6, 1217.6, 771.6, 670.0 cm^{-1}; MS (EI) *m/z* 161 [M-1]$^+$.

(E)-3-(4-isopropylphenyl) acrylic acid[17]



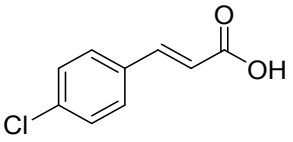
115.5 mg of **7f** was obtained from 188 mg (1 mmol) of **6f**. 61% yield; White solid; R_f = 0.3 (EtOAc/hexane = 3/7); m.p. 162-164 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.78 (d, *J* = 16.00 Hz, 1H), 7.49 (d, *J* = 8.09 Hz, 2H), 7.30 (d, *J* = 8.01 Hz, 2H),6.42 (d, *J* = 16.05 Hz, 1H), 2.98-2.89 (m, 1H), 1.28 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ:172.4, 152.4, 147.4, 131.8, 128.7, 127.3, 116.3, 34.3, 23.9; IR (KBr) ν: 3390.3, 2926.2, 1628.3, 1273.6, 1216.6, 776.6, 669.6 cm^{-1}.

(E)-3-(4-fluorophenyl) acrylic acid[16]



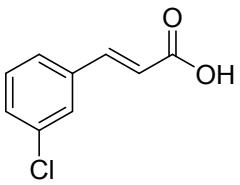
89.5 mg of **7g** was obtained from 164 mg (1 mmol) of **6g**. 54% yield; White solid; R_f = 0.3 (EtOAc/hexane = 3/7); m.p. 200-202 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.78-7.73 (dd, *J* = 15.97, 2.37 Hz, 1H), 7.56-7.54 (m, 2H), 7.10 (t, *J* = 8.54 Hz, 2H), 6.38 (d, *J* = 16.12 Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$ +DMSO-d) δ: 167.5, 164.7, 161.4, 142.4, 130.4, 129.6, 129.5, 118.5, 115.6, 115.3; IR (KBr) ν: 3405.9, 3019.5, 1638.0, 1402.8, 1216.1, 770.7, 669.2 cm^{-1}; MS (EI) *m/z* 165 $[M-1]^+$.

(E)-3-(4-chlorophenyl) acrylic acid[16]



92.5 mg of **7h** was obtained from 180 mg (1 mmol) of **6h**. 51% yield; White solid; R_f = 0.3 (EtOAc/hexane = 3/7); m.p. 240-242 ºC; ^{1}H NMR (300 MHz, DMSO-d) δ: 7.72 (d, *J* = 8.51 Hz, 2H), 7.58 (d, *J* = 16.04 Hz, 1H), 7.47 (d, *J* = 8.48 Hz, 2H), 6.55 (d, *J* = 16.00 Hz, 1H); ^{13}C NMR (75 MHz, DMSO-d) δ: 167.3, 142.4, 134.6, 133.1, 129.8, 128.8, 120.0; IR (KBr) ν: 3405.5, 3019.3, 1629.8, 1399.1, 1216.6, 1156.0, 1069.2, 771.1, 669.6 cm^{-1}; MS (EI) *m/z* 181 $[M-1]^+$.

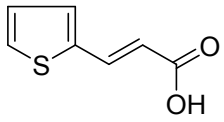
(E)-3-(3-chlorophenyl) acrylic acid[16]



76.5 mg of **7i** was obtained from 180 mg (1 mmol) of **6i**. 42% yield; White solid; R_f = 0.3 (EtOAc/hexane = 3/7); m.p. 156-158 ºC; ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.72 (d, *J* = 16.03 Hz, 1H), 7.54 (t, *J* = 1.59 Hz, 1H), 7.44-7.42 (m, 1H), 7.40-7.38 (m, 1H), 7.37-7.33 (m, 1H), 6.46 (d, *J* = 15.91 Hz, 1H); ^{13}C NMR (75 MHz, DMSO-d) δ: 167.3, 142.3, 136.5, 133.7,

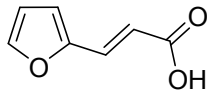
130.6, 129.8, 127.8, 126.8, 120.9; IR (KBr) ν: 3389.1, 1631.3, 1402.8, 1217.8, 1068.3, 771.6, 668.9 cm^{-1}; MS (EI) *m/z* 181 $[M-1]^+$.

(E)-3-(thiophen-2-yl) acrylic acid[18]



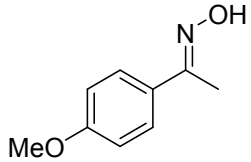
89 mg of **7j** was obtained from 152 mg (1 mmol) of **6j**. 58% yield; White solid; R_f = 0.3 (EtOAc/hexane = 3/7); m.p. 141-143 ºC; ^{1}H NMR (300 MHz, DMSO-d) δ: 12.40 (brs, 1H), 7.71 (d, *J* = 15.76 Hz, 1H), 7.69 (d, *J* = 5.06 Hz, 1H), 7.50 (d, *J* = 3.45 Hz, 1H), 7.14 (dd, *J* = 4.95, 3.73 Hz, 1H), 6.17 (d, *J* = 15.68 Hz, 1H); ^{13}C NMR (75 MHz, DMSO-d) δ: 167.2, 138.8, 136.7, 131.6, 129.4, 128.4, 117.4; IR (KBr) ν: 3414.2, 2987.4, 2253.6, 1644.8, 1218.9, 1027.2, 756.3, 664.0 cm^{-1}; MS (EI) *m/z* 153 $[M-1]^+$.

(E)-3-(furan-2-yl) acrylic acid[18]



84 mg of **7k** was obtained from 136 mg (1 mmol) of **6k**. 61% yield; White solid, R_f = 0.3 (EtOAc/hexane = 7/3); m.p. 130-132 ºC; ^{1}H NMR (300 MHz, DMSO-d) δ: 7.83 (brs, 1H), 7.39 (d, *J* = 16.14 Hz, 1H), 6.92 (d, *J* = 3.26 Hz, 1H), 6.63-6.61 (m, 1H), 6.51 (d, *J* = 15.95 Hz, 1H); ^{13}C NMR (75 MHz, DMSO-d) δ: 167.2, 150.2, 145.6, 130.7, 115.9, 115.3, 112.6; IR (KBr) ν: 3412.2, 2998.2, 1637.7, 1216.0, 1053.5, 1028.4, 757.2, 667.5 cm^{-1}; MS (EI) *m/z* 137 $[M-1]^+$.

3.0 Procedure for the synthesis of oxime 2a:



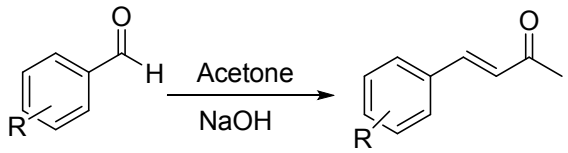
(E)-1-(4-methoxyphenyl) ethan-1-one oxime[19]

A mixture of acetophenone **1a** Hydroxylamine hydrochloride (2 mmol, 2 eq.) and CuI (30 mol%) in dimethyl sulfoxide (10 mL) was stirred at 50 °C under oxygen atmosphere for 2 h .

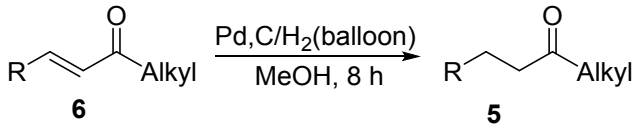
After completion of the reaction, as indicated by TLC, the mixture was diluted with water, filtered and extracted with EtOAc (3×20mL). The extract was washed with brine, drying over Na_2SO_4 and evaporation, the crude product was purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc) to afford the product **2a**. 99% yield; White solid , R_f = 0.6 (EtOAc/hexane = 3/7); ^{1}H NMR (300 MHz, $CDCl_3$) δ: 8.69 (brs, 1H), 7.59-7.56 (m, 2H), 6.92-6.89 (m, 2H), 3.83 (s, 3H), 2.28 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 160.6, 155.7, 129.2, 127.5, 114.0, 55.5,12.3; IR (KBr) ν: 3208.1, 3077.5, 2976.8, 1621.1, 1516.2, 1298, 1025.4, 920, 752cm^{-1}; MS (EI) *m/z* 166 [M $^+$].

5.0. Synthesis of starting materials:

5.1. synthesis of (E)-4-arylbut-3-en-2-ones (6) was done following the procedure given in the ref. *Chem. Med. Chem.* 2009, 4, 963-966. [20]



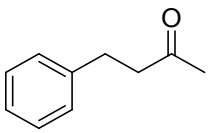
5.2. General procedure for the synthesis of 4-arylbutan-2-ones:



6 **5**

The substituted 4-arylbutan-2-ones were prepared by hydrogenation of the corresponding enones at room temperature at 50 psi in methanol utilizing a catalyst 5% Pd on carbon. The catalyst was filtered off and the resulting ketone was purified by column chromatography.

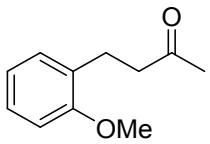
4-phenylbutan-2-one[21]



145 mg of **5a** was obtained from 146 mg (1 mmol) of **6a**. 98% yield; Colourless liquid; R_f = 0.5 (EtOAc/hexane = 1/9); ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.27-7.25 (m, 2H), 7.20-7.16 (m,

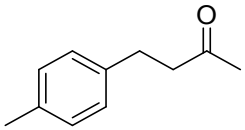
3H), 2.89 (t, *J* = 7.28 Hz, 2H), 2.75 (t, *J* = 7.48 Hz, 2H), 2.13 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 207.9, 141.1, 128.6, 128.4, 126.2, 45.2, 30.1, 29.9.

4-(2-methoxyphenyl) butan-2-one[22]



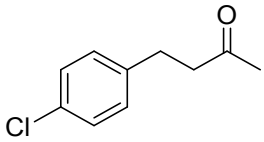
174 mg of **5b** was obtained from 176 mg (1 mmol) of **6b**. 98% yield; Colourless liquid; R_f = 0.5 (EtOAc/hexane = 1/9); ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.20-7.17 (m, 1H), 7.12 (dd, *J* = 7.34, 1.49 Hz, 1H), 6.88-6.83 (m, 2H), 3.81 (s, 3H), 2.88 (t, *J* = 8.02 Hz, 2H), 2.72 (t, *J* = 8.06 Hz, 2H), 2.13 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 208.8, 157.8, 130.1, 129.4, 127.6, 120.6, 110.3, 55.3, 43.8, 30.0, 25.1.

4-(p-tolyl) butan-2-one[23]



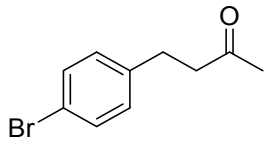
158.5 mg of **5c** was obtained from 160 mg (1 mmol) of **6e**. 98% yield; Colourless liquid, R_f = 0.5 (EtOAc/hexane = 1/9); ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.08-7.04 (m, 4H), 2.84 (t, *J* = 7.55 Hz, 2H), 2.71 (t, *J* = 7.55 Hz, 2H), 2.29 (s, 3H), 2.11 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 208.0, 138.0, 135.6, 129.2, 128.2, 45.4, 30.1, 29.4, 21.0.

4-(4-chlorophenyl) butan-2-one[23]



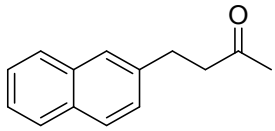
178 mg of **5d** was obtained from 180 mg (1 mmol) of **6h**. 98% yield; Colourless liquid; R_f = 0.5 (EtOAc/hexane = 1/9); ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.29-7.26 (m, 2H), 7.20-7.17 (m, 2H), 2.89 (t, *J* = 7.74 Hz, 2H), 2.75 (t, *J* = 7.91 Hz, 2H), 2.13 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 2.8.0, 141.1, 128.6, 128.4, 126.2, 45.2, 30.1, 29.8.

4-(4-bromophenyl) butan-2-one [23]



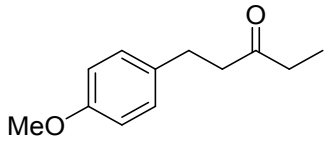
220.5 mg of **5e** was obtained from 223 mg (1 mmol) of **6l**. 98% yield; Colourless liquid; R_f = 0.5 (EtOAc/hexane = 1/9); ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.29-7.26 (m, 2H), 7.19-7.17 (m, 2H), 2.89 (t, *J* = 7.85 Hz, 2H), 2.76 (t, *J* = 7.96 Hz, 2H), 2.13 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 208.1, 141.1, 128.6, 128.4, 126.3, 45.3, 30.2, 29.9.

4-(naphthalen-2-yl) butan-2-one[21]



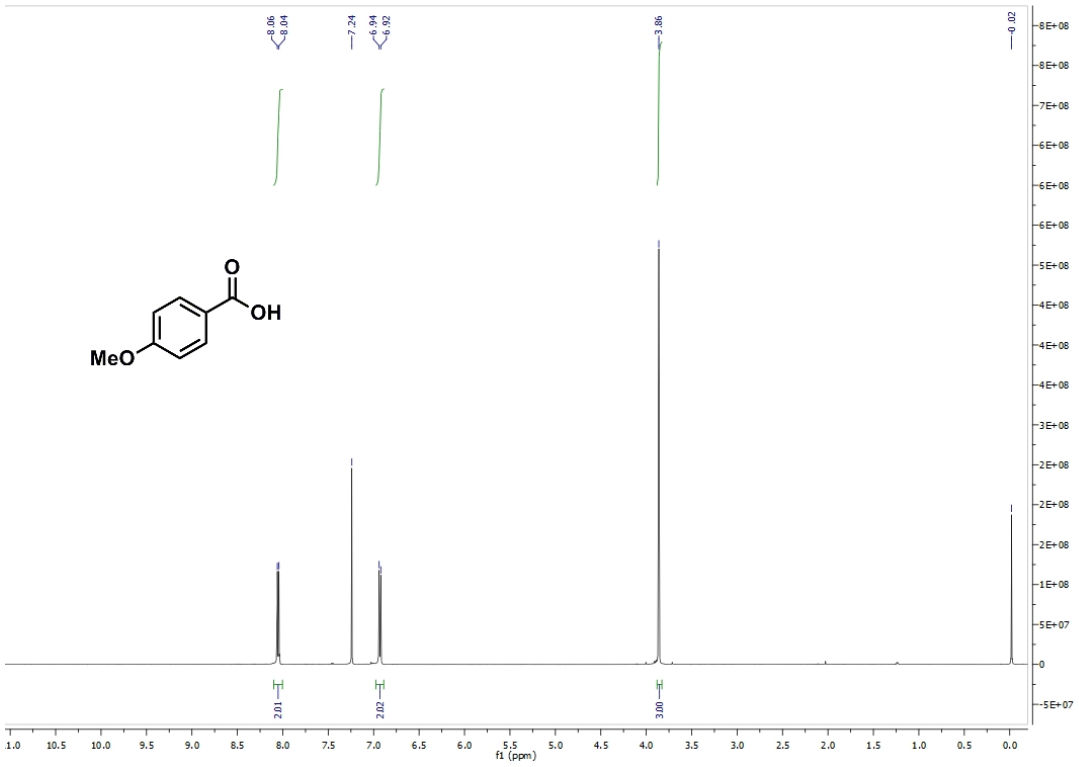
188 mg of **5f** was obtained from 196 mg (1 mmol) of **6m**. 95% yield; White solid; R_f = 0.5 (EtOAc/hexane = 1/9); ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.81-7.75 (m, 3H), 7.62 (s, 1H), 7.48-7.39 (m, 2H), 7.31(dd, *J* = 8.41, 1.45 Hz, 1H), 3.06 (t, *J* = 7.33 Hz, 2H), 2.84 (t, *J* = 7.76 Hz, 2H), 2.15 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 208.0, 138.7, 132.2, 128.3, 127.8, 127.6, 127.2, 126.5, 126.2, 125.5, 45.2, 30.3, 30.1.

1-(4-methoxyphenyl) pentan-3-one [24]

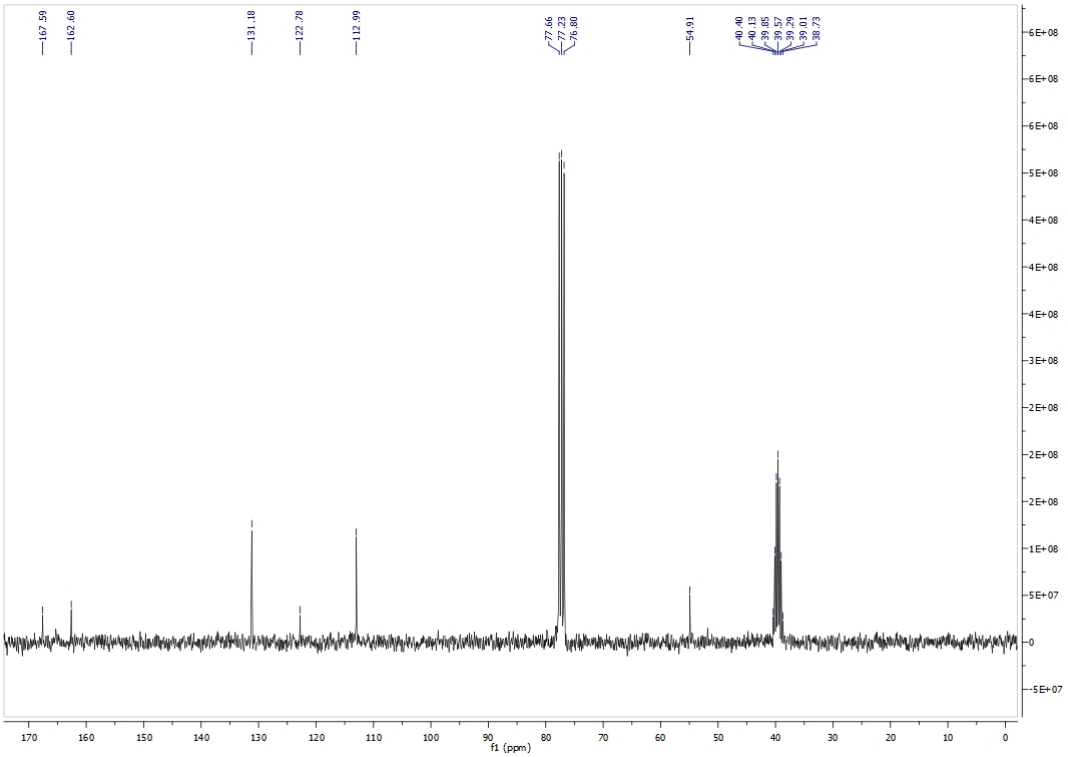


188 mg of **5g** was obtained from 190 mg (1 mmol) of **6n**. 98% yield; Colourless liquid, R_f = 0.5 (EtOAc/hexane = 1/9); ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.10 (d, *J* = 8.53 Hz, 2H), 6.82 (d, *J* = 8.53 Hz, 2H), 3.78 (s, 3H), 2.84 (t, *J* = 7.44 Hz, 2H), 2.70 (t, *J* = 7.77 Hz, 2H), 2.39 (q, *J* = 14.62,7.35 Hz, 2H), 1.04 (t, *J* = 7.35 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ: 211.0, 158.0, 133.3, 129.3, 114.0, 55.3, 44.3, 36.3, 29.1, 7.9.

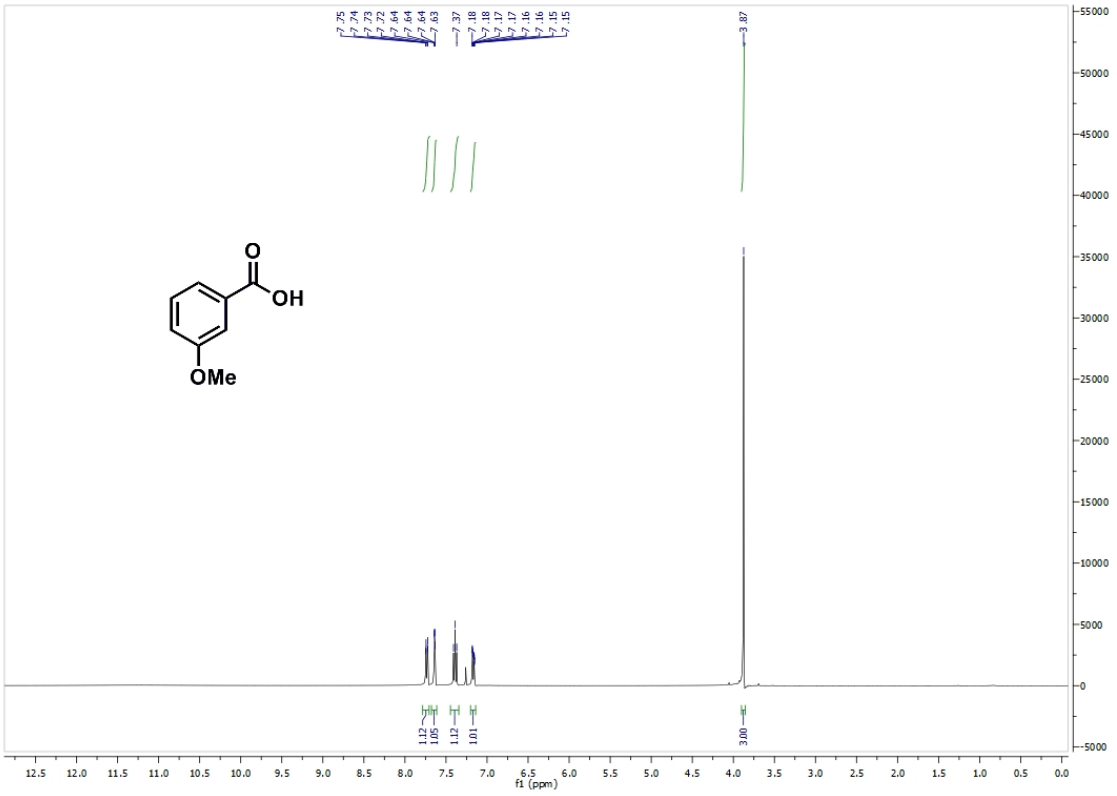
^{1}H and ^{13}C NMR spectra of synthesised compounds



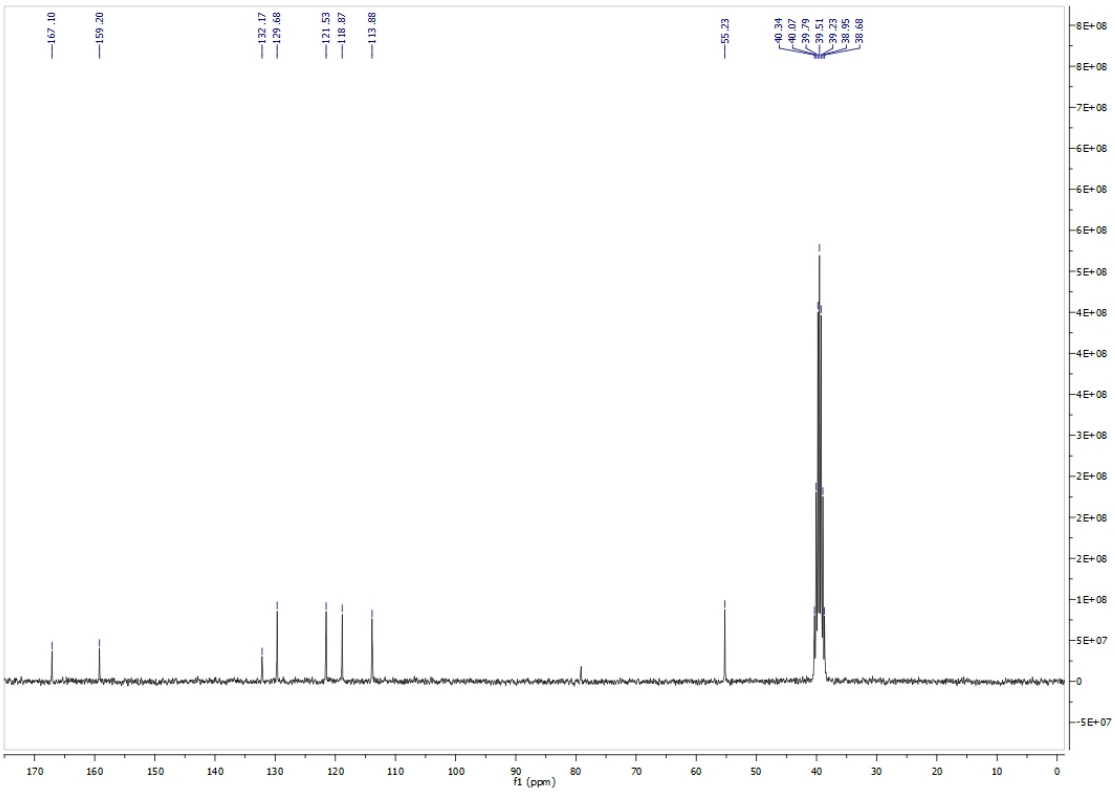
^{1}H-NMR spectrum of **3a** (300 MHz, $CDCl_3$)



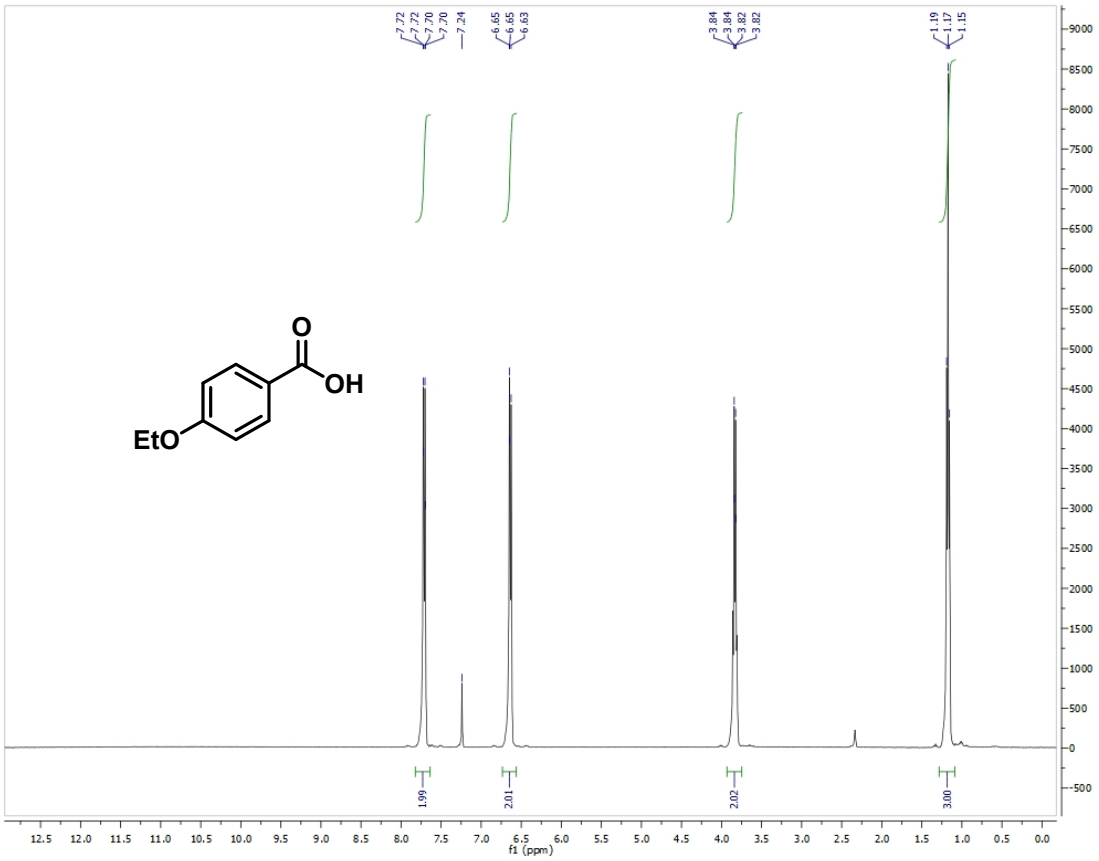
^{13}C-NMR spectrum of **3a** (75 MHz, $CDCl_3$ + DMSO)



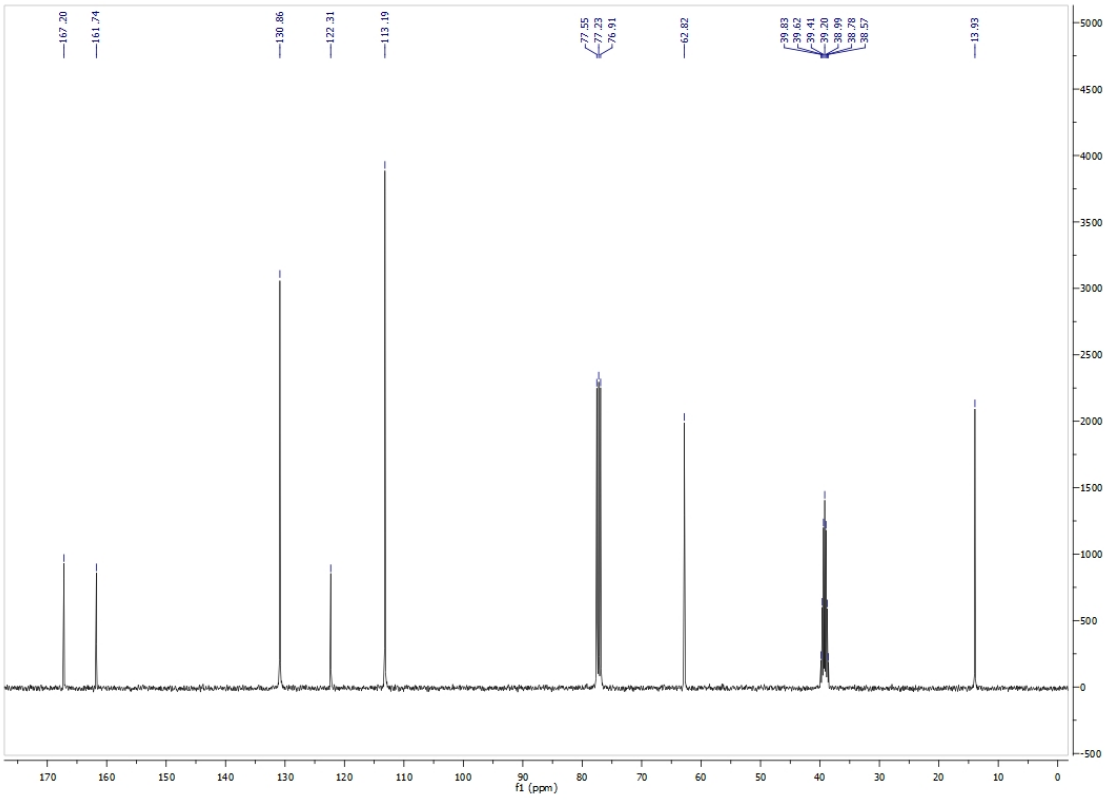
^{1}H-NMR spectrum of **3b** (300 MHz,$CDCl_3$)



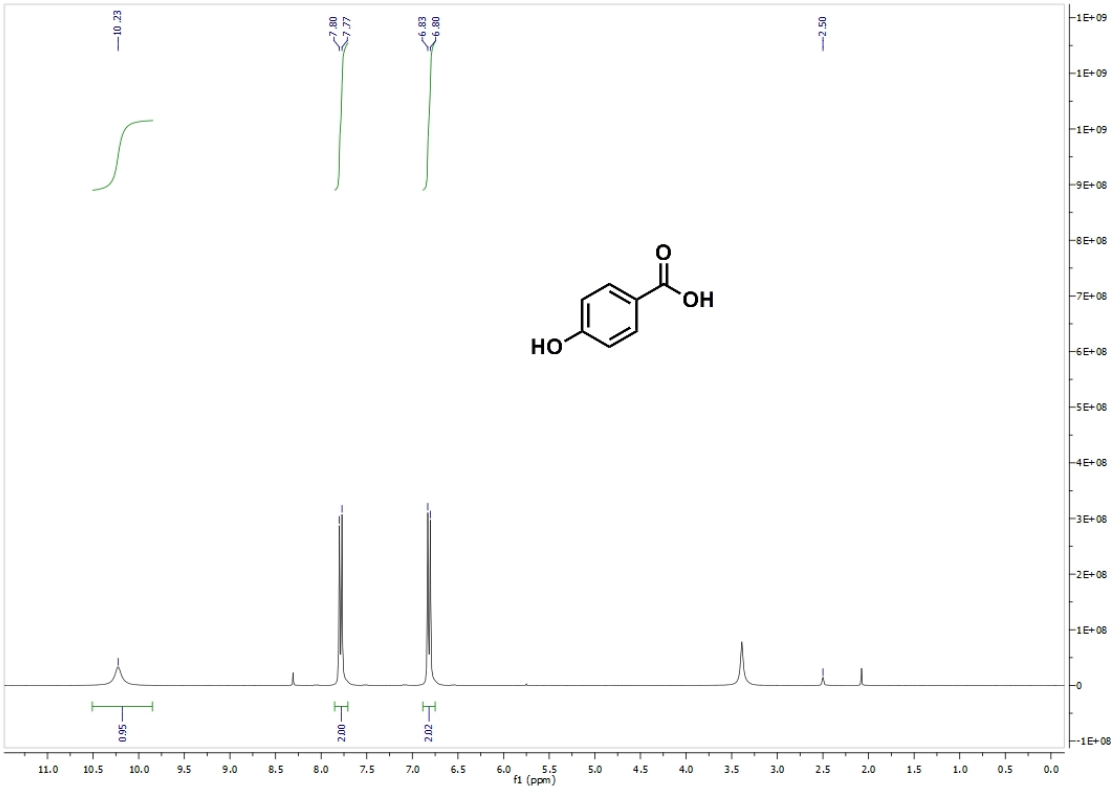
^{13}C-NMR spectrum of **3b** (75 MHz, DMSO)



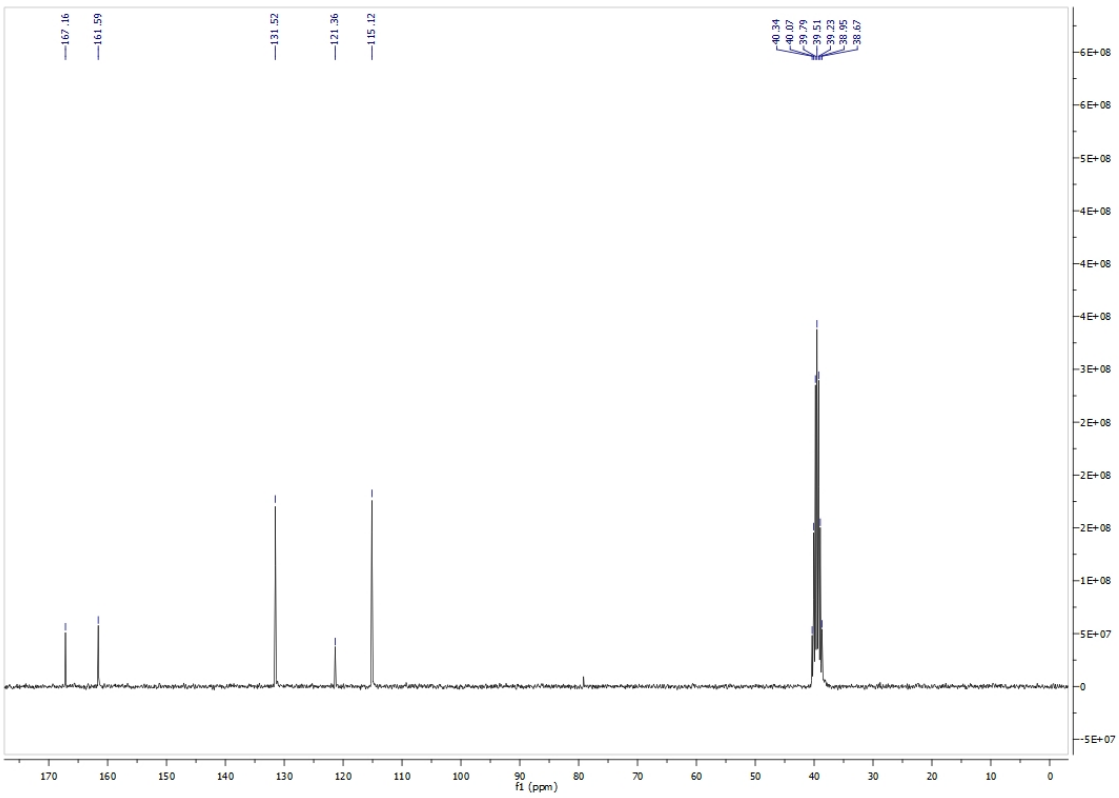
^{1}H-NMR spectrum of **3c** (300 MHz, $CDCl_3$ + DMSO)



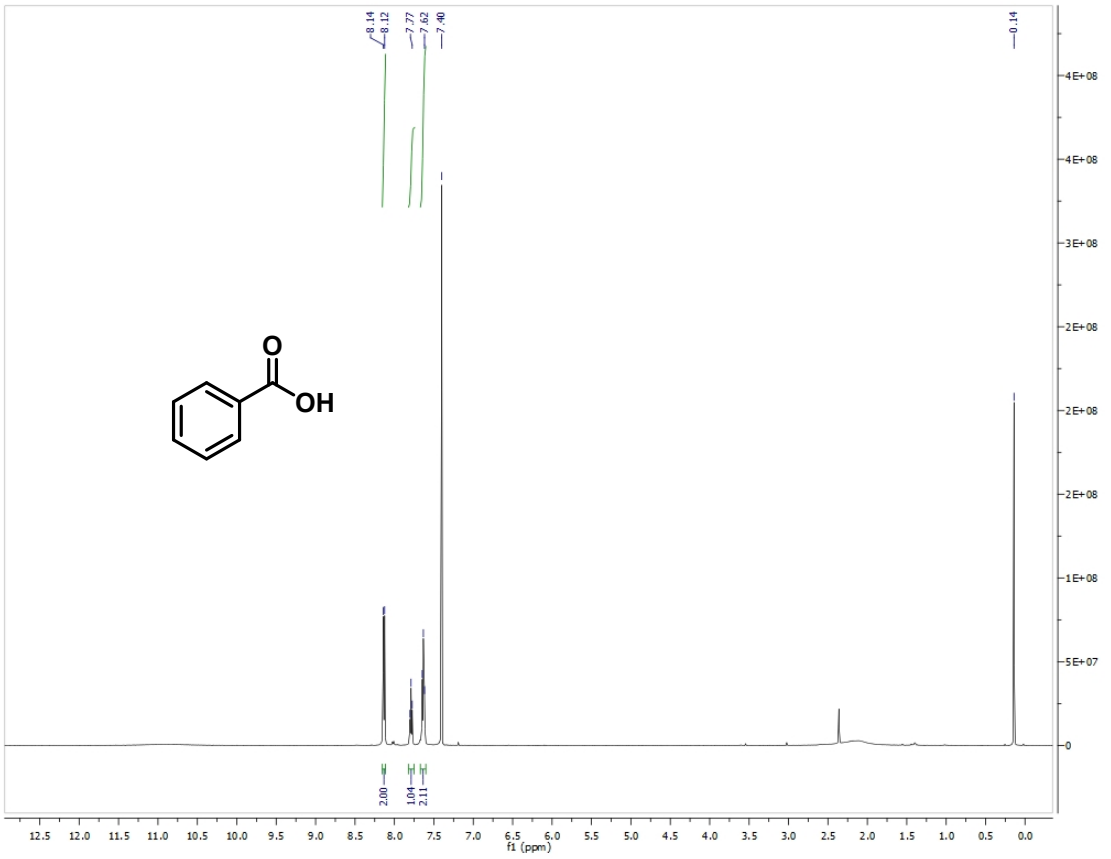
^{13}C-NMR spectrum of **3c** (75 MHz, $CDCl_3$ + DMSO)



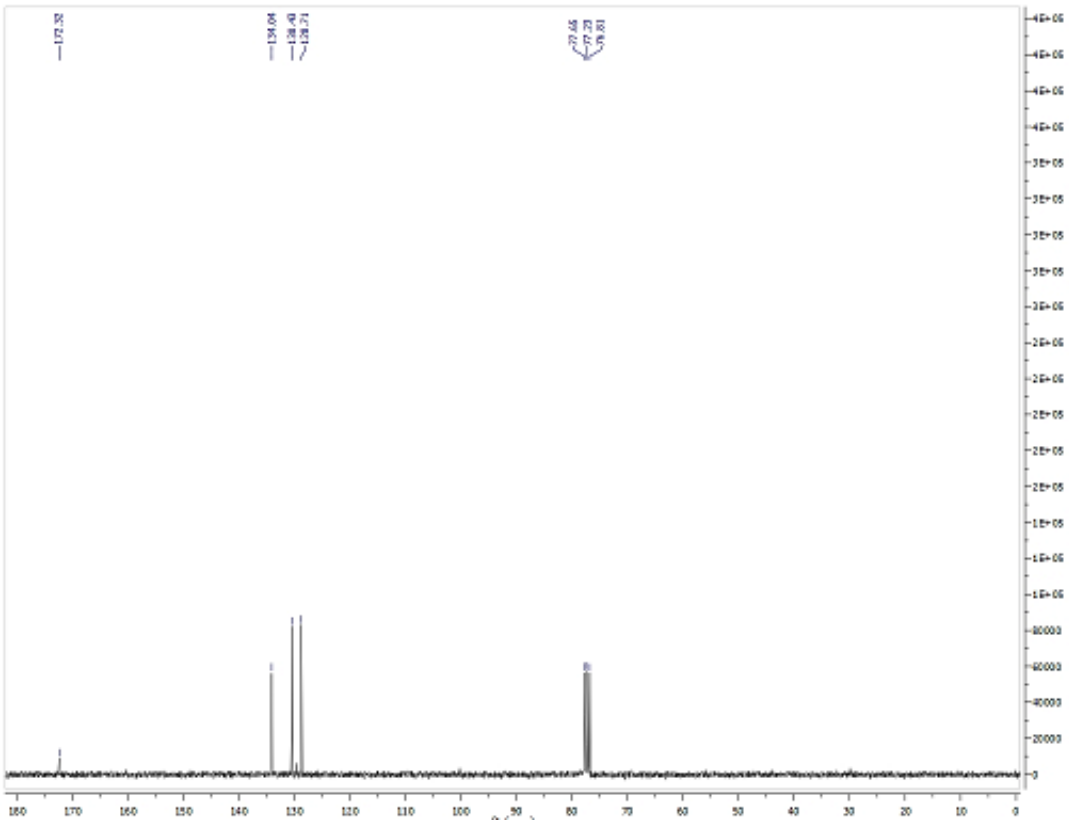
^{1}H-NMR spectrum of **3d** (300 MHz, DMSO)



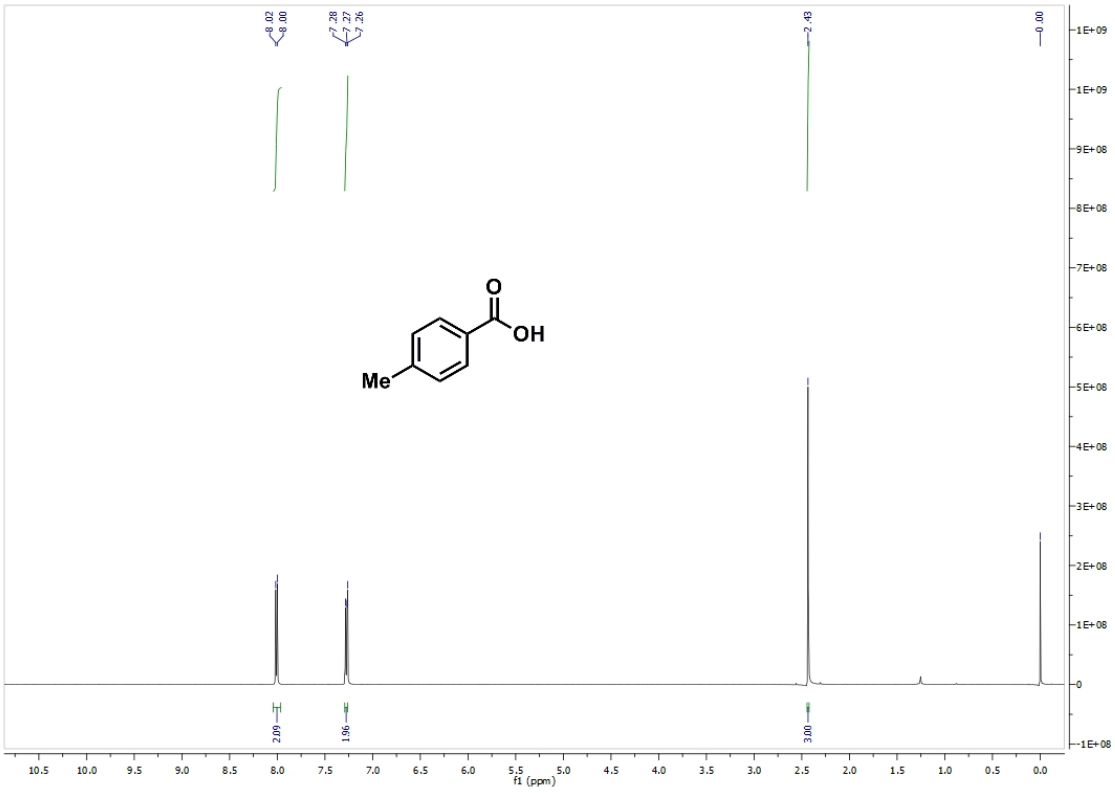
^{13}C-NMR spectrum of **3d** (75 MHz, DMSO)



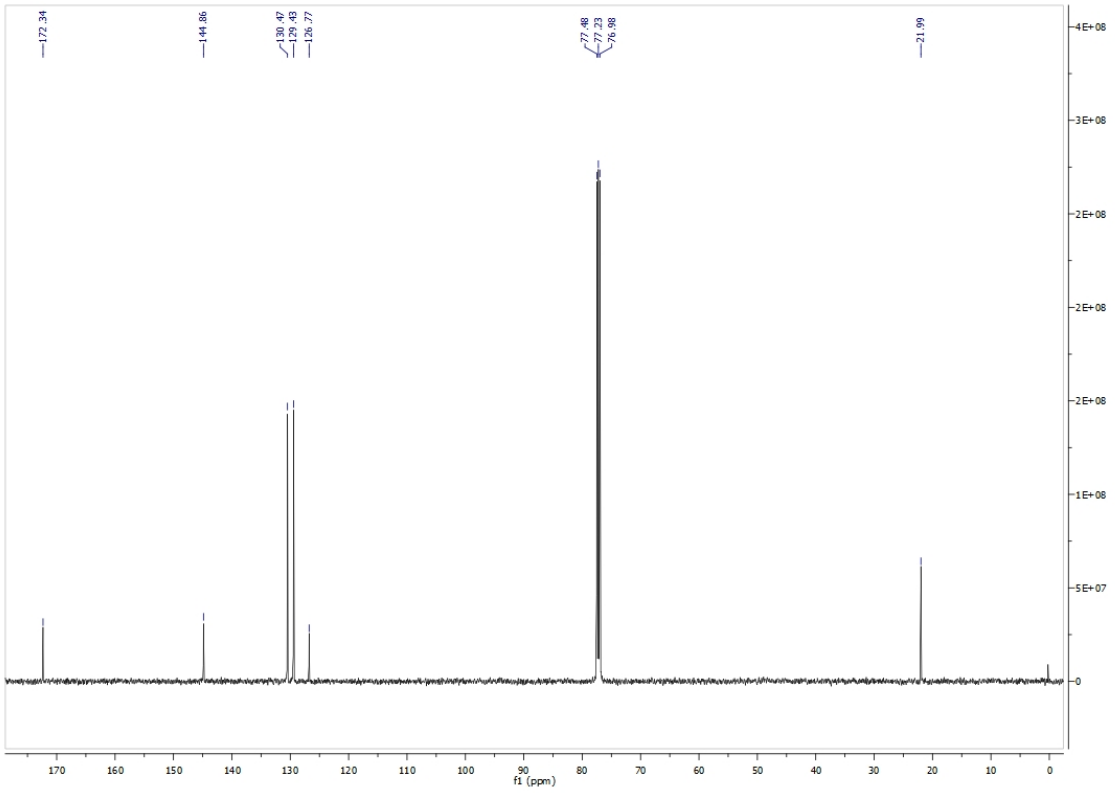
^{1}H-NMR spectrum of **3e** (300 MHz, CDCl3)



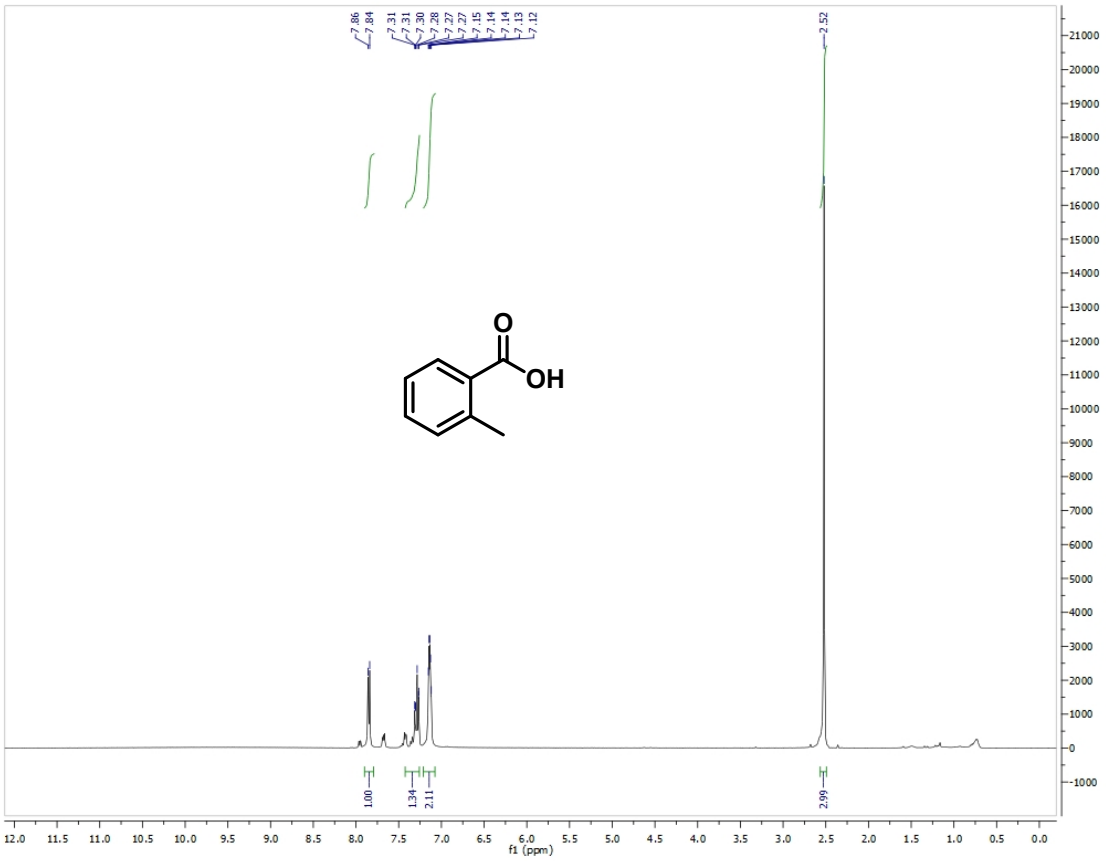
^{13}C-NMR spectrum of **3e** (75 MHz, $CDCl_3$)



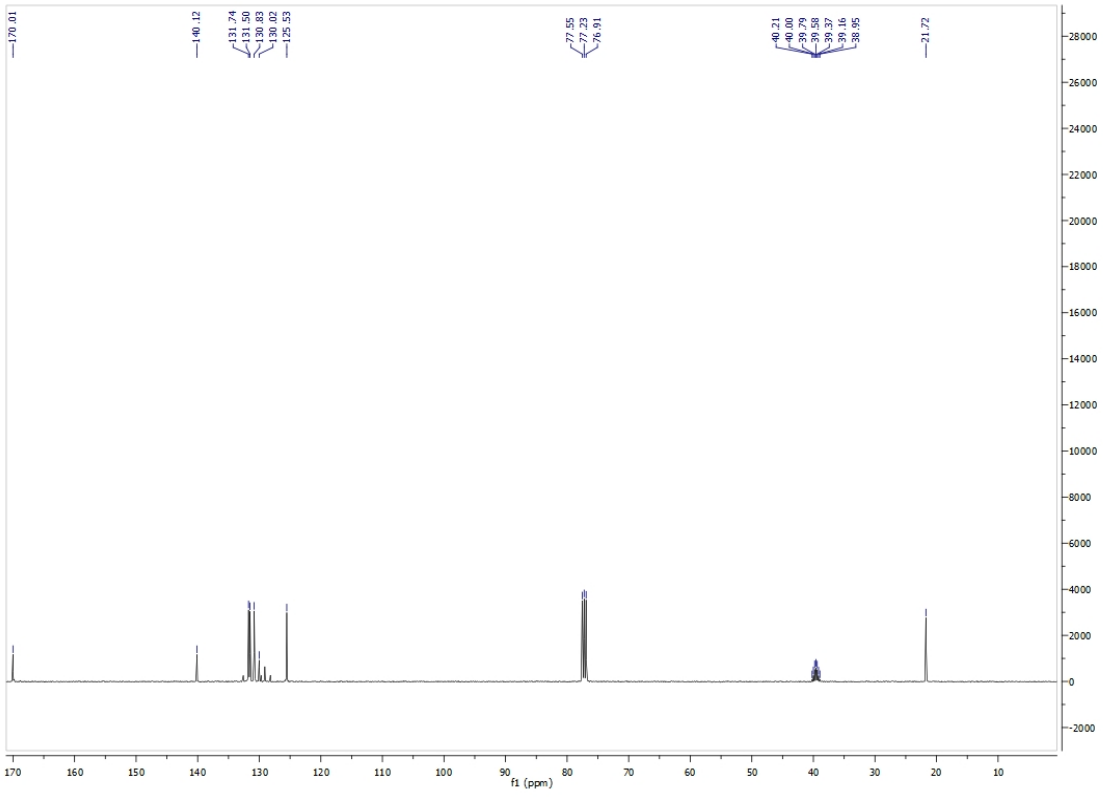
^{1}H-NMR spectrum of **3f** (300 MHz, $CDCl_3$)



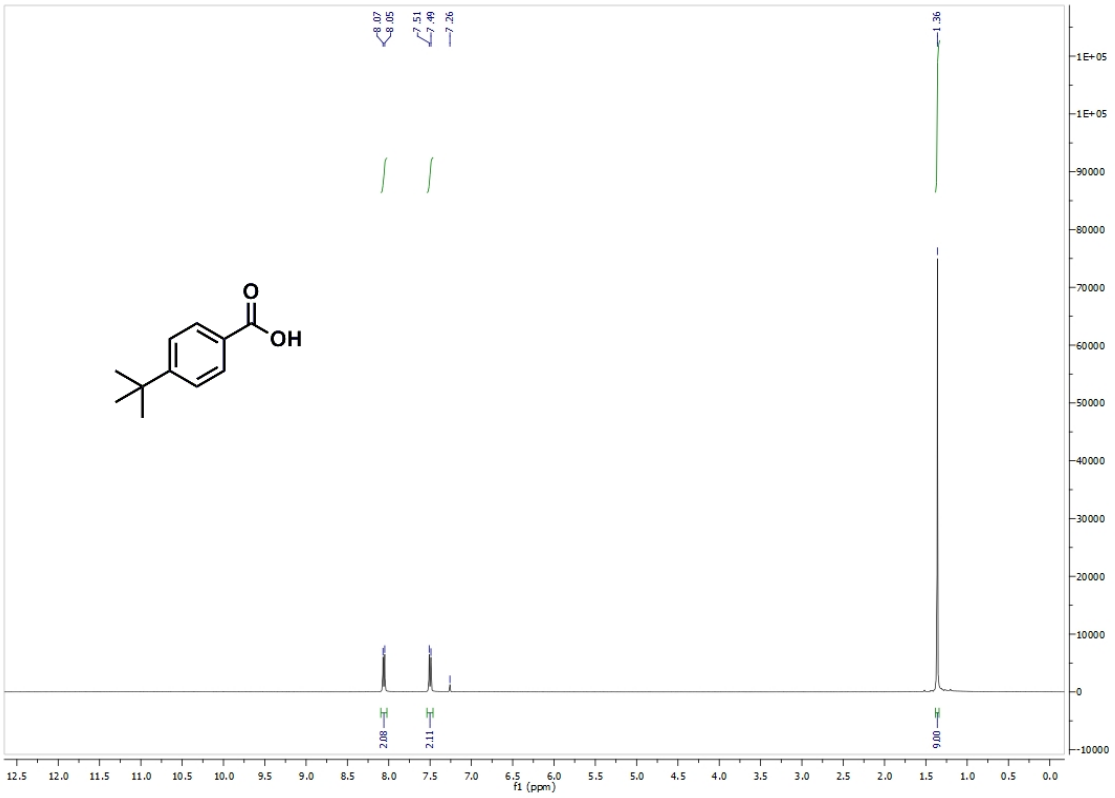
^{13}C-NMR spectrum of **3f** (75 MHz, $CDCl_3$)



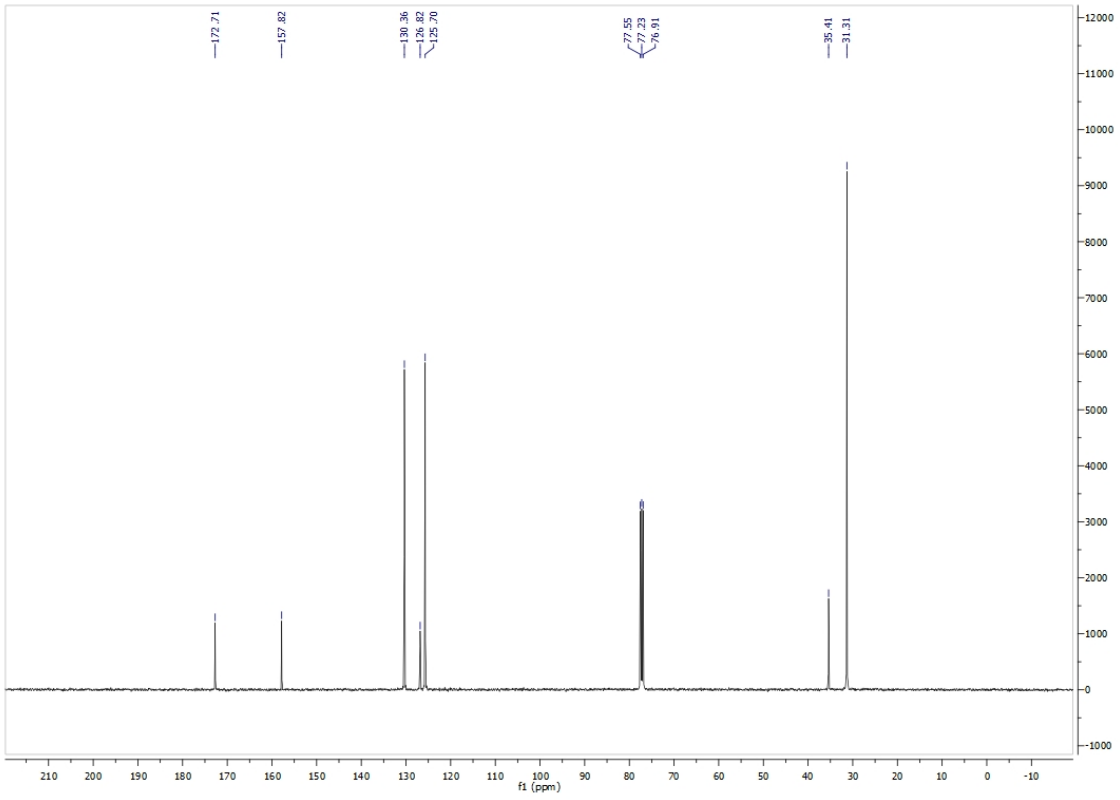
^{1}H-NMR spectrum of **3g** (300 MHz, $CDCl_3$)



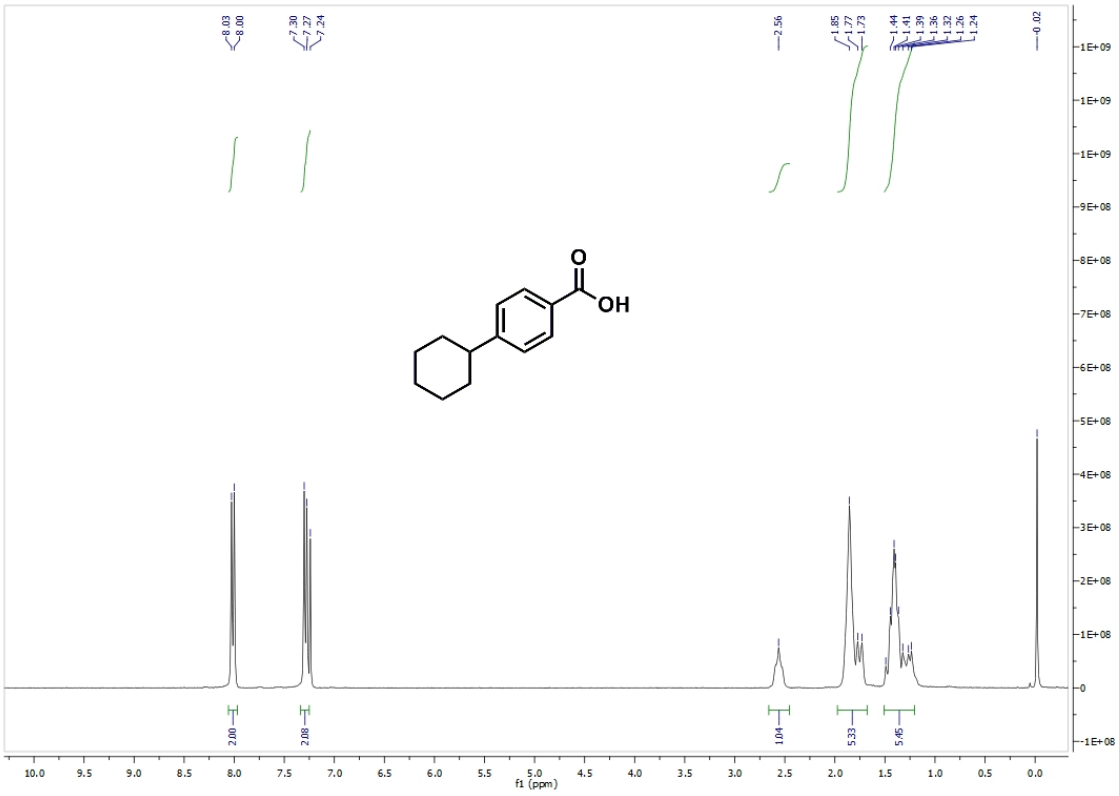
^{13}C-NMR spectrum of **3g**(75 MHz, $CDCl_{3+}$ DMSO)



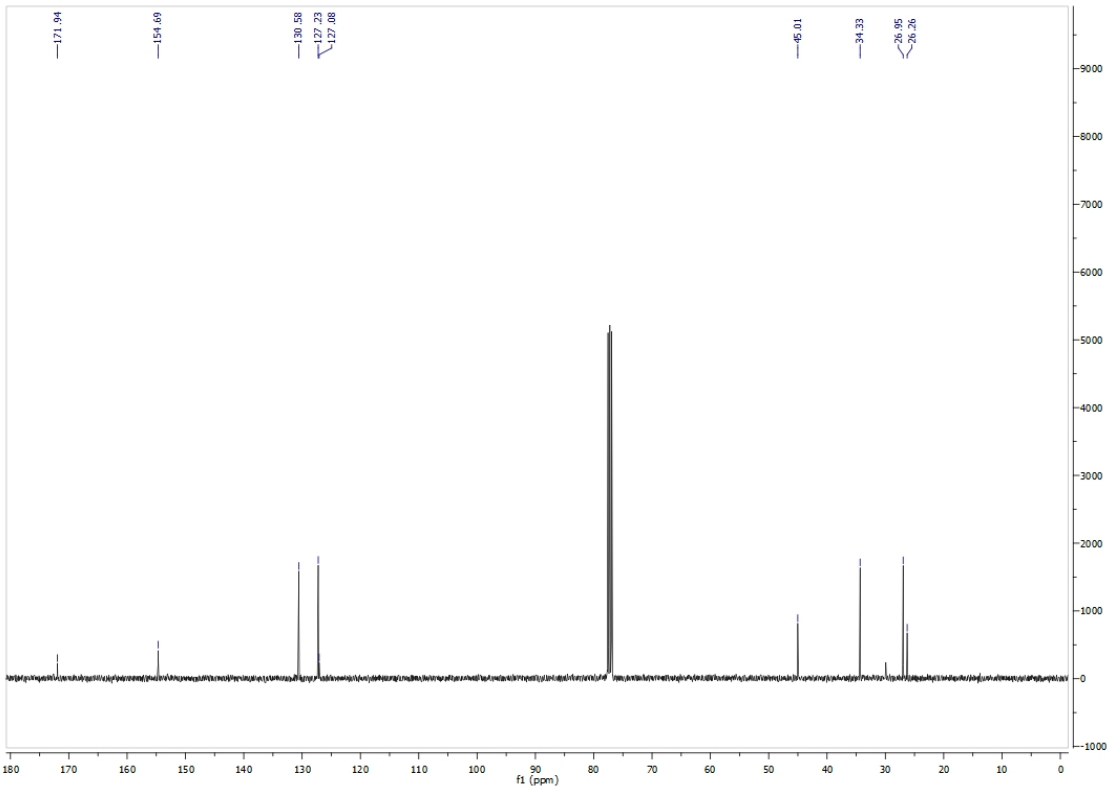
^{1}H-NMR spectrum of **3h** (300 MHz, $CDCl_3$)



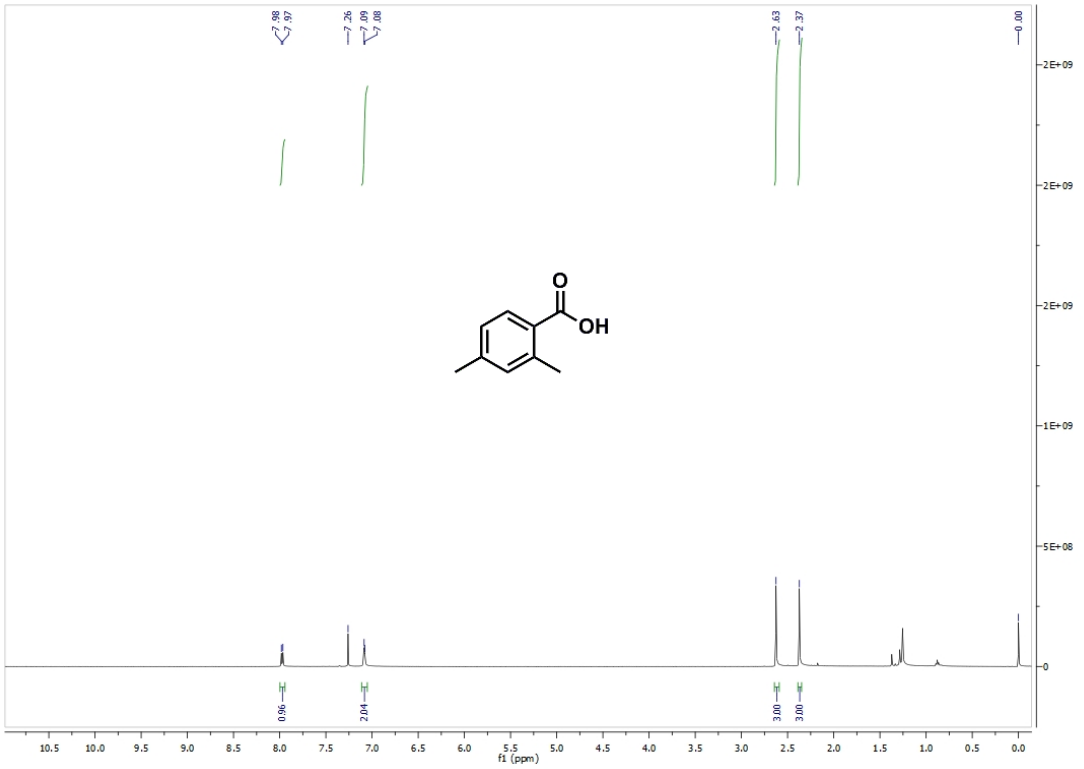
^{13}C-NMR spectrum of **3h** (75 MHz, $CDCl_3$)



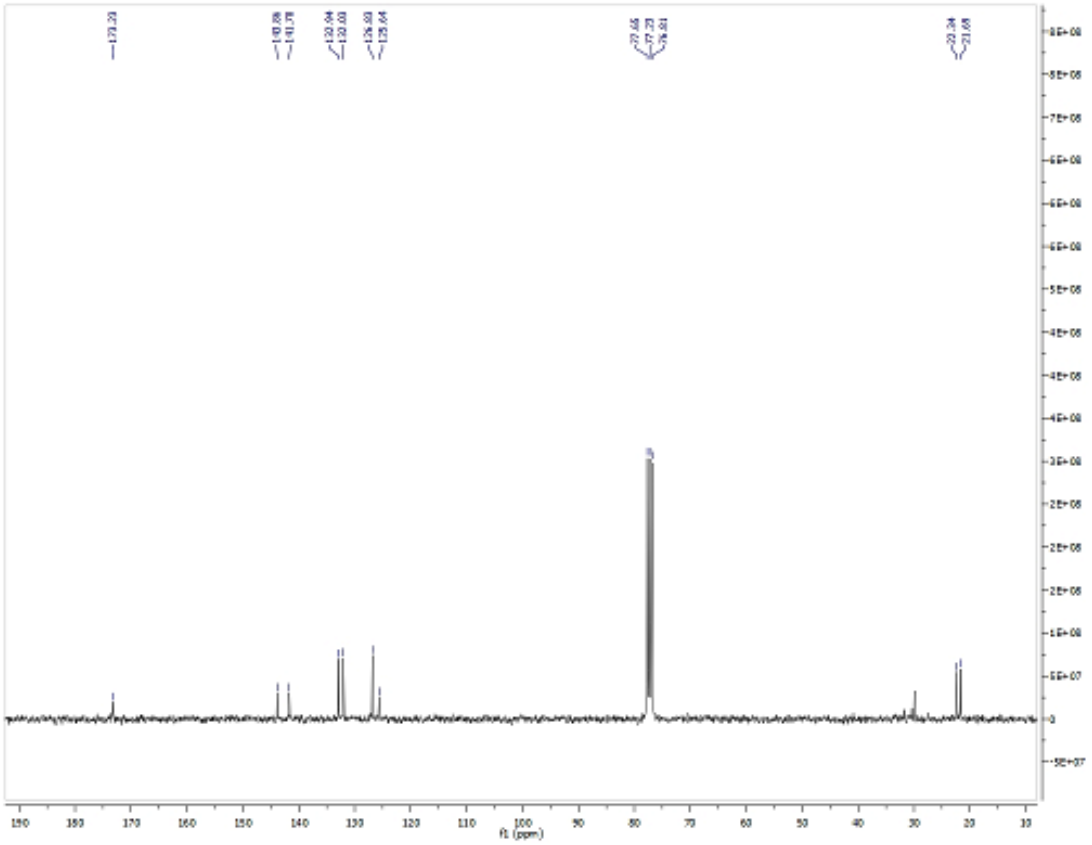
^{1}H-NMR spectrum of **3i** (300 MHz, $CDCl_3$)



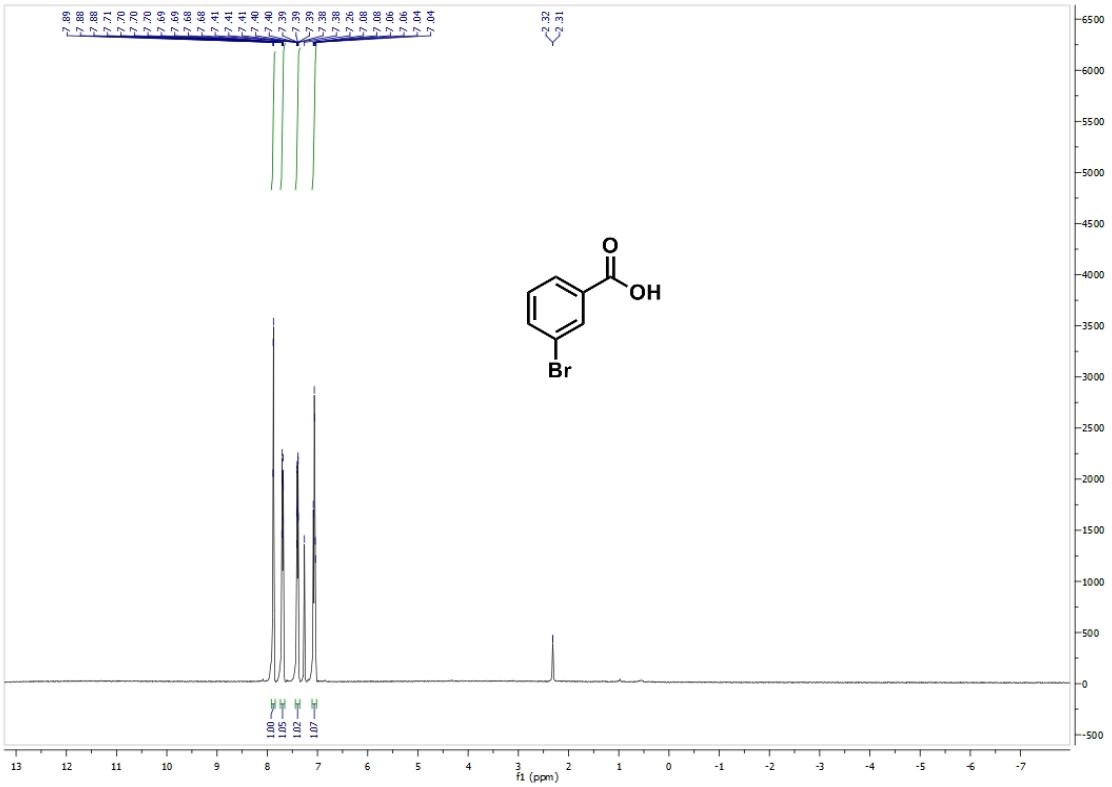
^{13}C-NMR spectrum of **3i** (75 MHz, $CDCl_3$)



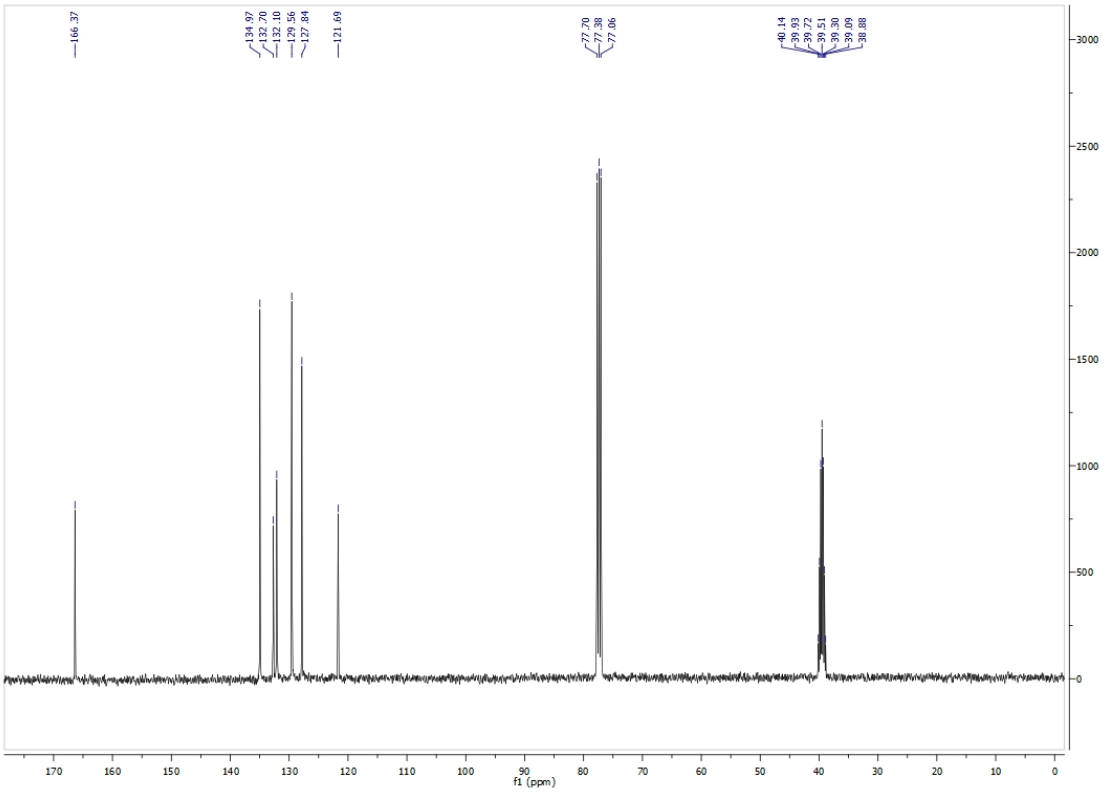
^{1}H-NMR spectrum of **3j** (300 MHz, $CDCl_3$)



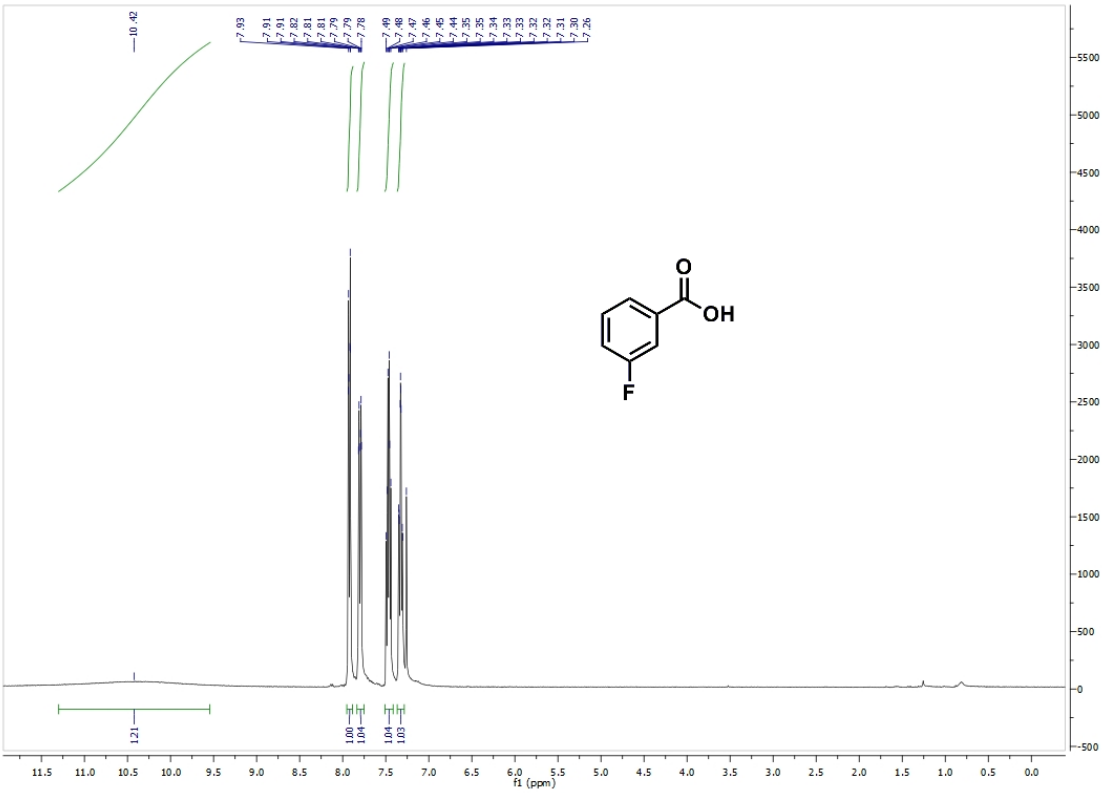
^{13}C-NMR spectrum of **3j** (75 MHz, $CDCl_3$)



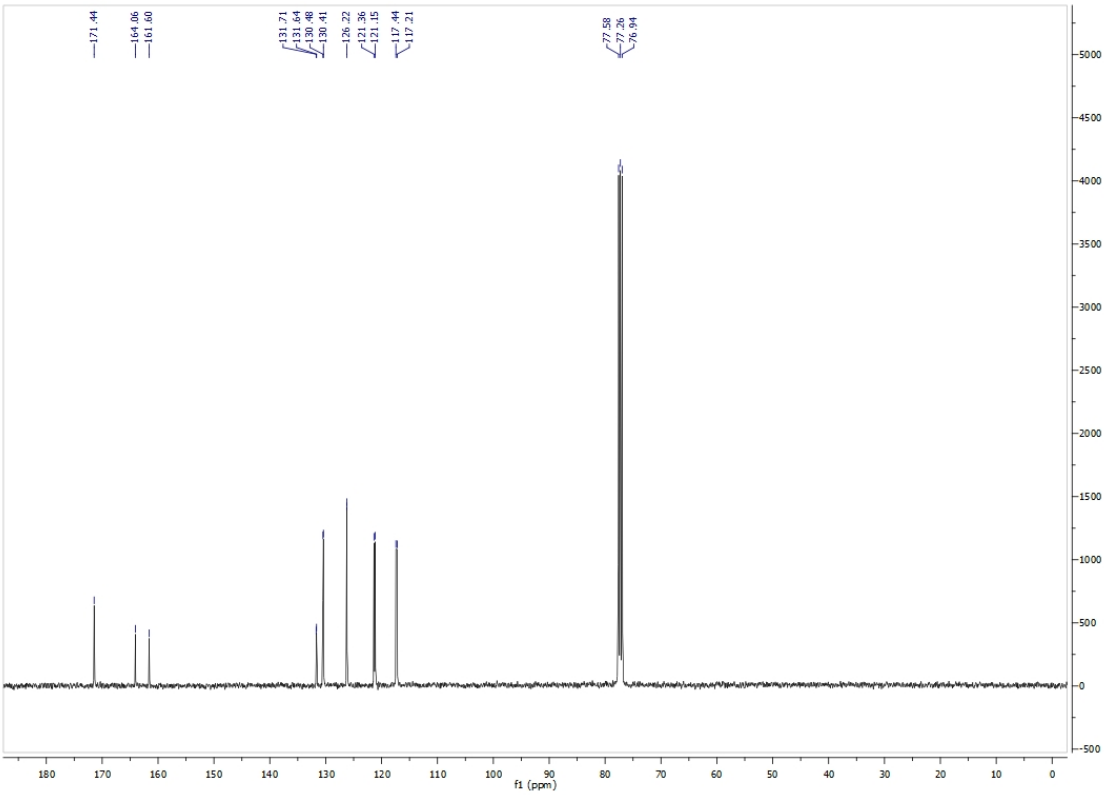
^{1}H-NMR spectrum of **3k** (300 MHz, DMSO)



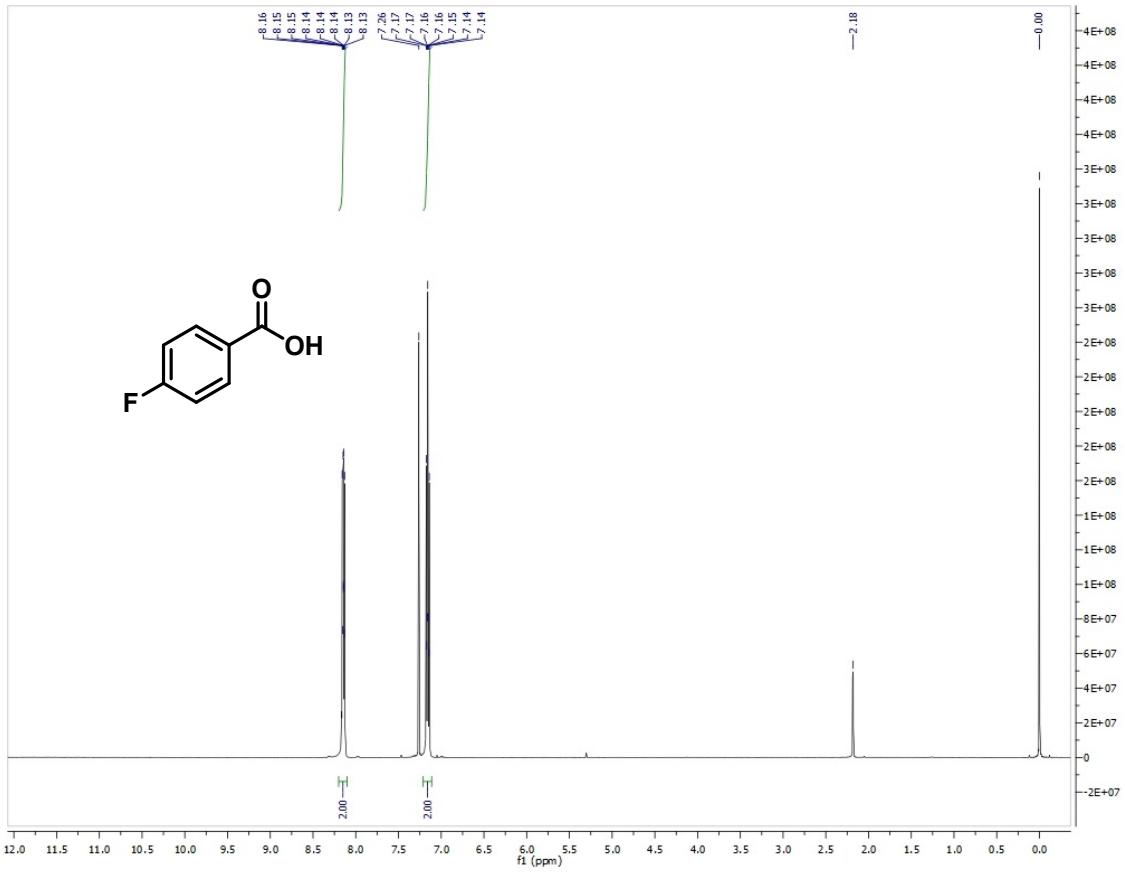
^{13}C -NMR spectrum of **3k** (300 MHz, $CDCl_{3+}$ DMSO)



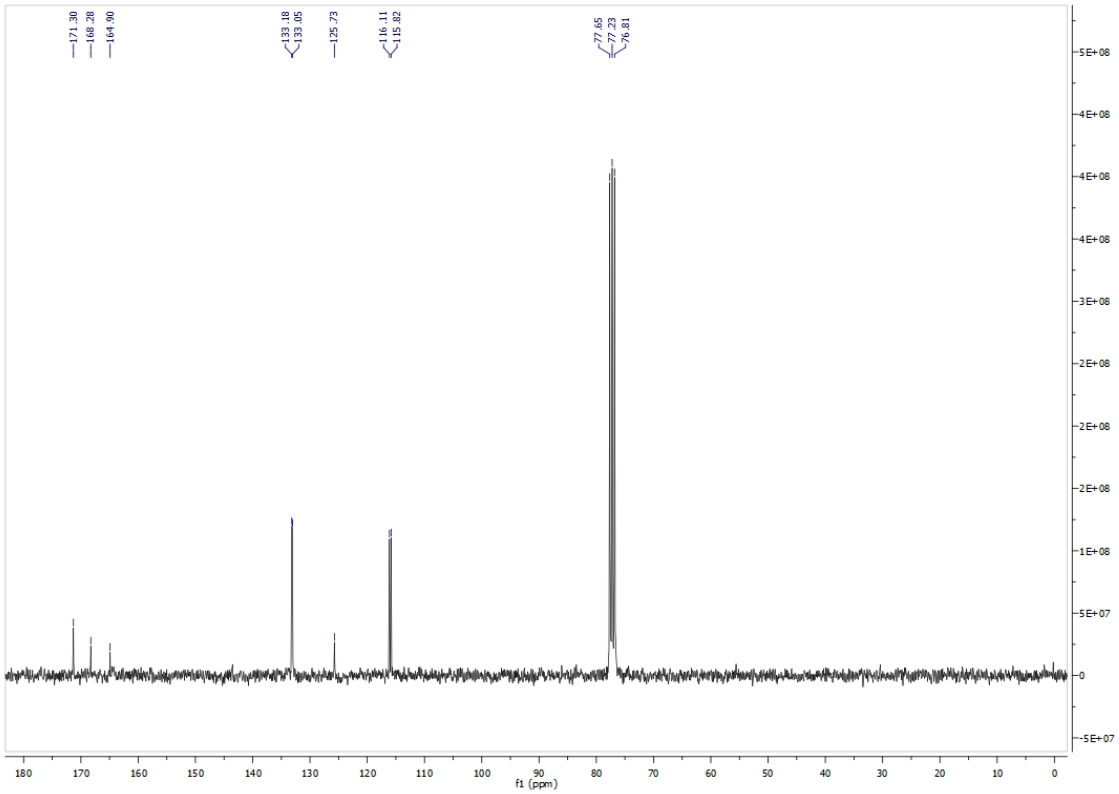
^{1}H-NMR spectrum of **3l** (300 MHz, $CDCl_3$)



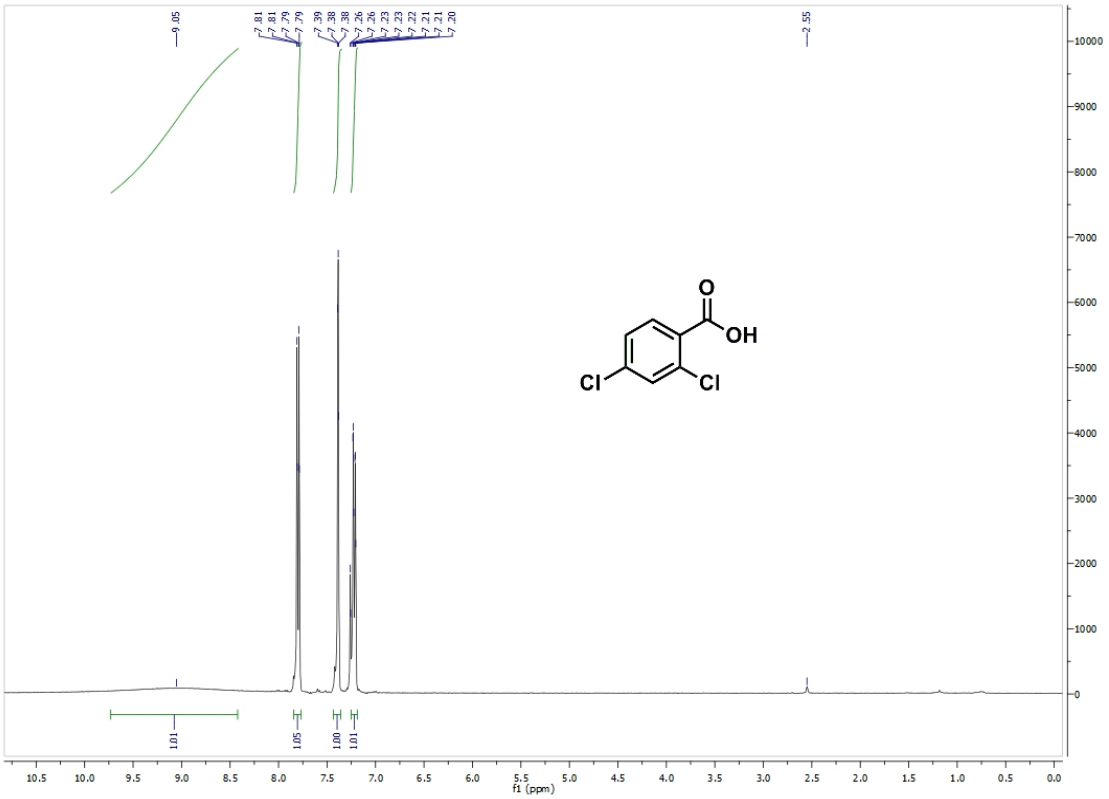
^{13}C -NMR spectrum of **3l** (300 MHz, $CDCl_3$)



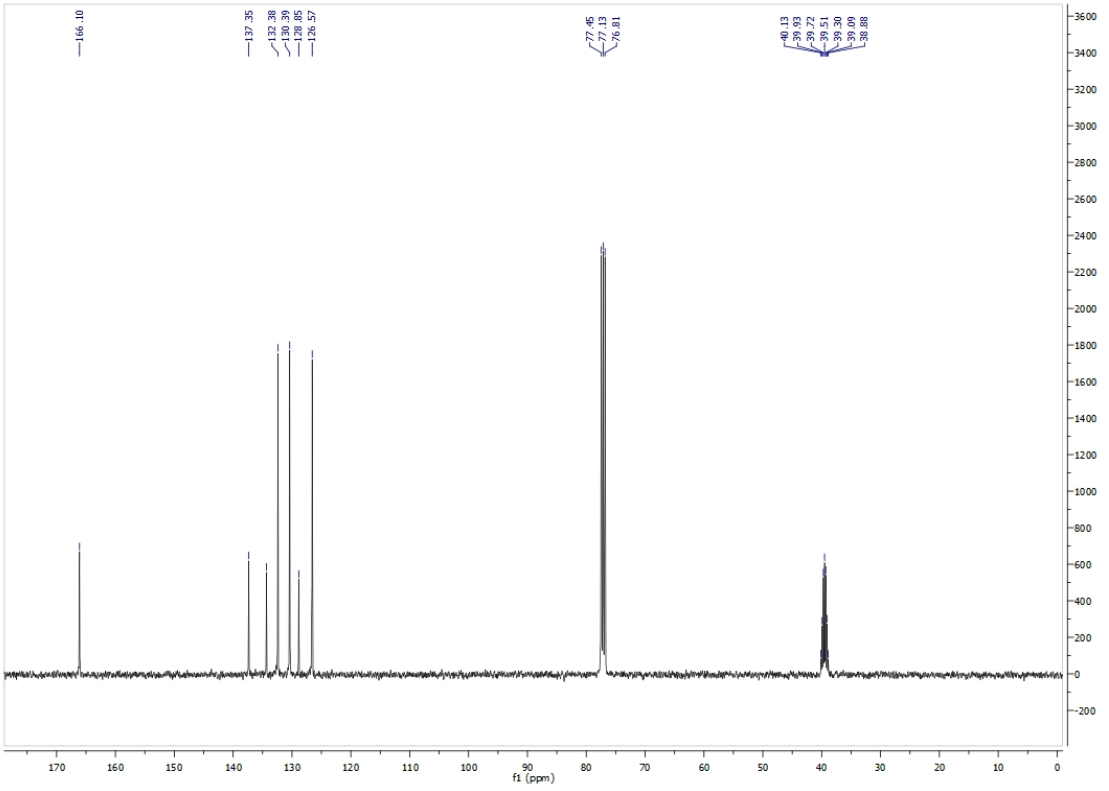
^{1}H-NMR spectrum of **3m** (300 MHz, $CDCl_3$)



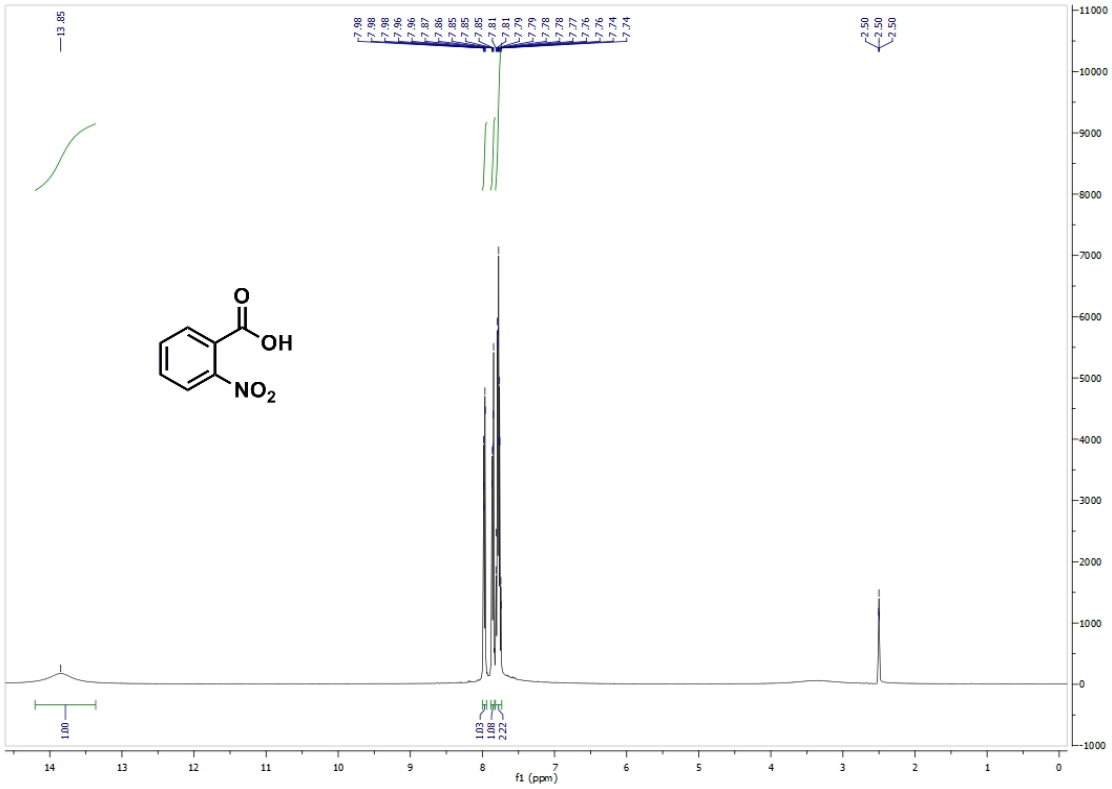
^{13}C -NMR spectrum of **3m** (300 MHz, $CDCl_3$)



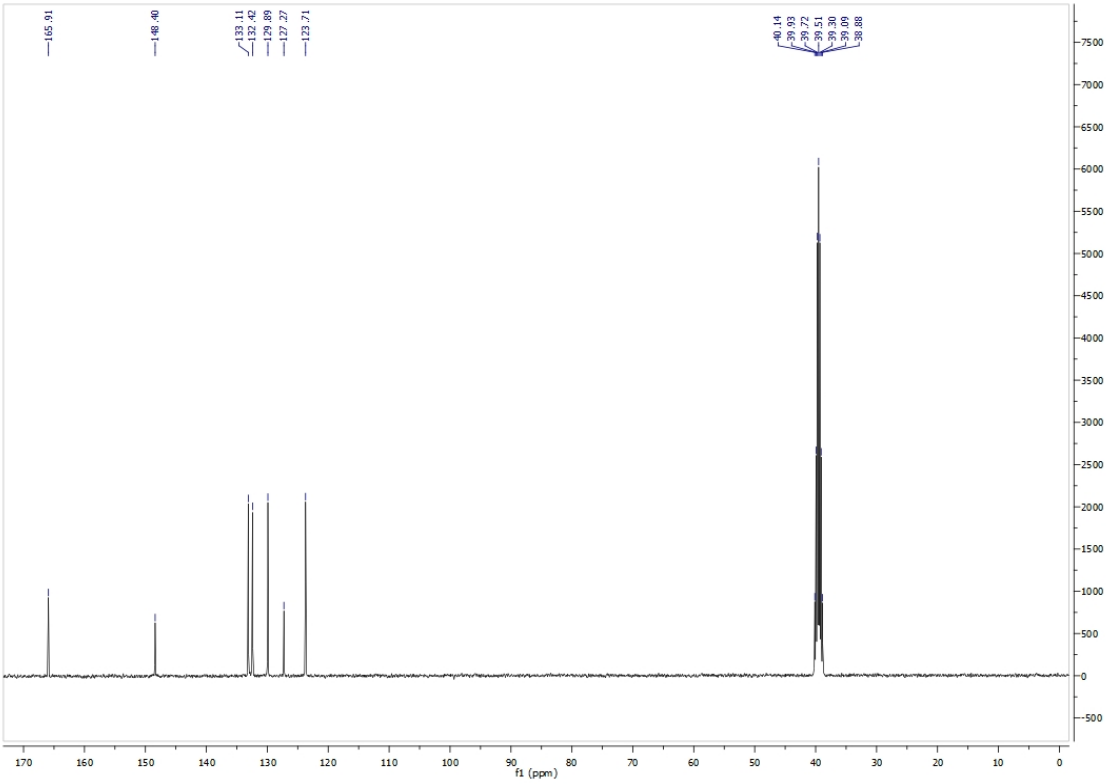
^{1}H-NMR spectrum of **3n** (300 MHz, DMSO)



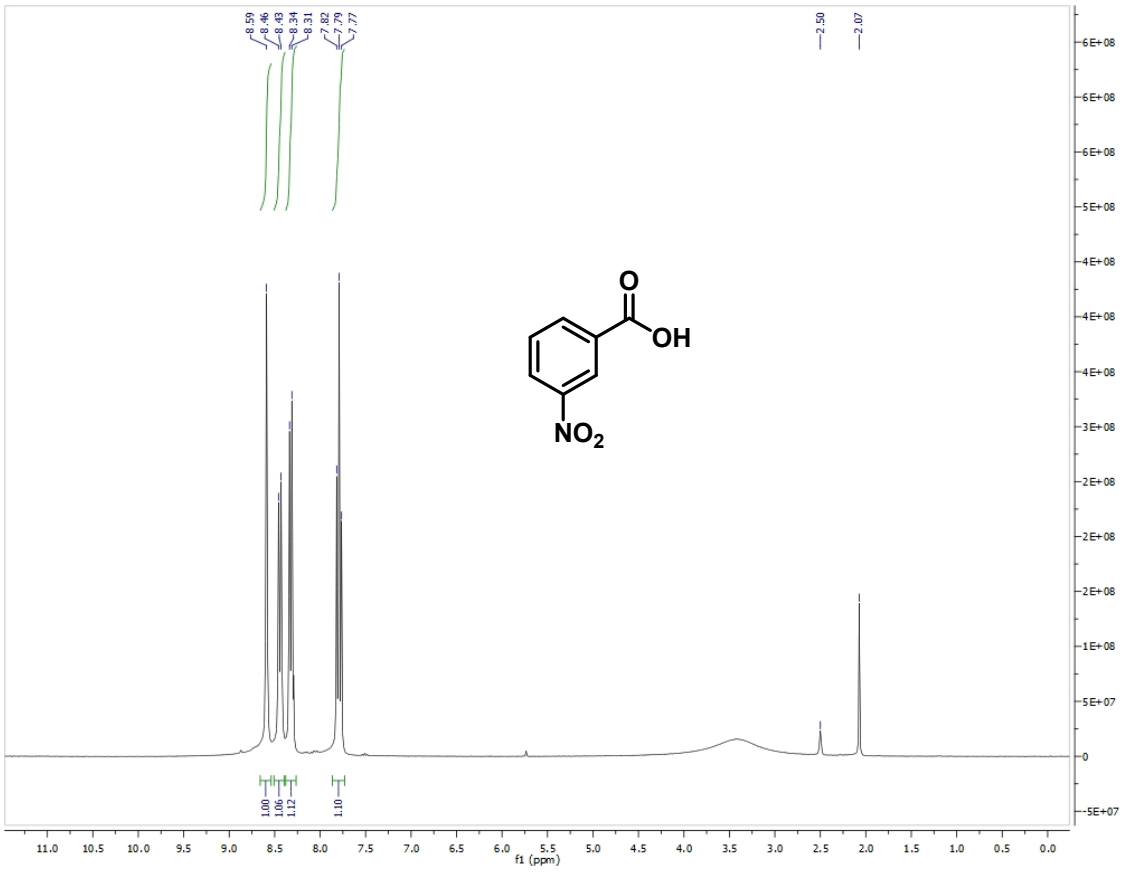
^{13}C -NMR spectrum of **3n** (300 MHz, $CDCl_{3+}$ DMSO)



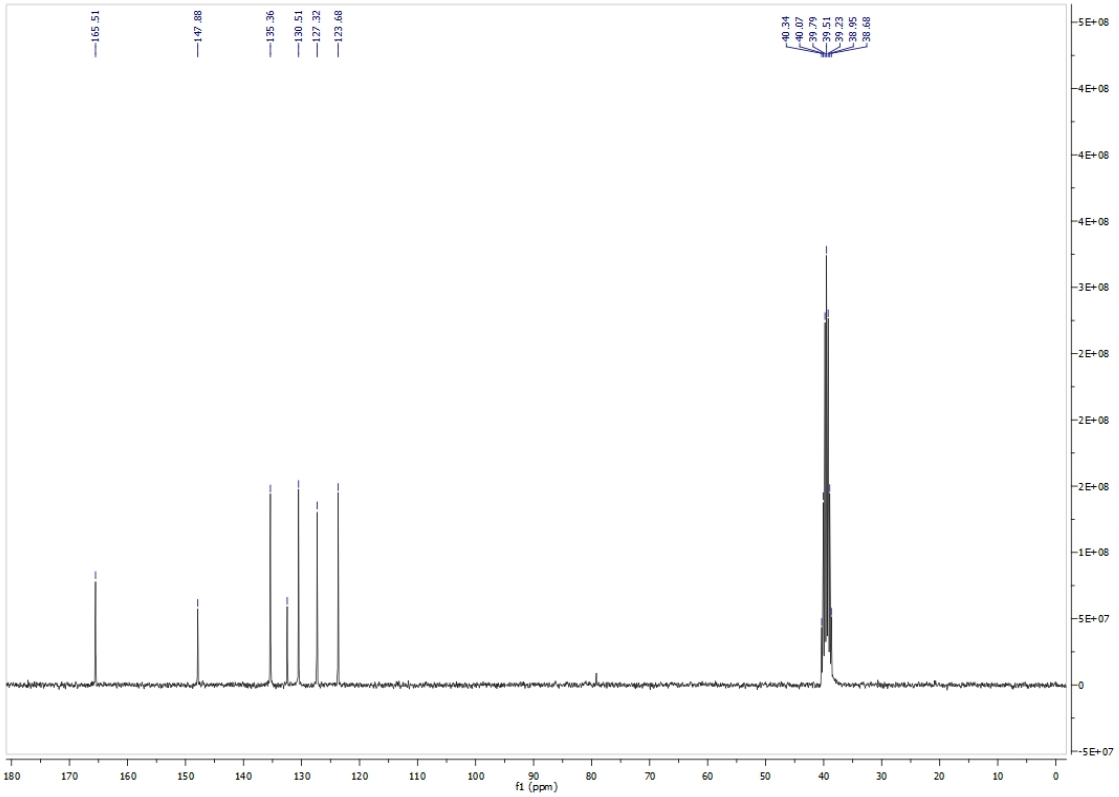
^{1}H-NMR spectrum of **3o** (300 MHz, DMSO)



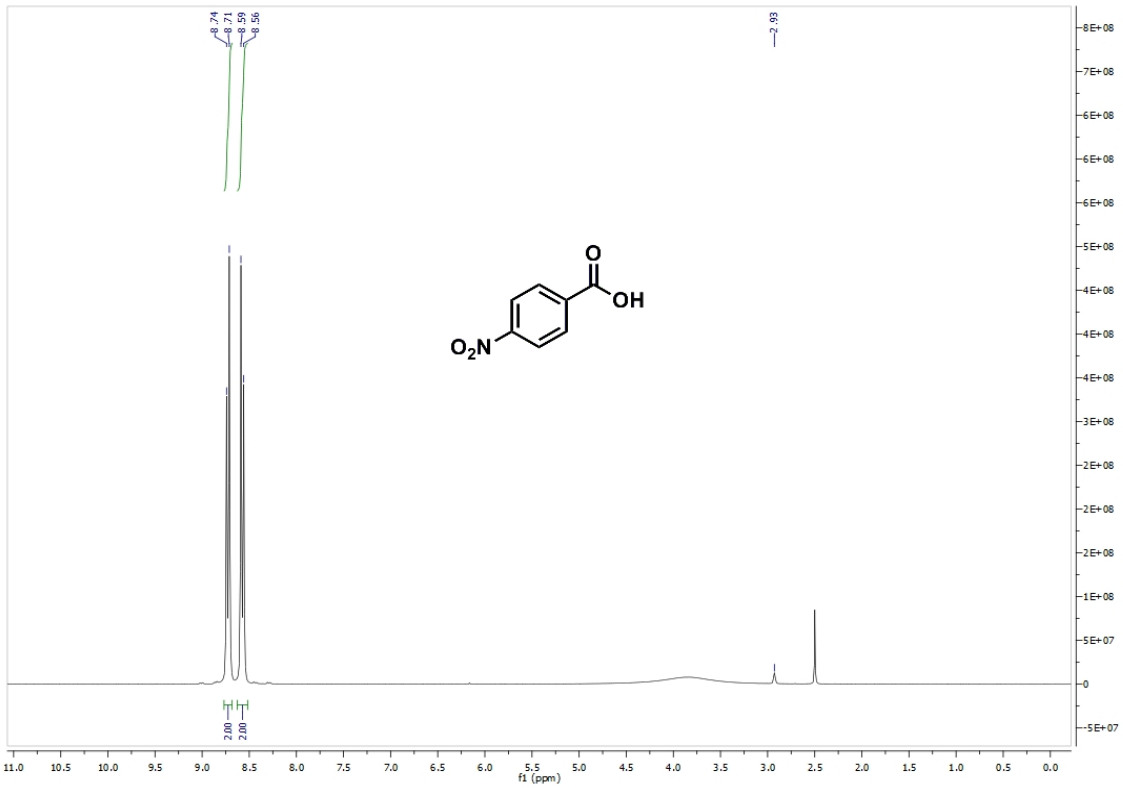
^{13}C -NMR spectrum of **3o** (300 MHz, DMSO)



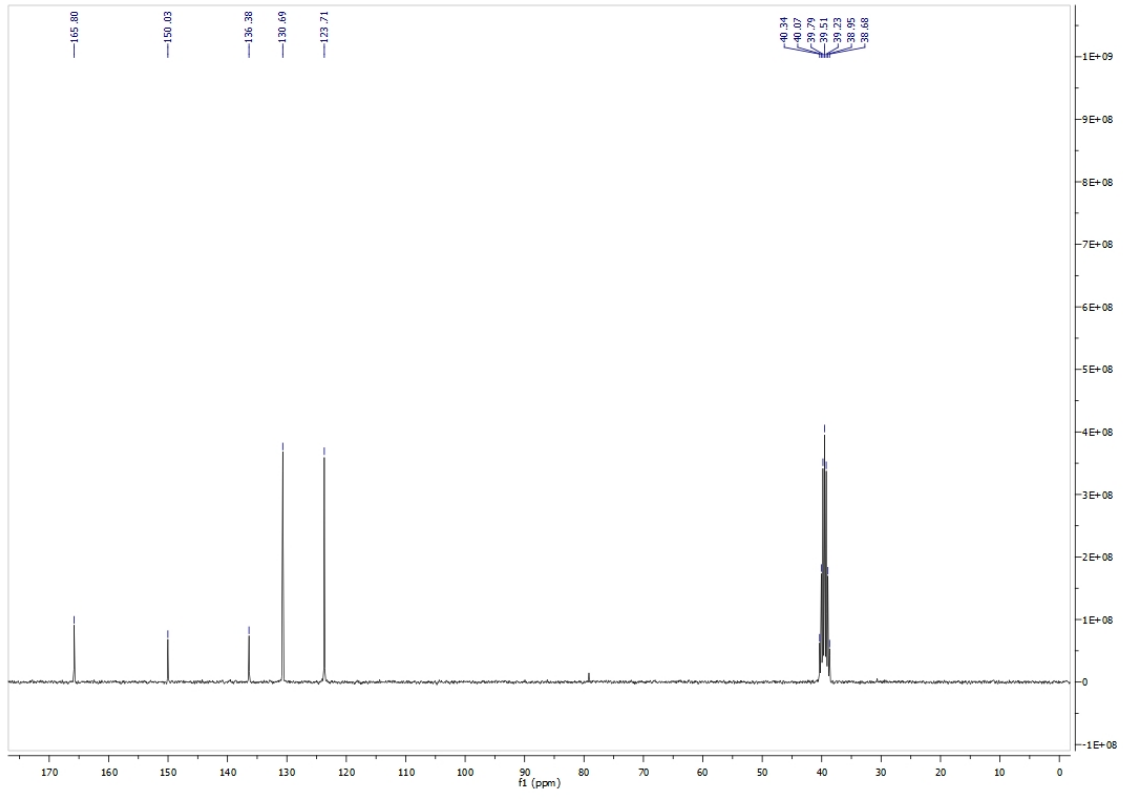
^{1}H-NMR spectrum of **3p** (300 MHz, DMSO)



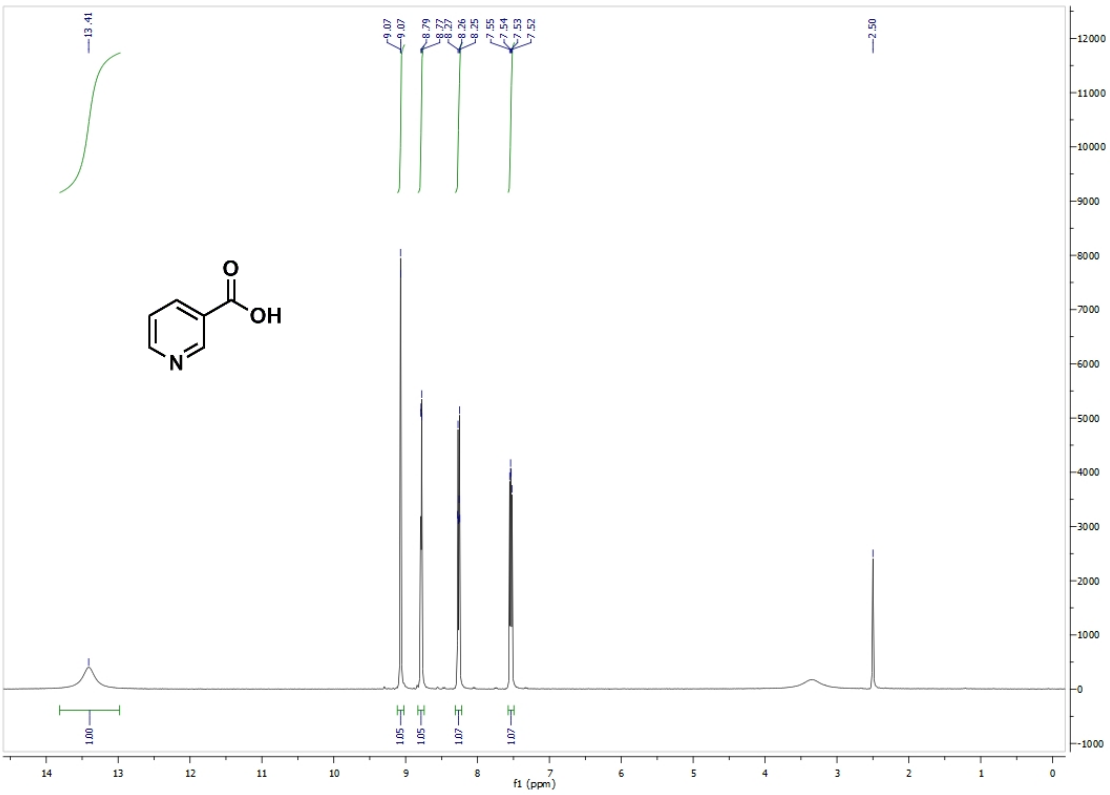
^{13}C -NMR spectrum of **3p** (300 MHz, DMSO)



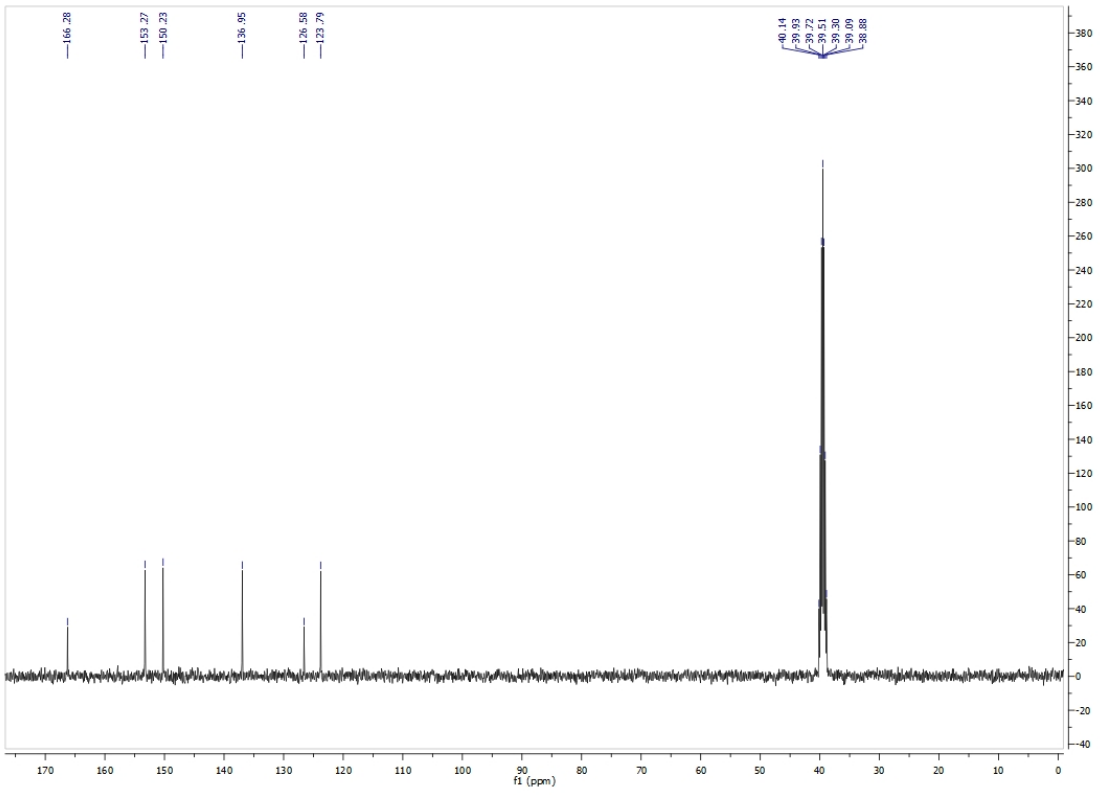
^{1}H-NMR spectrum of **3q** (300 MHz, DMSO)



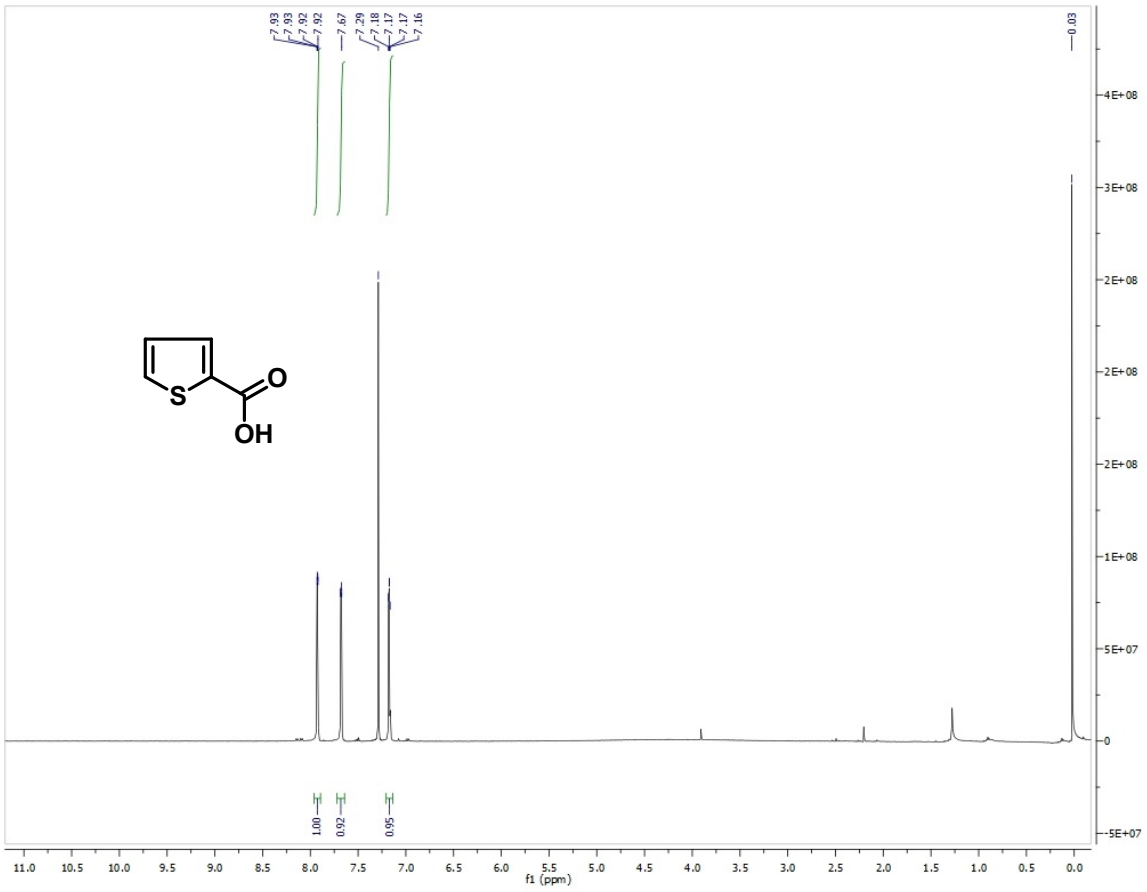
^{13}C -NMR spectrum of **3q** (300 MHz, DMSO)



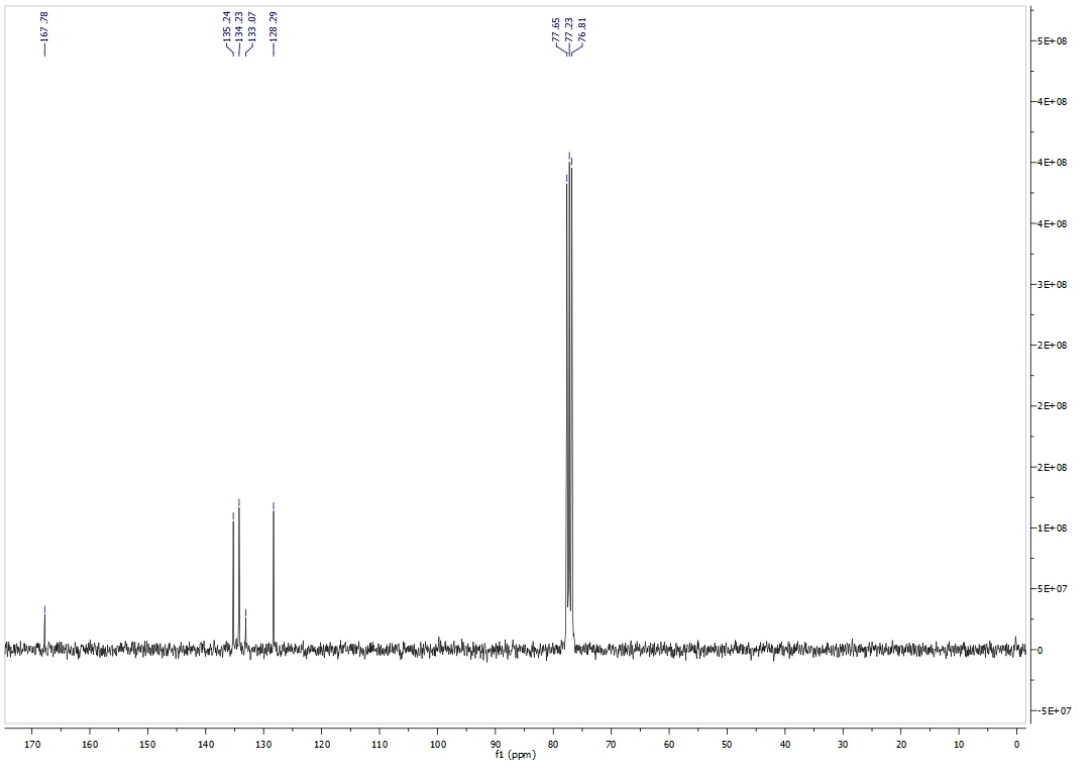
^{1}H-NMR spectrum of **3r** (300 MHz, DMSO)



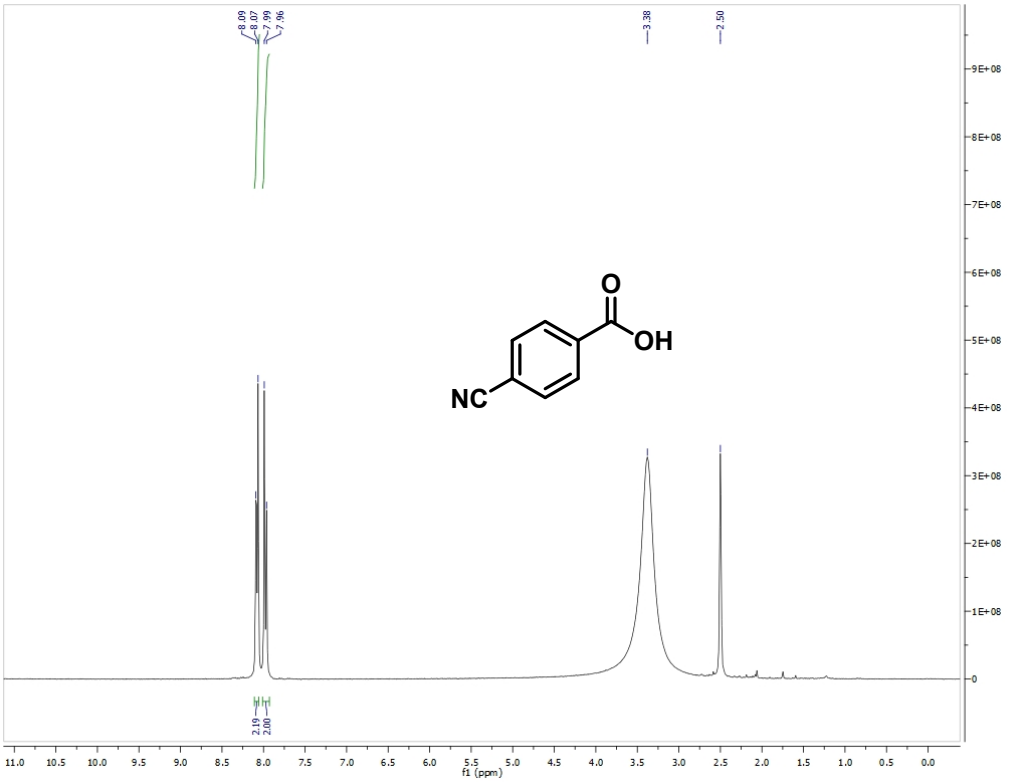
^{13}C -NMR spectrum of **3r** (300 MHz, DMSO)



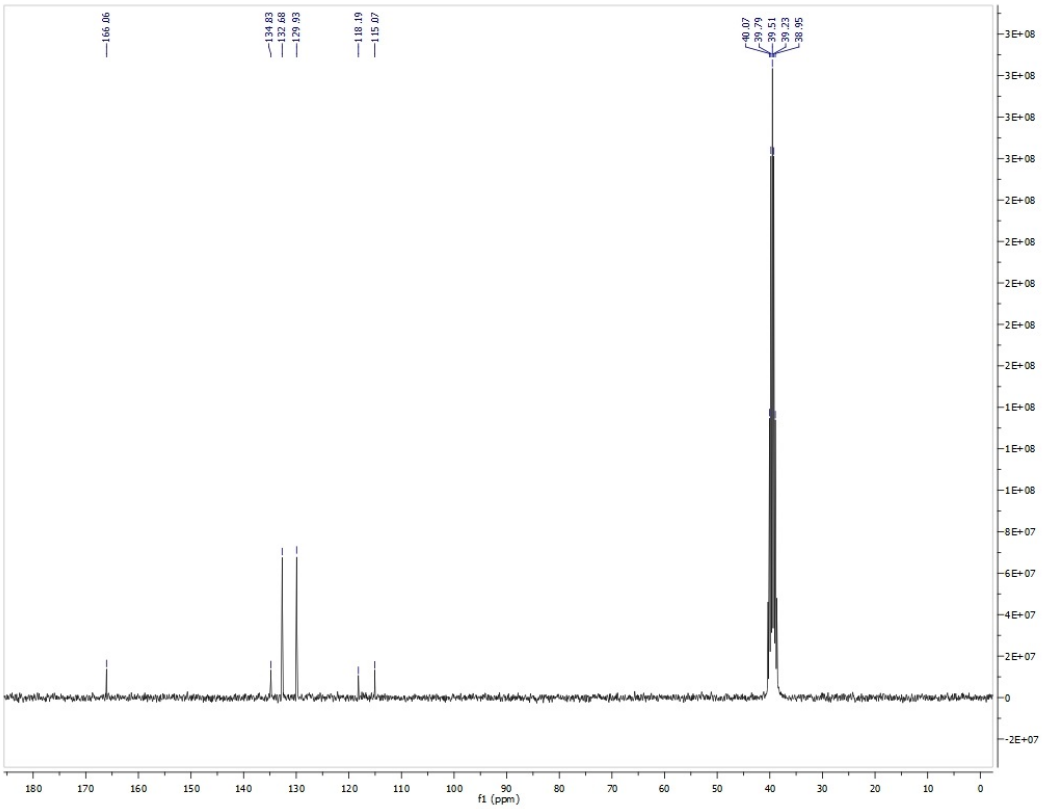
^{1}H-NMR spectrum of **3s** (300 MHz, $CDCl_3$)



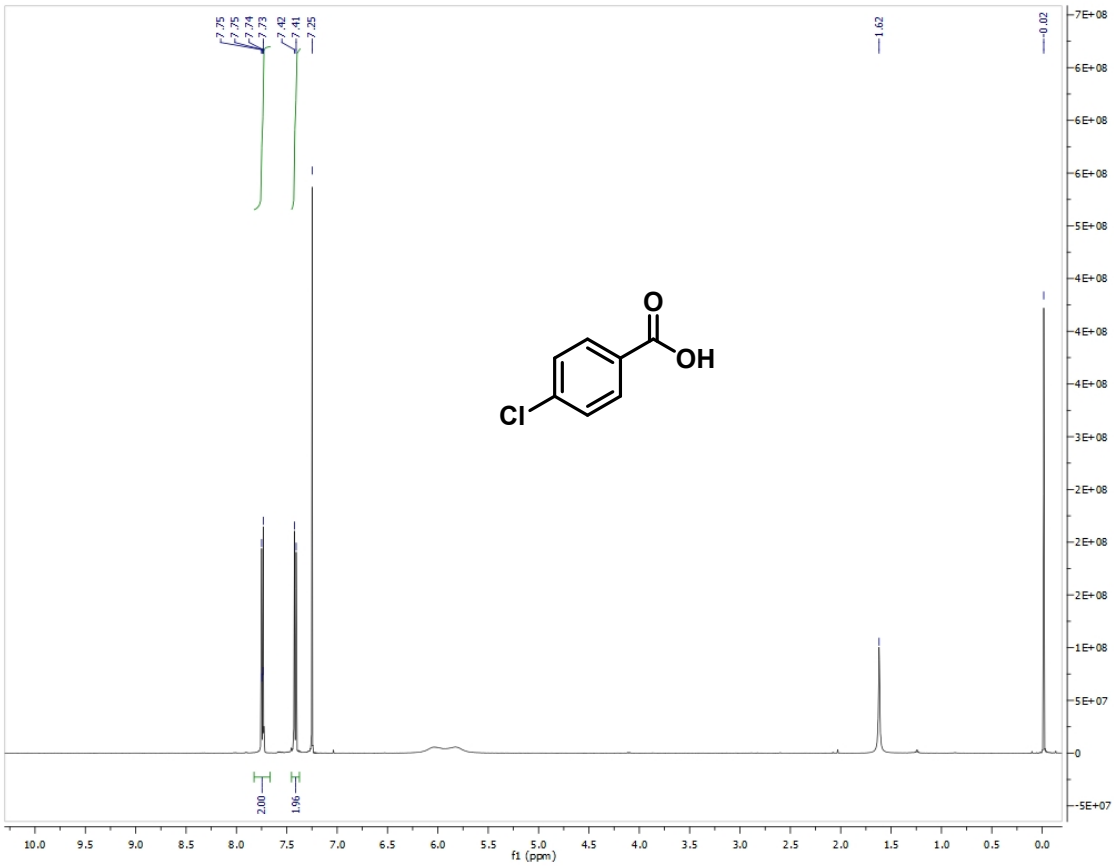
^{13}C -NMR spectrum of **3s** (300 MHz, $CDCl_3$)



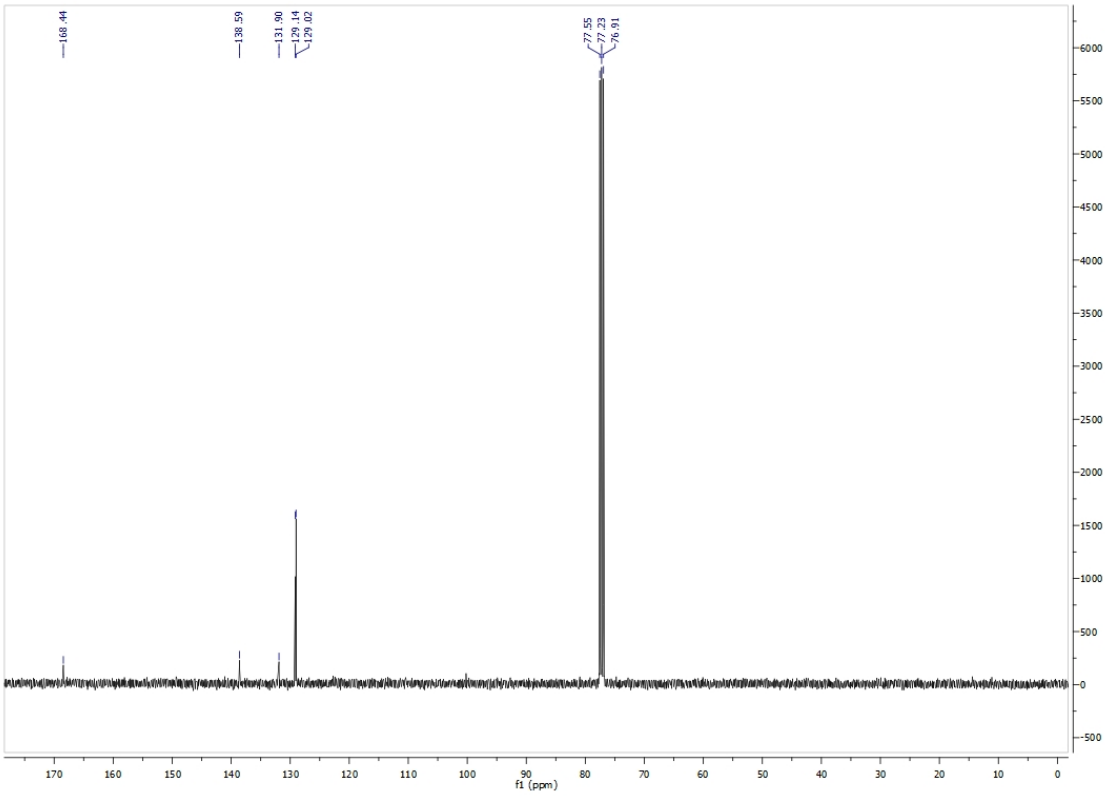
^{1}H-NMR spectrum of **3t** (300 MHz, DMSO)



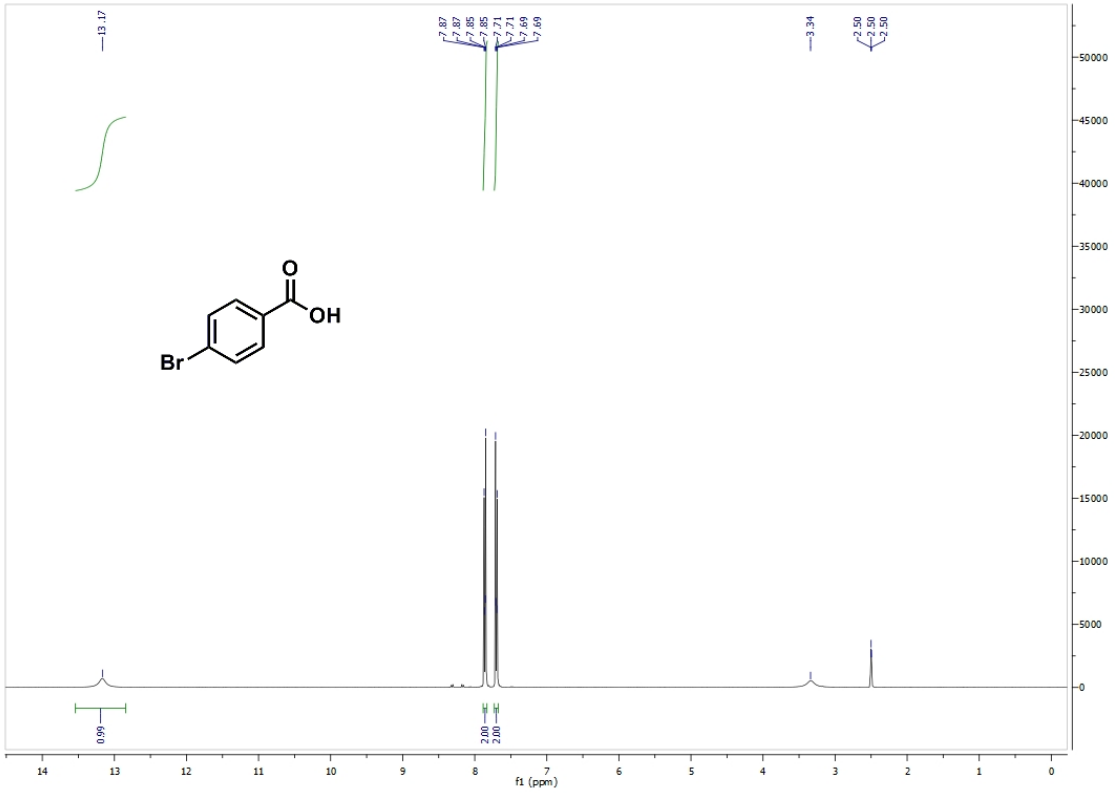
^{13}C -NMR spectrum of **3t** (300 MHz, DMSO)



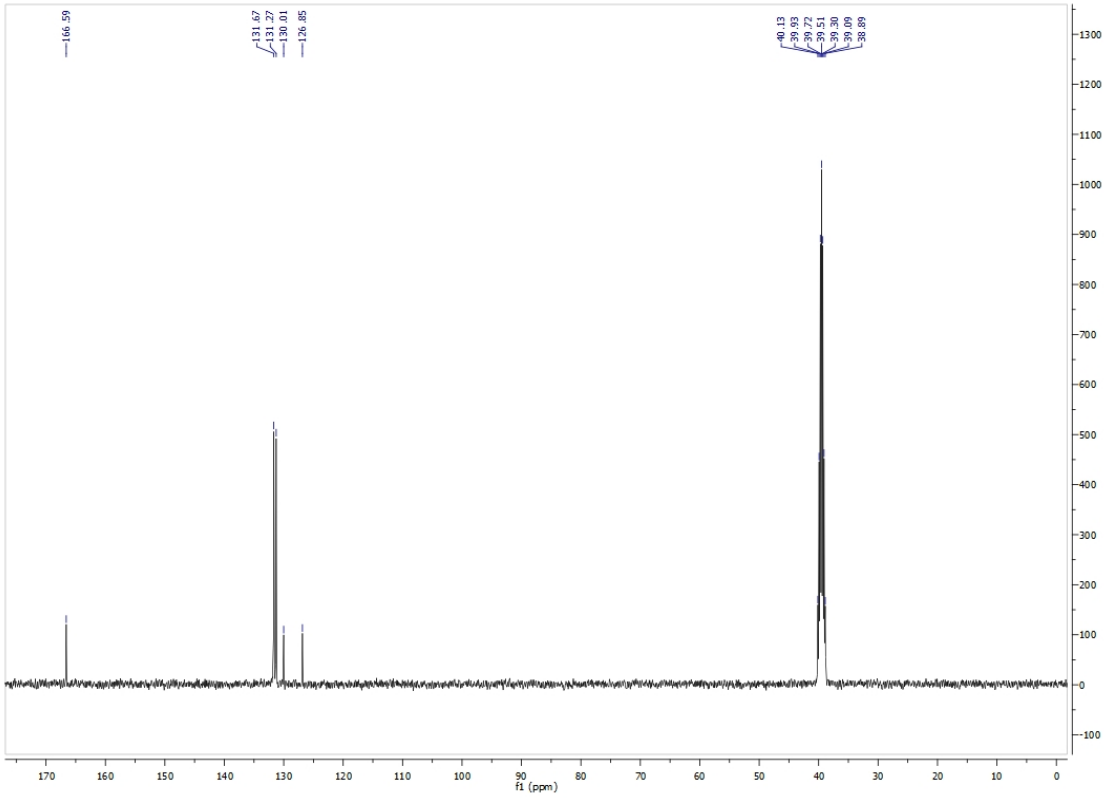
^{1}H-NMR spectrum of **3u** (300 MHz, $CDCl_3$)



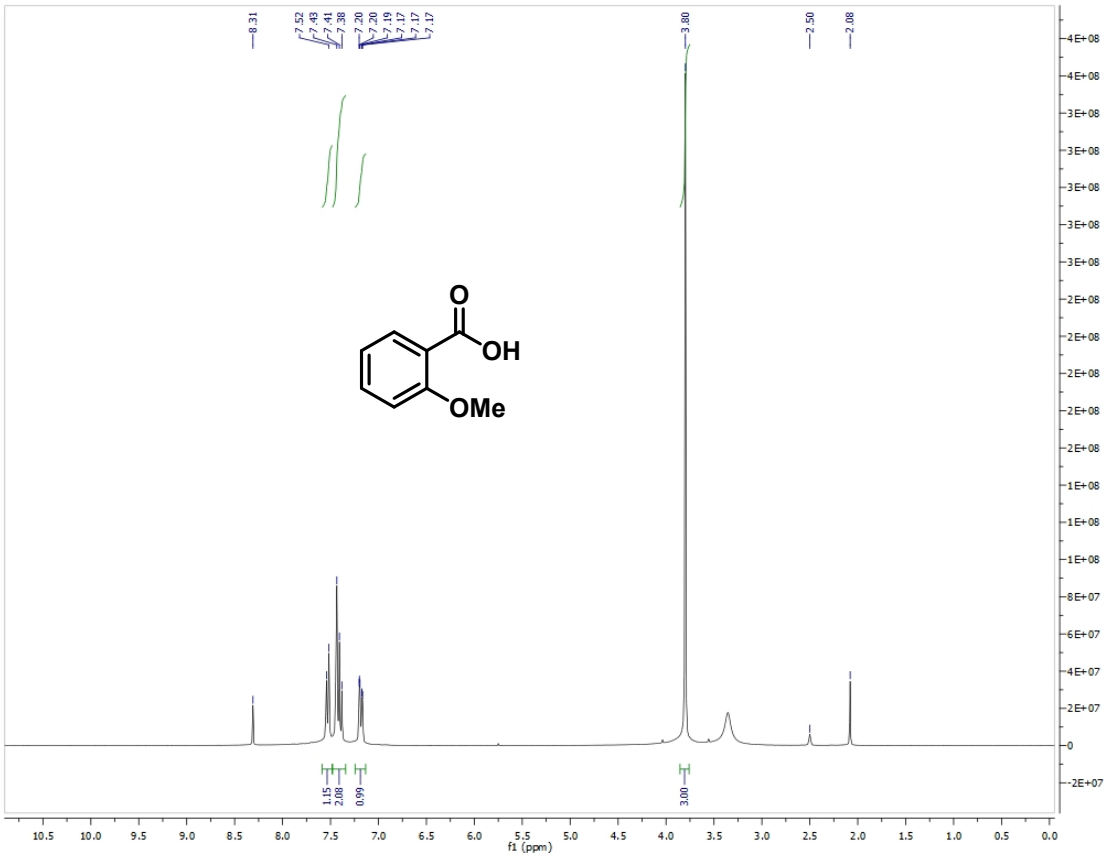
^{13}C -NMR spectrum of **3u** (300 MHz, $CDCl_3$)



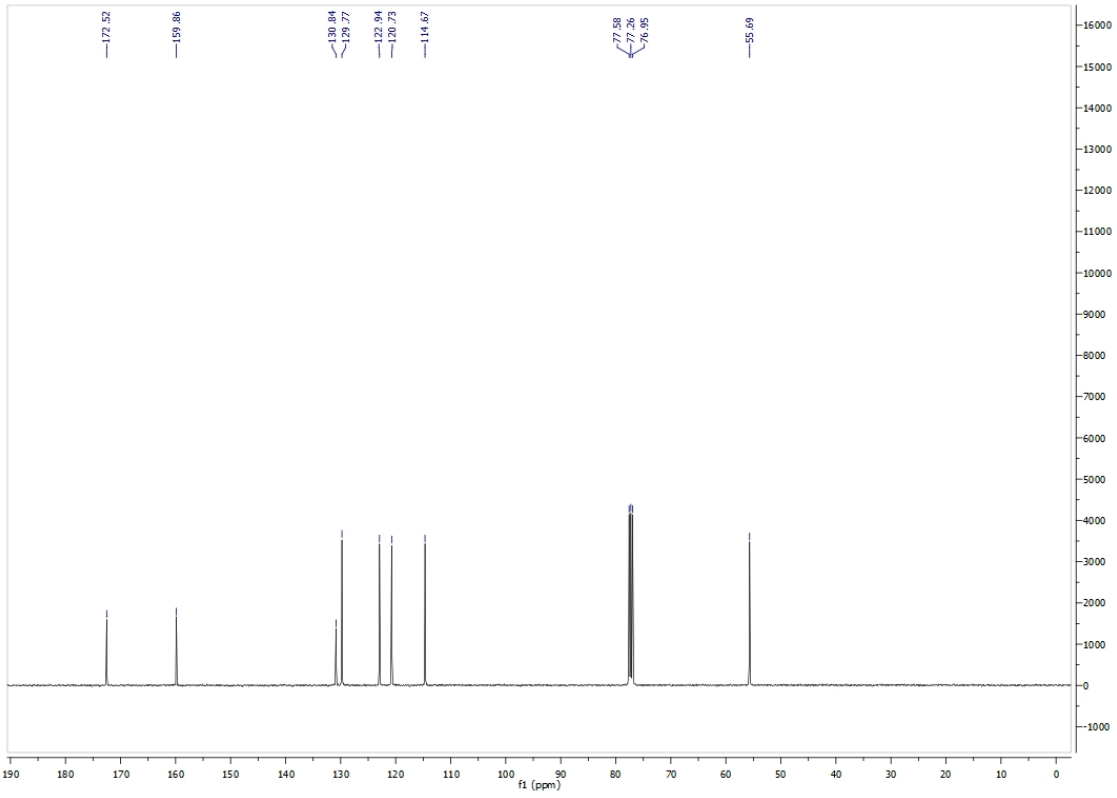
^{1}H-NMR spectrum of **3v** (300 MHz, DMSO)



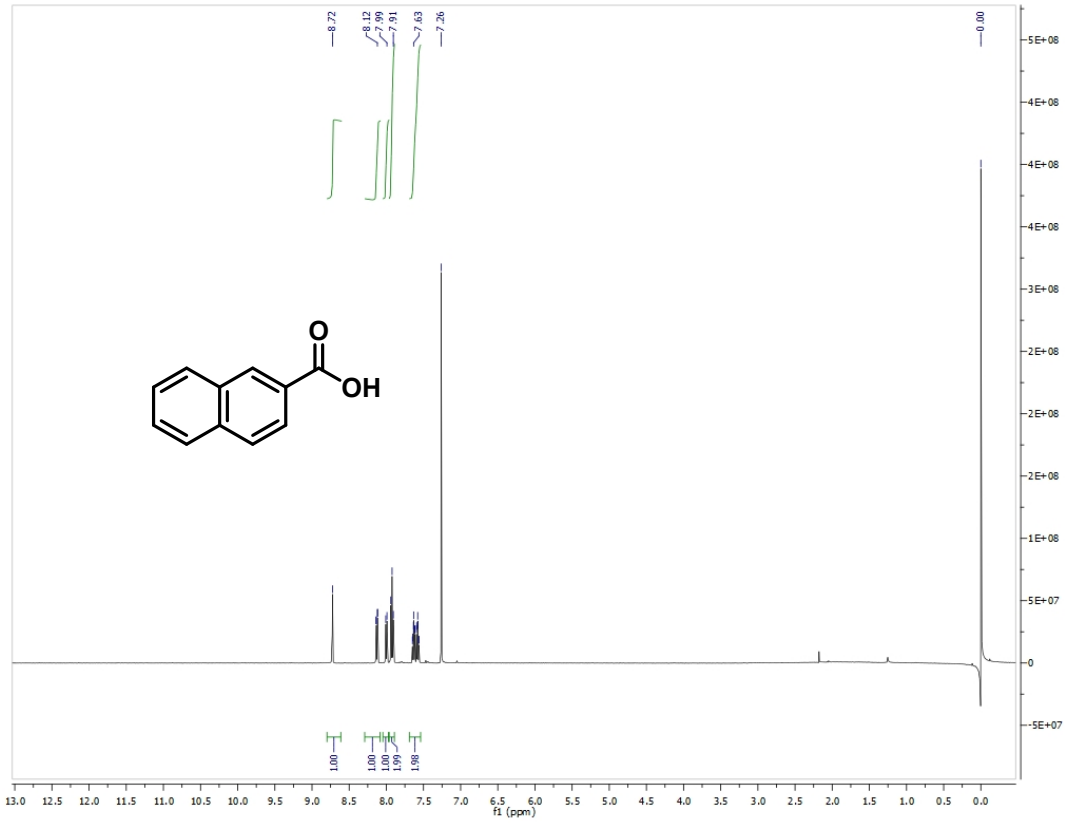
^{13}C -NMR spectrum of **3v** (300 MHz, DMSO)



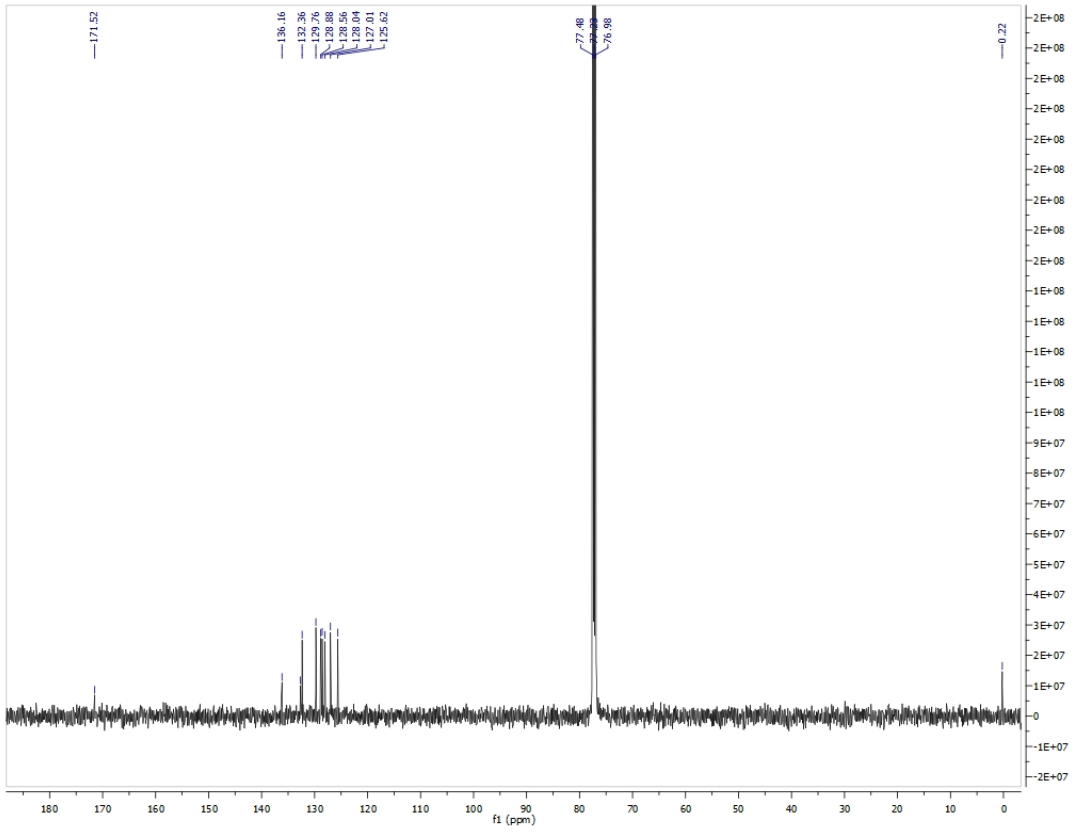
^{1}H-NMR spectrum of **3w** (300 MHz, $CDCl_3$)



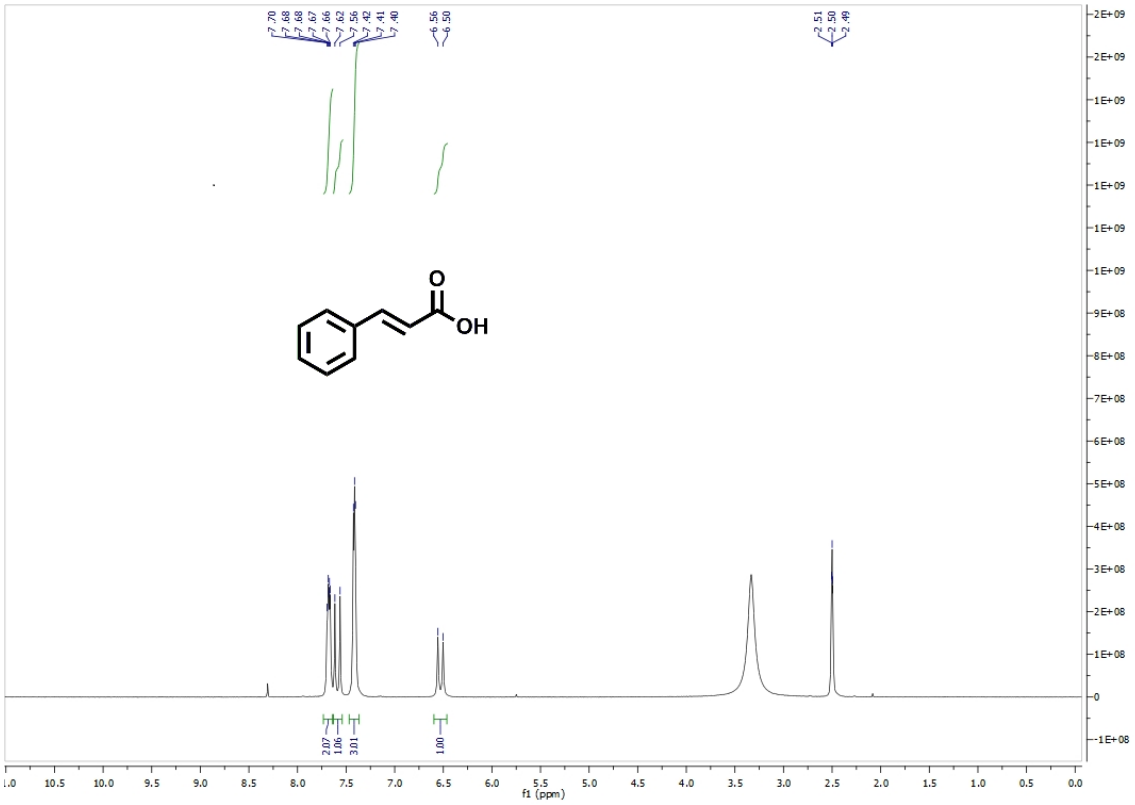
^{13}C -NMR spectrum of **3w** (300 MHz, $CDCl_3$)



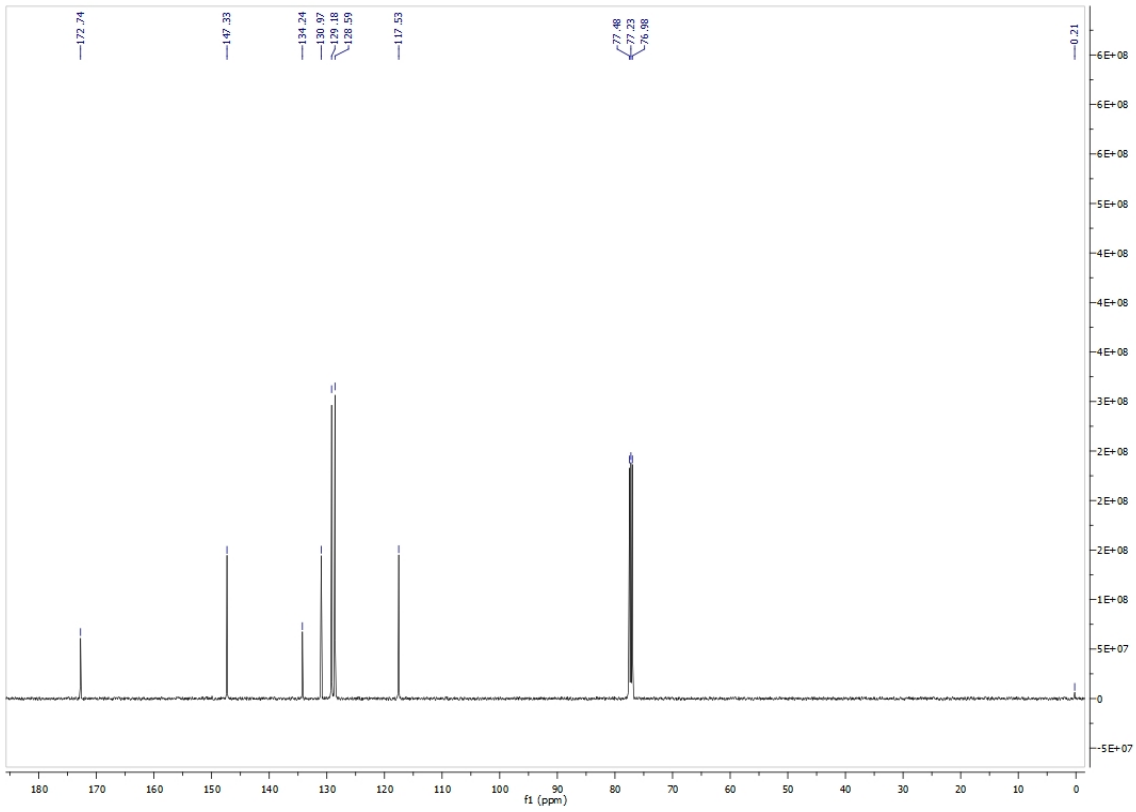
^{1}H-NMR spectrum of **3x** (300 MHz, $CDCl_3$)



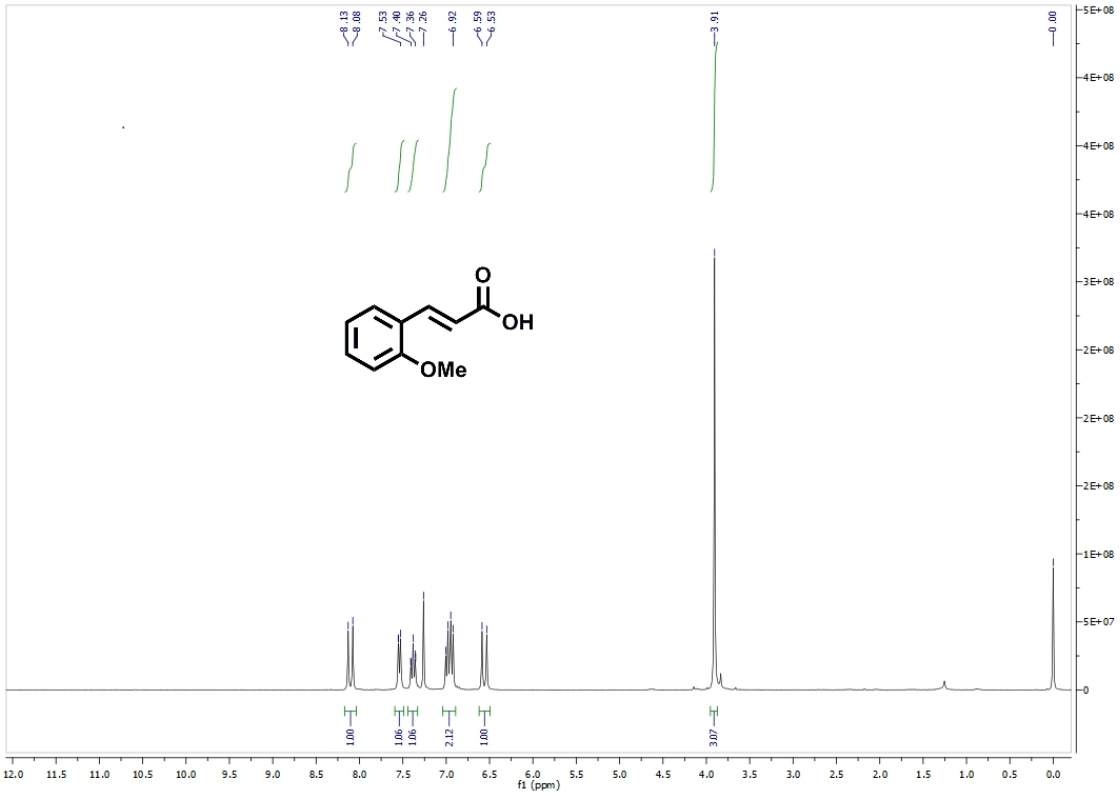
^{13}C -NMR spectrum of **3x** (300 MHz, $CDCl_3$)



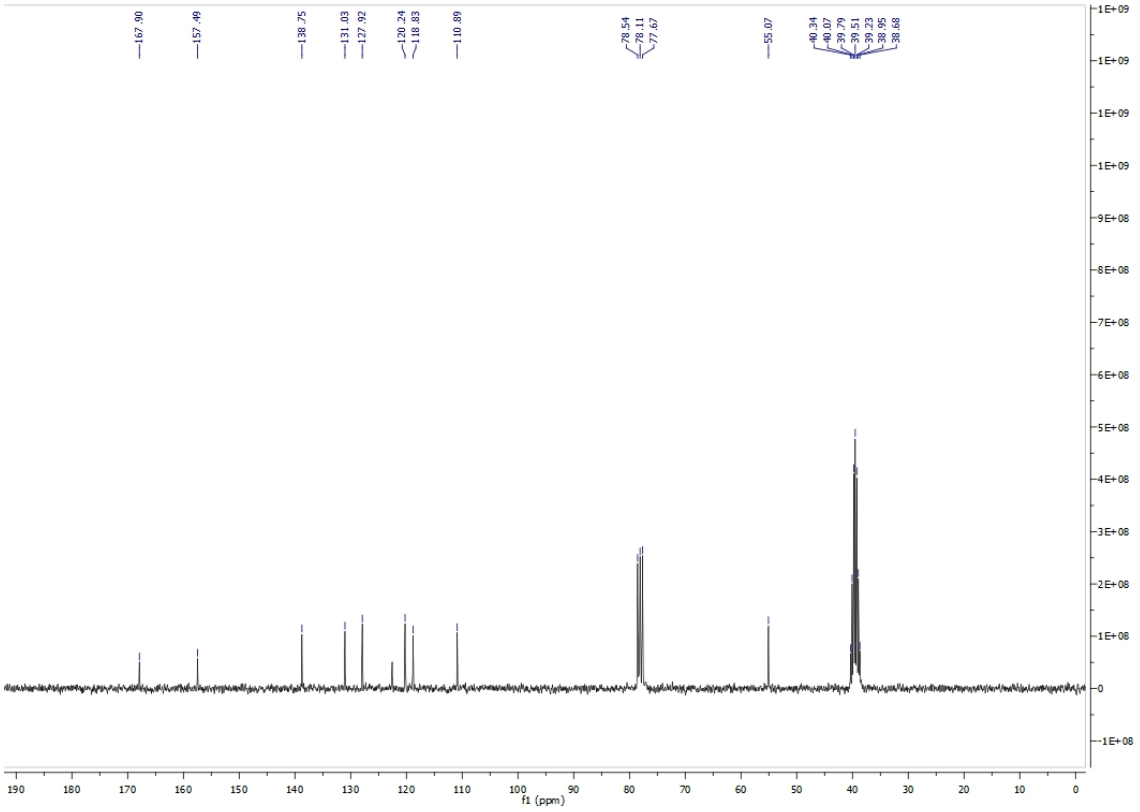
^{1}H-NMR spectrum of **7a** (300 MHz, DMSO)



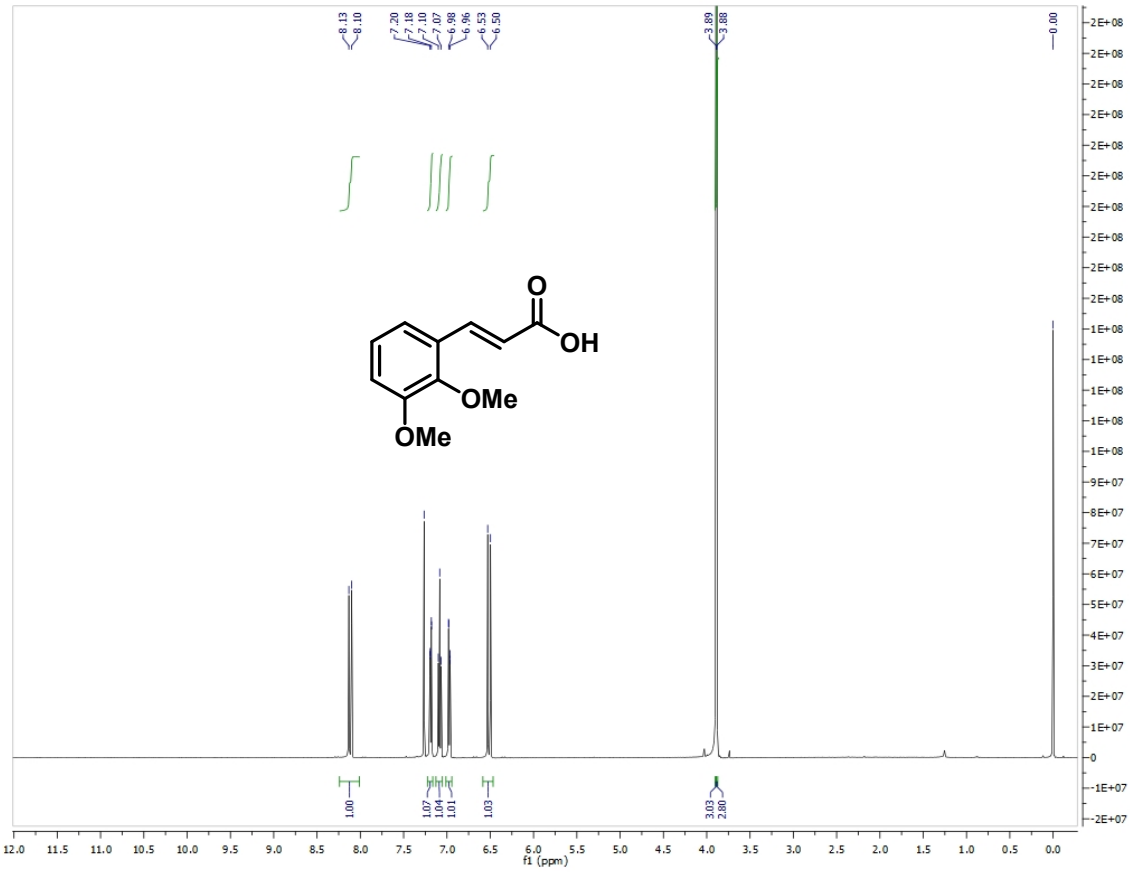
^{13}C -NMR spectrum of **7a** (300 MHz, $CDCl_3$)



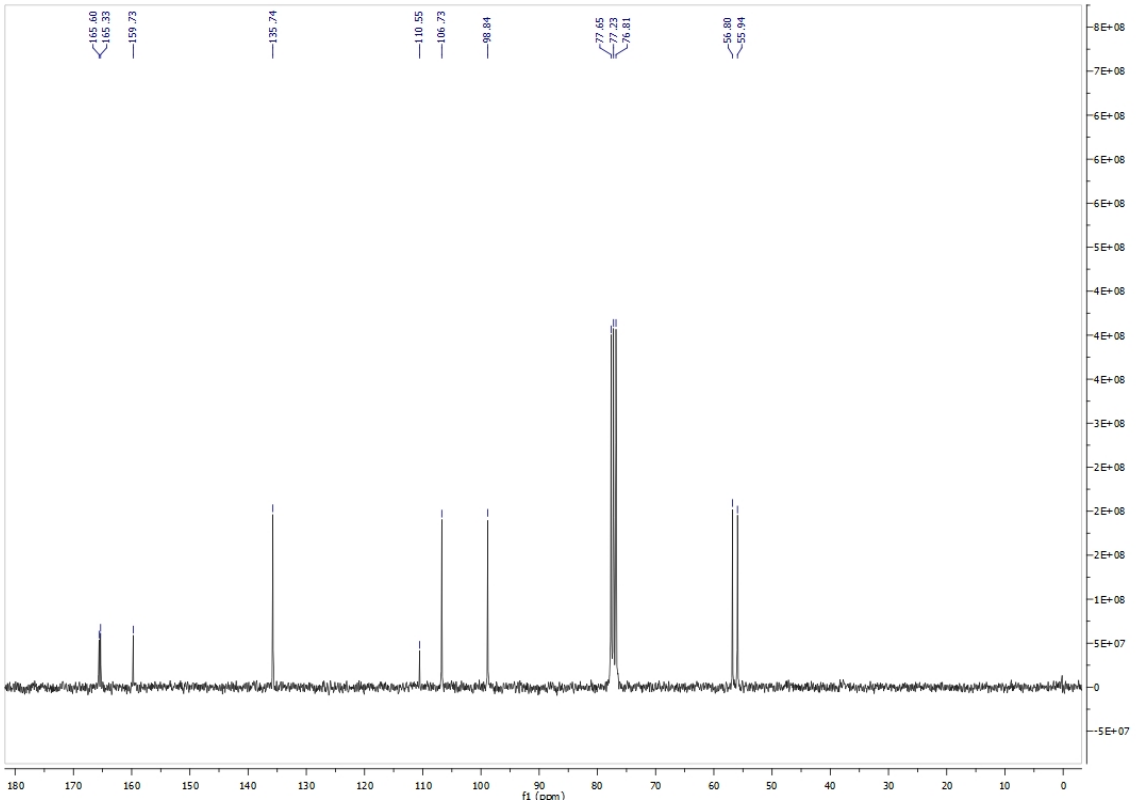
^{1}H-NMR spectrum of **7b** (300 MHz, $CDCl_3$)



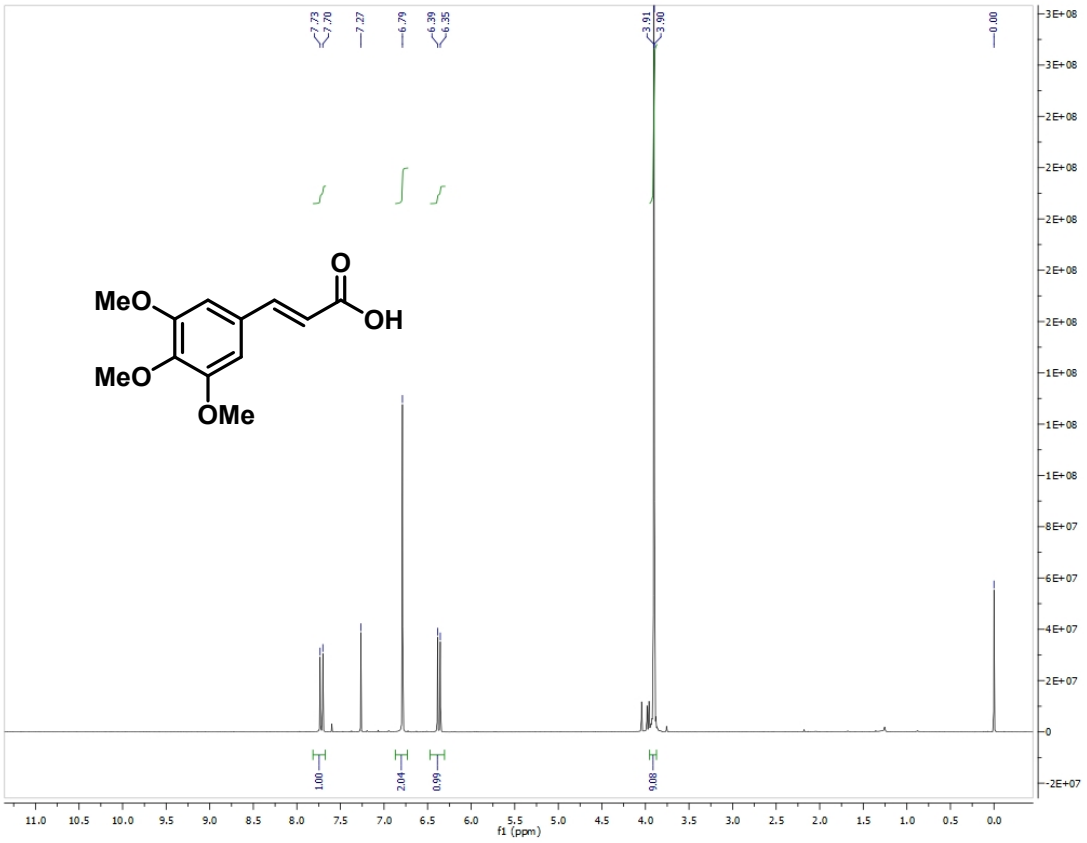
^{13}C -NMR spectrum of **7b** (300 MHz, $CDCl_{3+}$ DMSO)



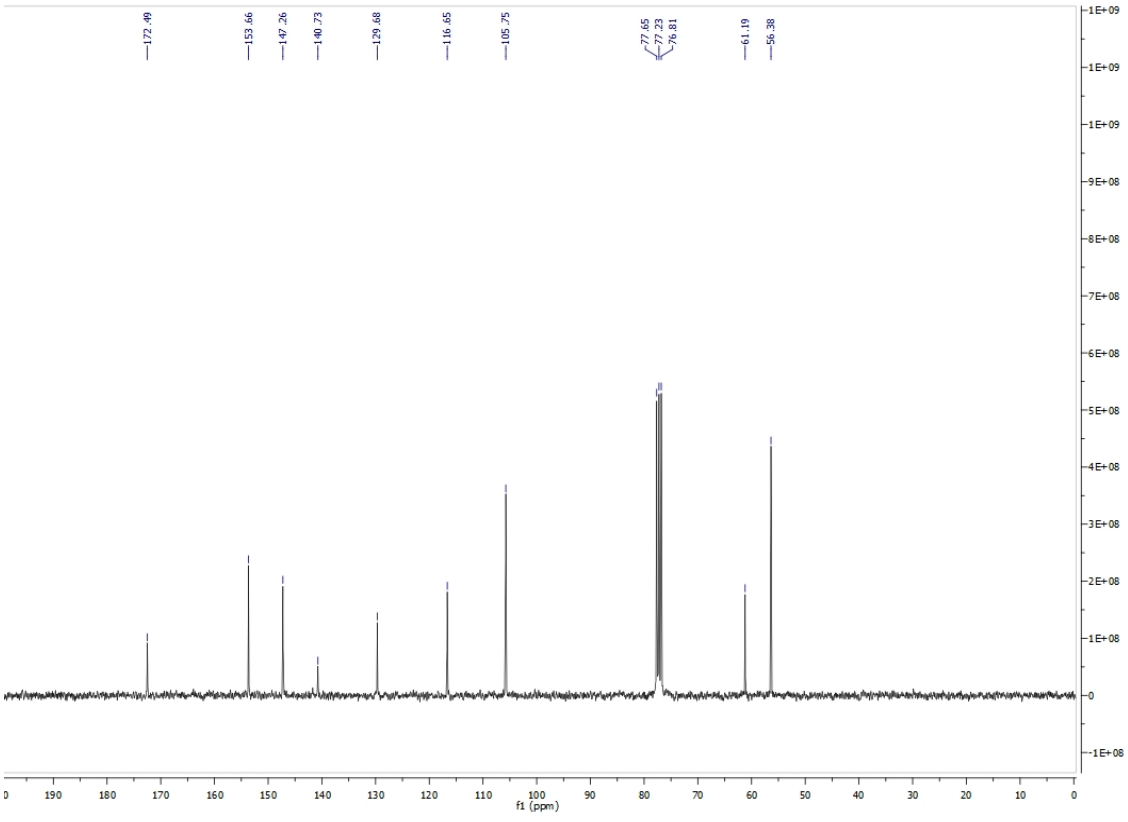
^{1}H-NMR spectrum of **7c** (300 MHz, $CDCl_3$)



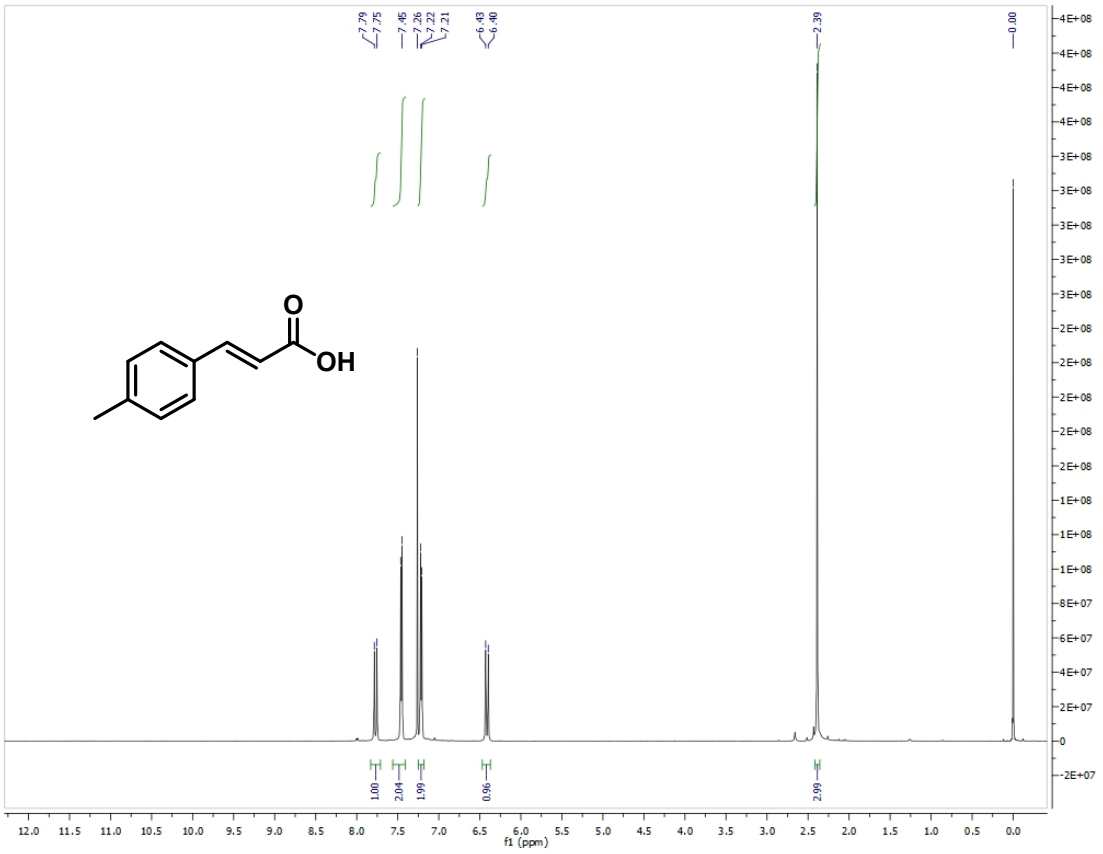
^{13}C -NMR spectrum of **7c** (300 MHz, $CDCl_3$)



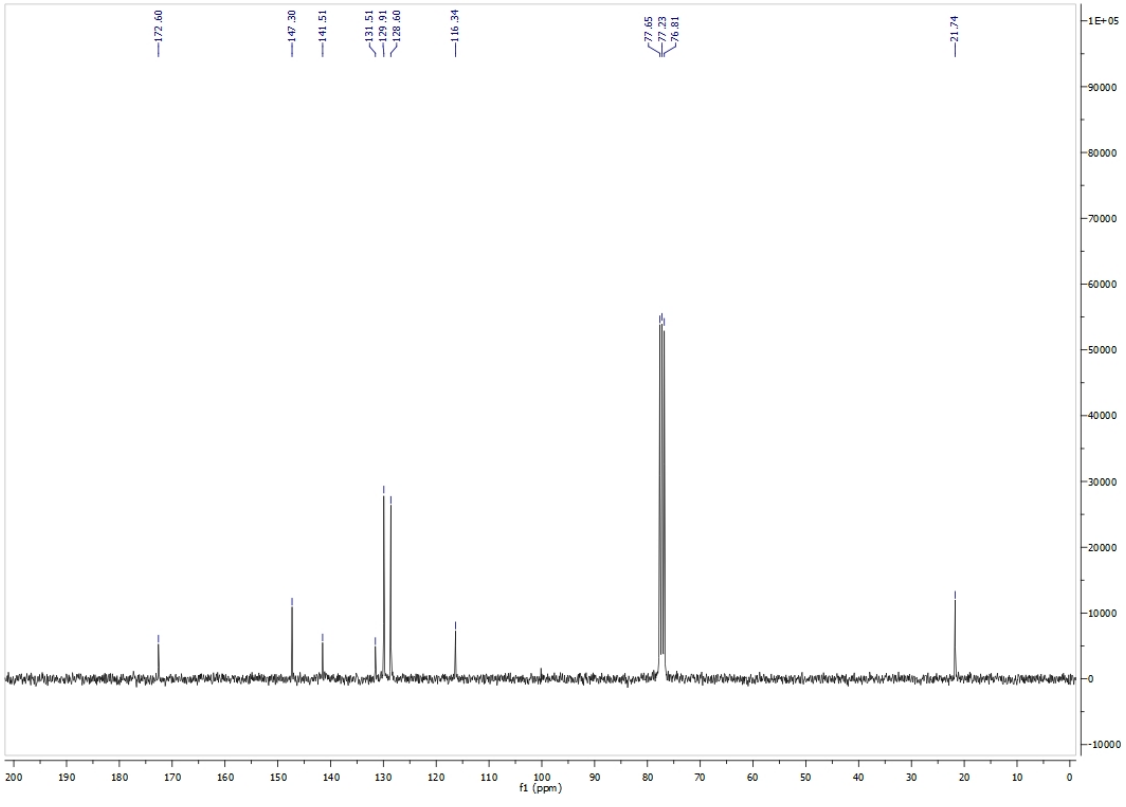
^{1}H-NMR spectrum of **7d** (300 MHz, $CDCl_3$)



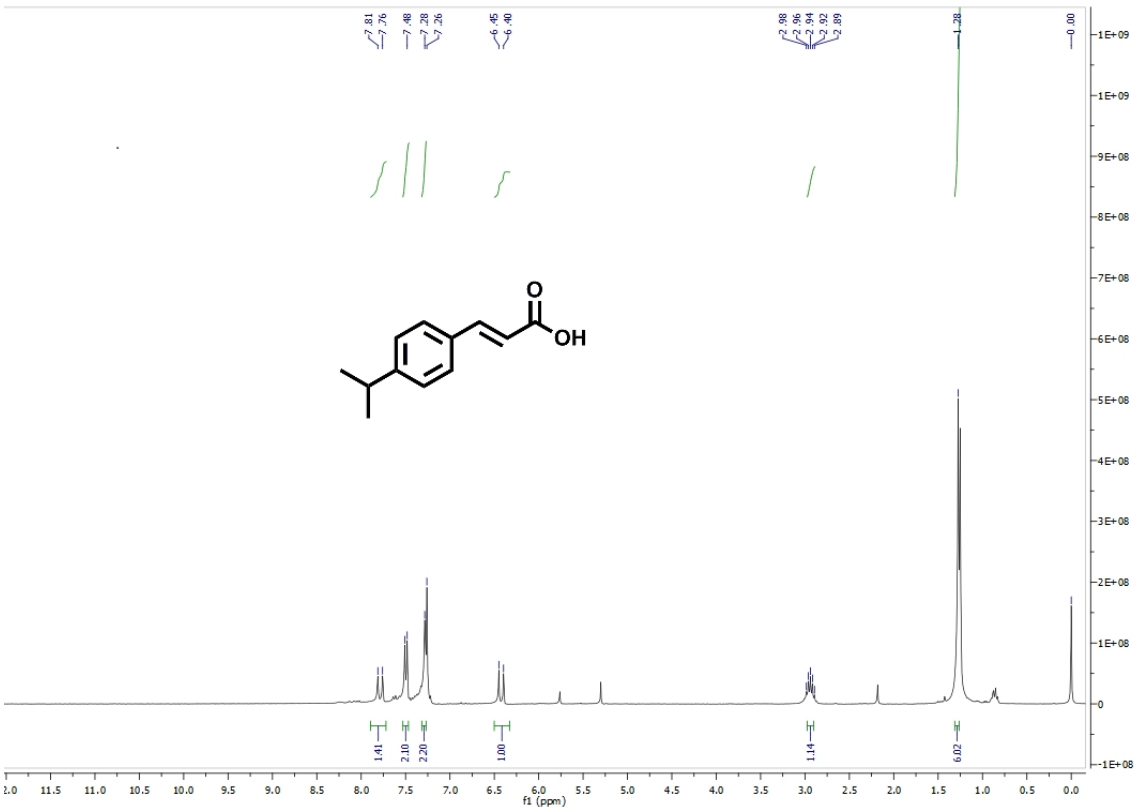
^{13}C -NMR spectrum of **7d** (300 MHz, $CDCl_3$)



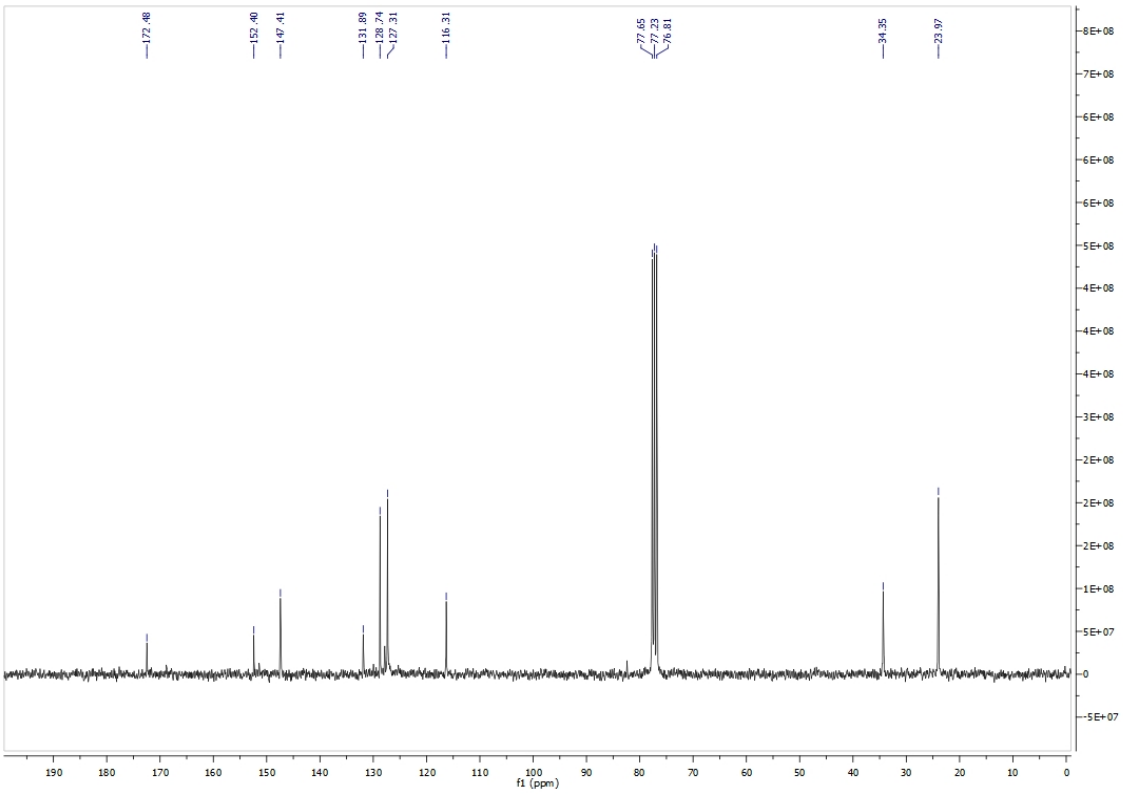
^{1}H-NMR spectrum of **7e** (300 MHz, $CDCl_3$)



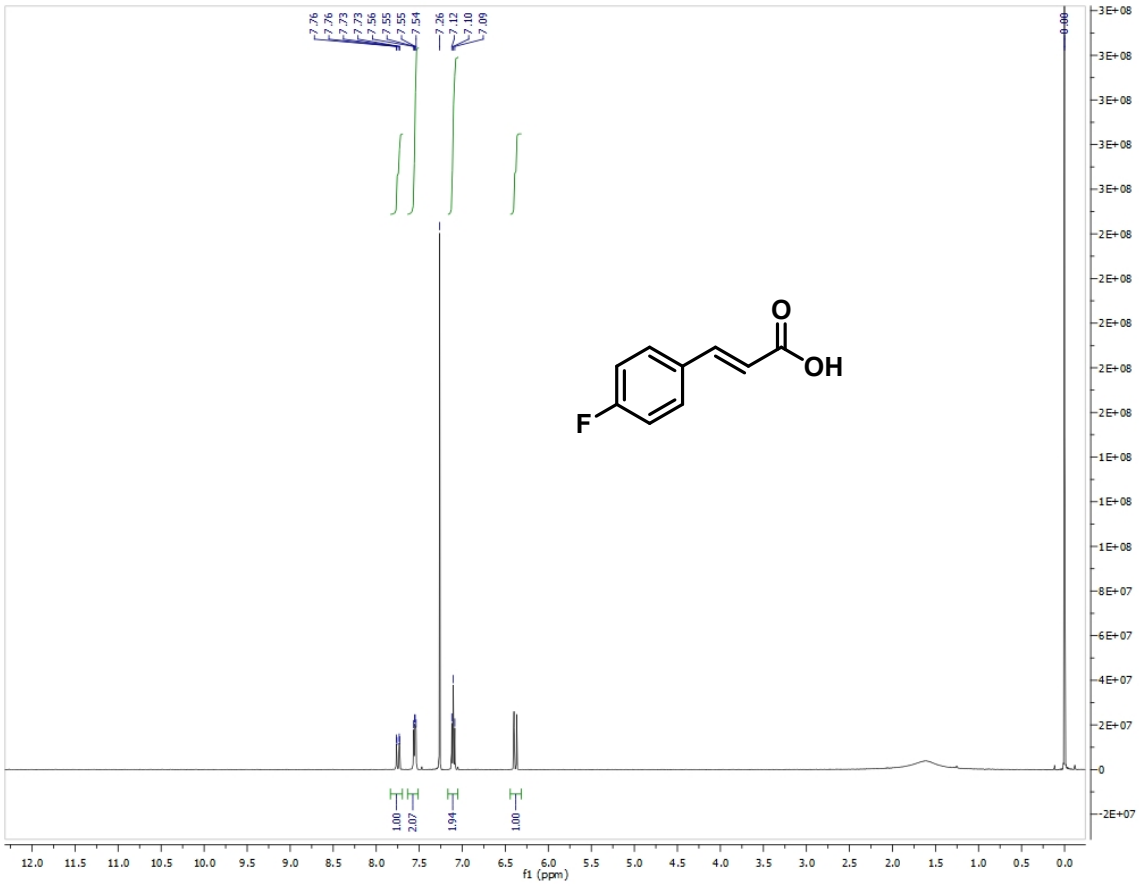
^{13}C -NMR spectrum of **7e** (300 MHz, $CDCl_3$)



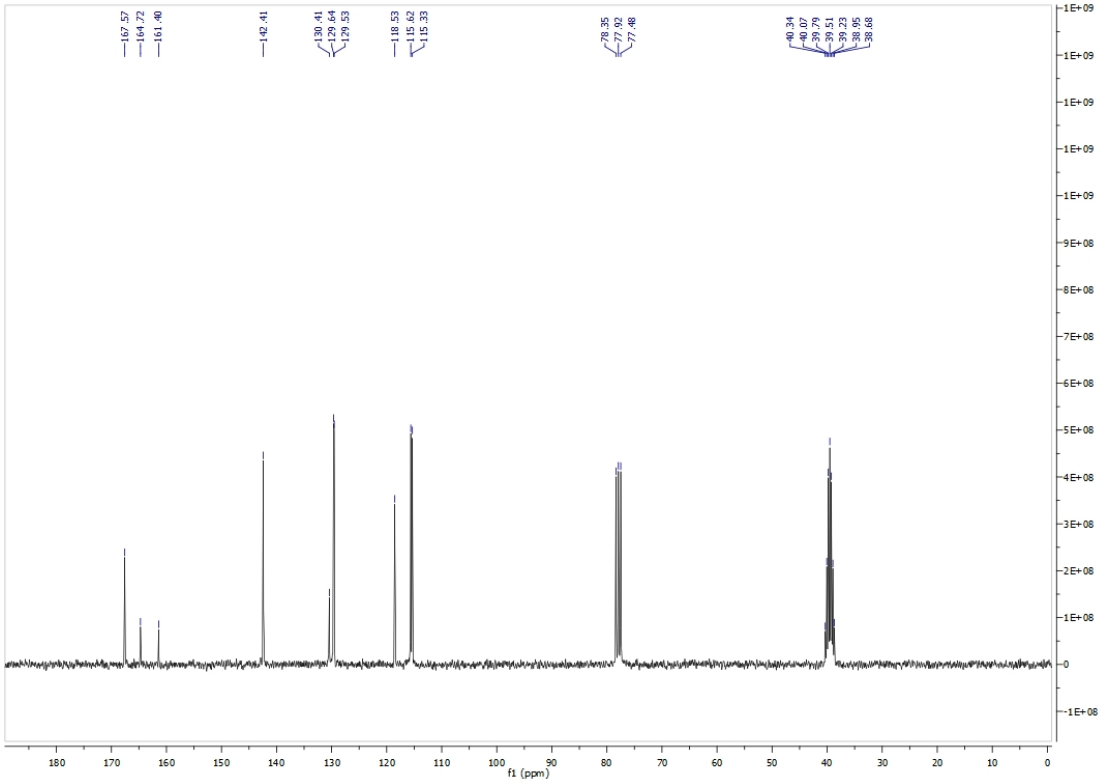
^{1}H-NMR spectrum of **7f** (300 MHz, $CDCl_3$)



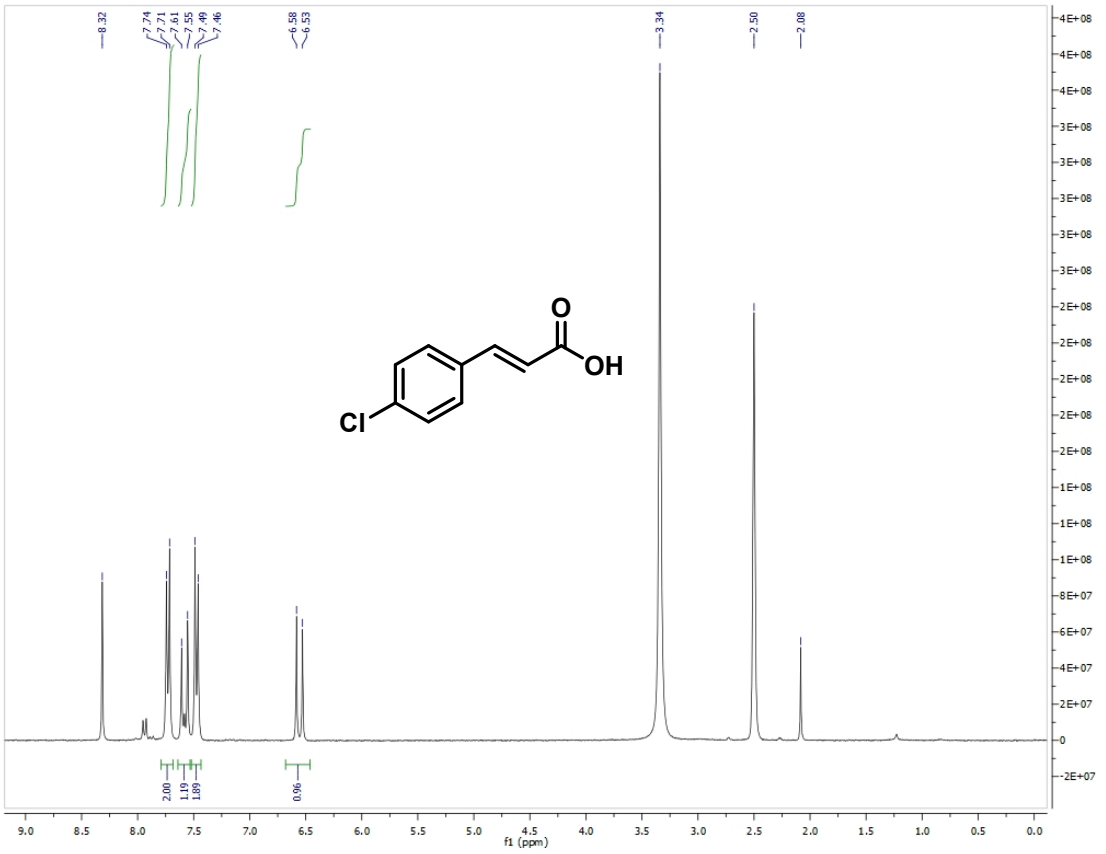
^{13}C -NMR spectrum of **7f** (300 MHz, $CDCl_3$)



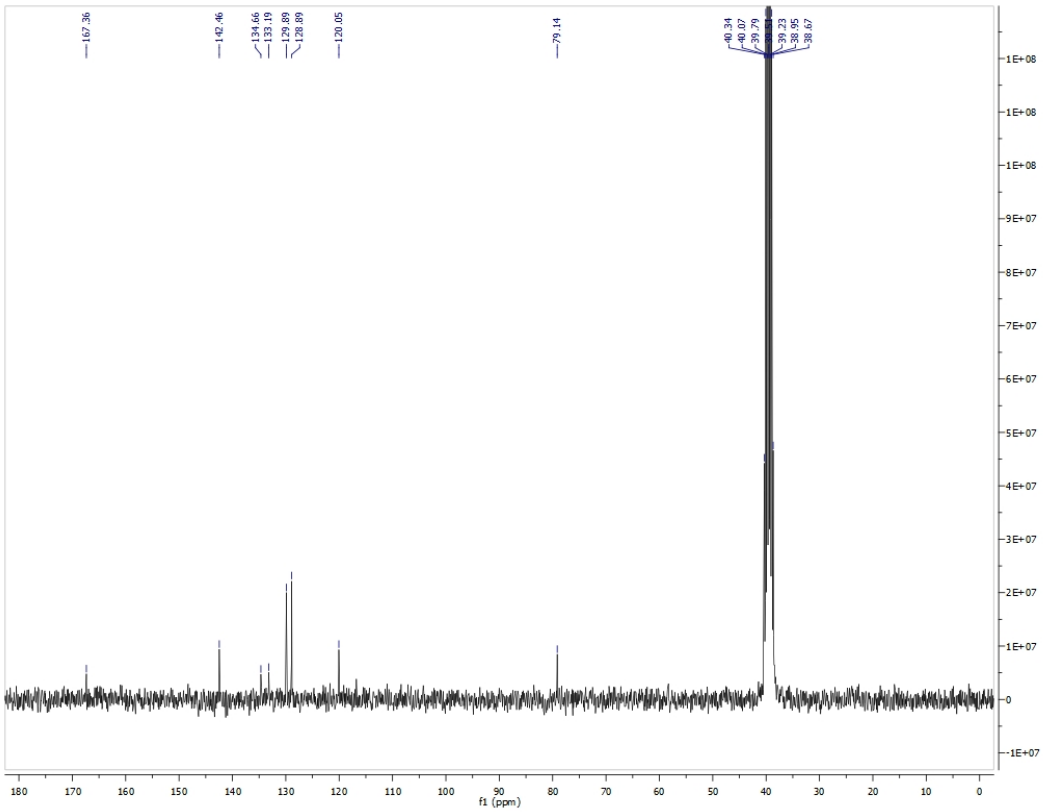
^{1}H-NMR spectrum of **7g** (300 MHz, $CDCl_3$)



^{13}C -NMR spectrum of **7g** (300 MHz, $CDCl_{3+}$DMSO)

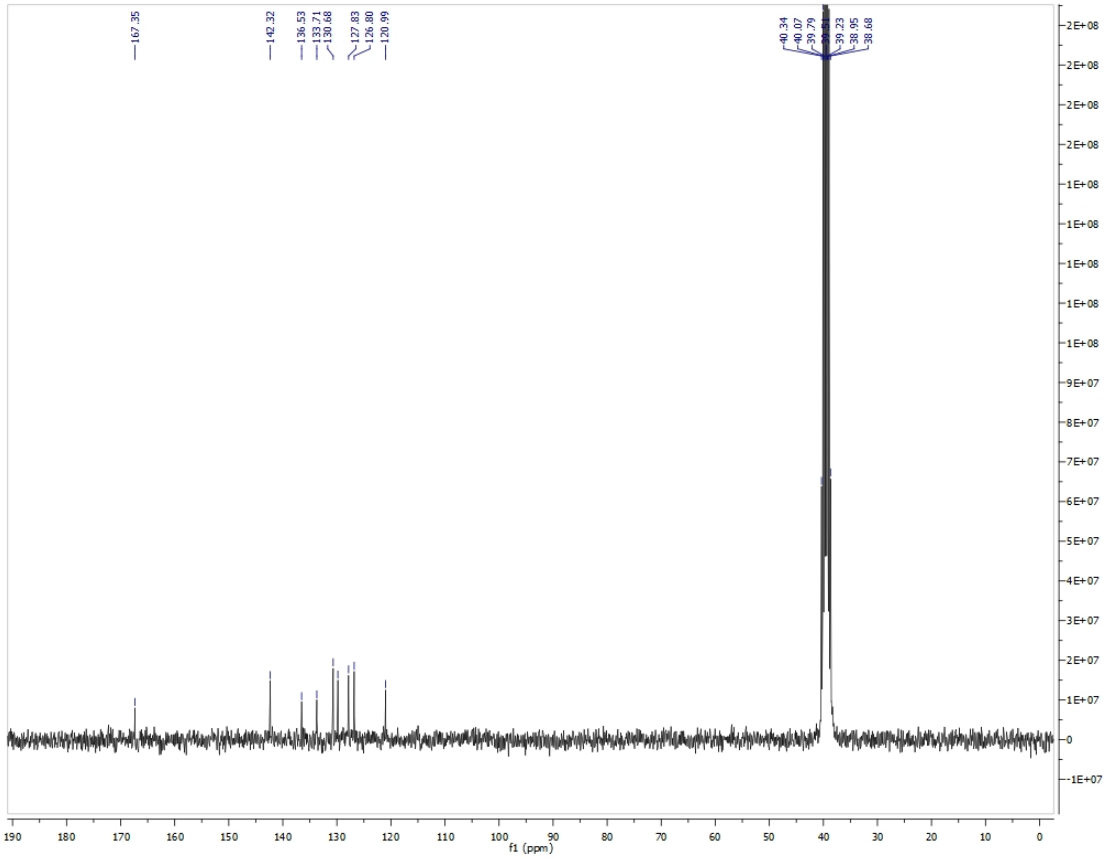


^{1}H-NMR spectrum of **7h** (300 MHz, DMSO)

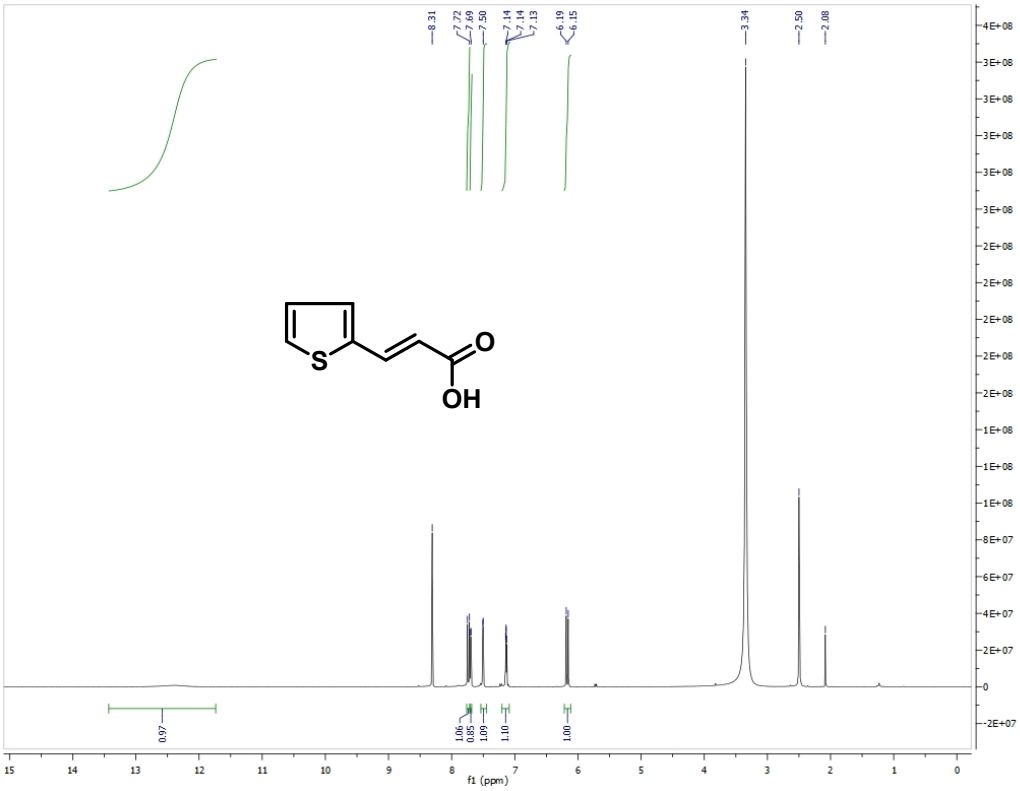


^{13}C -NMR spectrum of **7h** (300 MHz, DMSO)

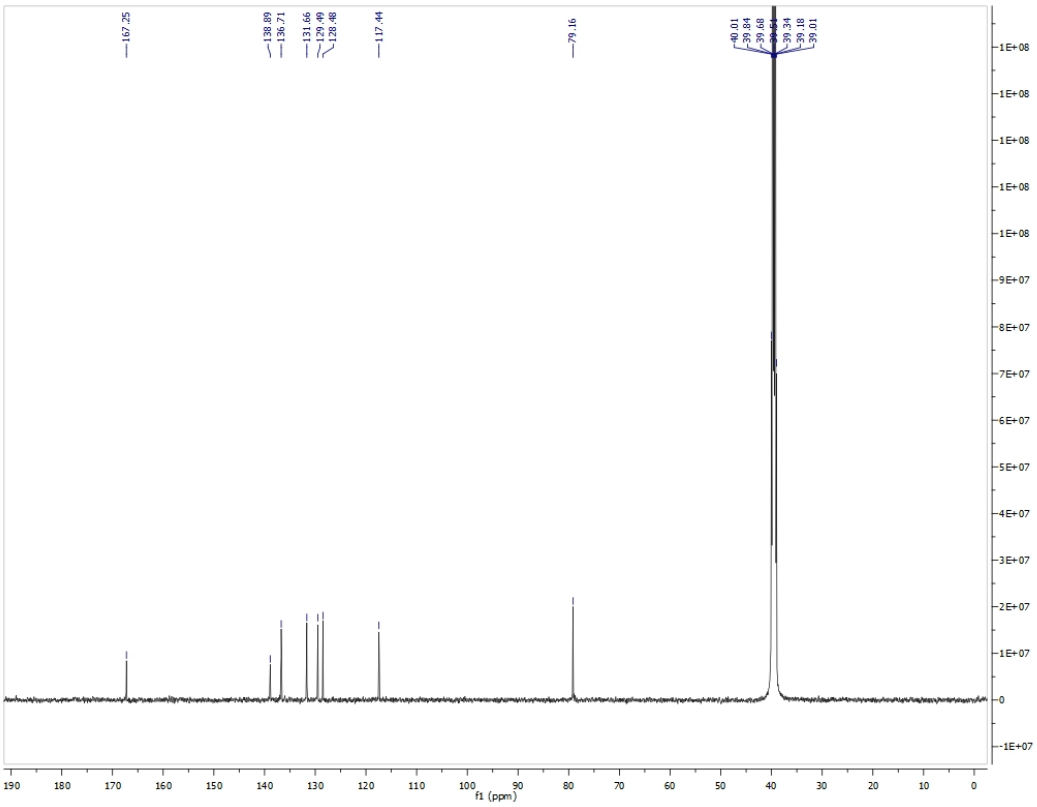
^{1}H-NMR spectrum of **7i** (300 MHz, $CDCl_3$)



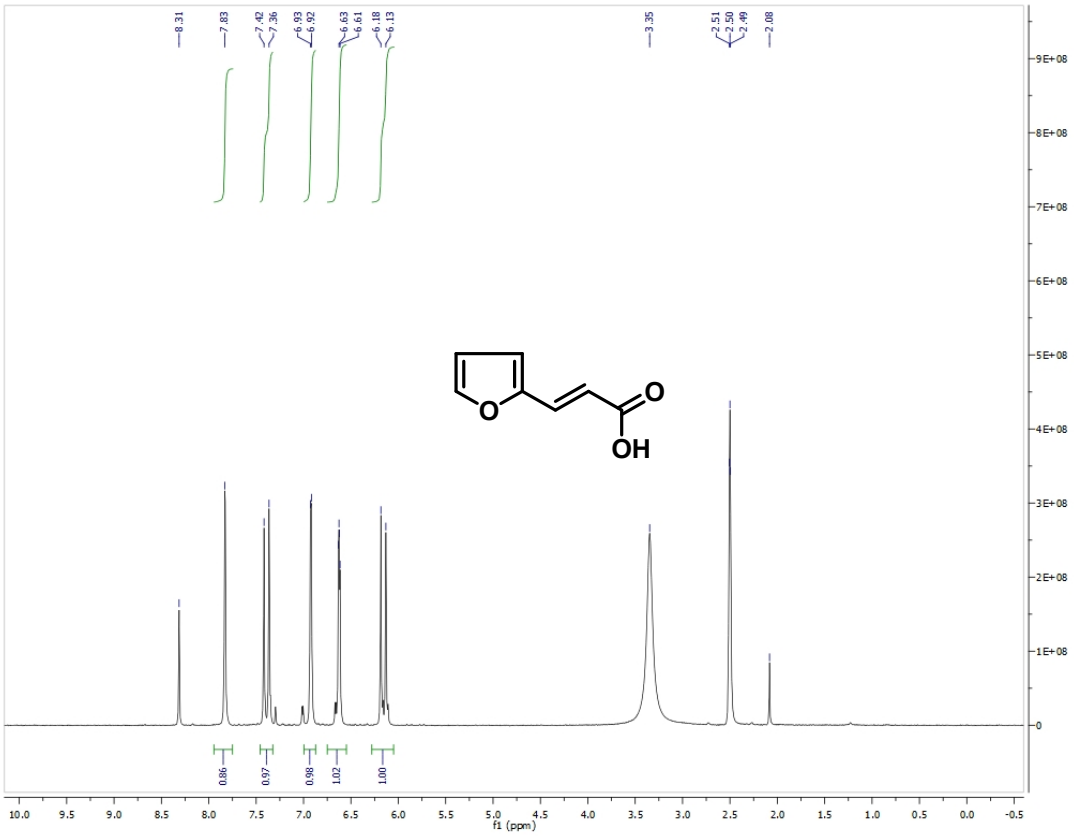
^{13}C -NMR spectrum of **7i** (300 MHz, DMSO)



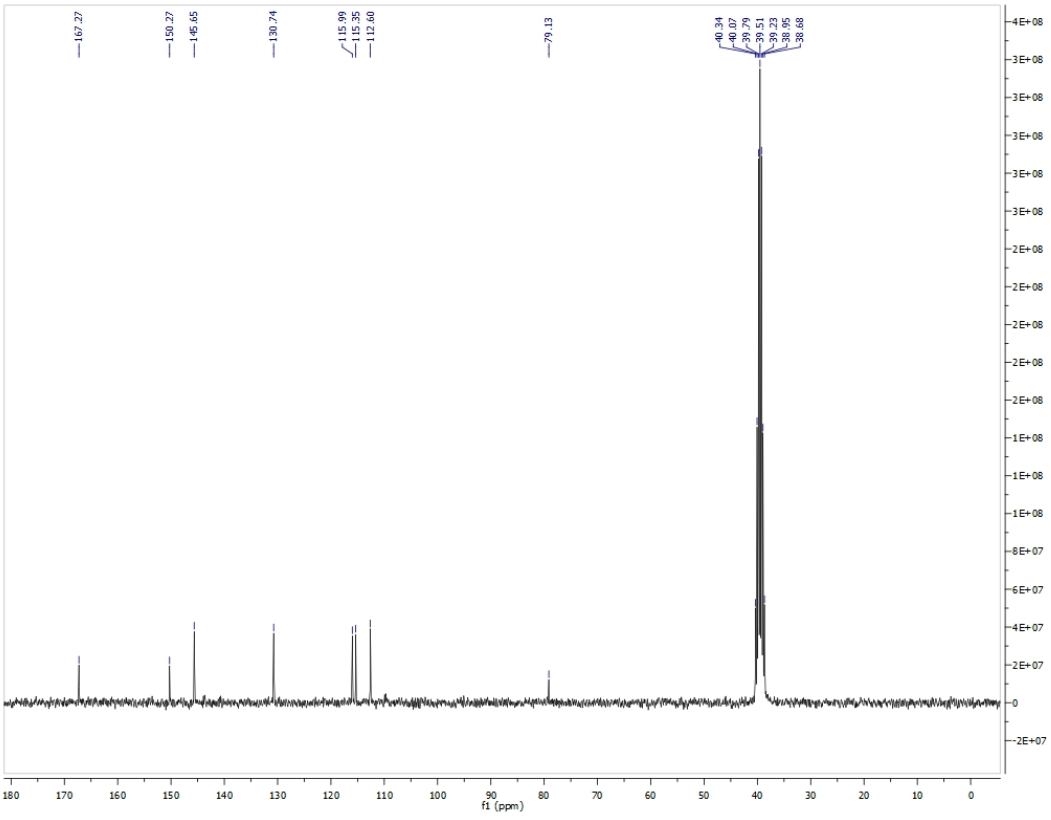
^{1}H-NMR spectrum of **7j** (300 MHz, DMSO)



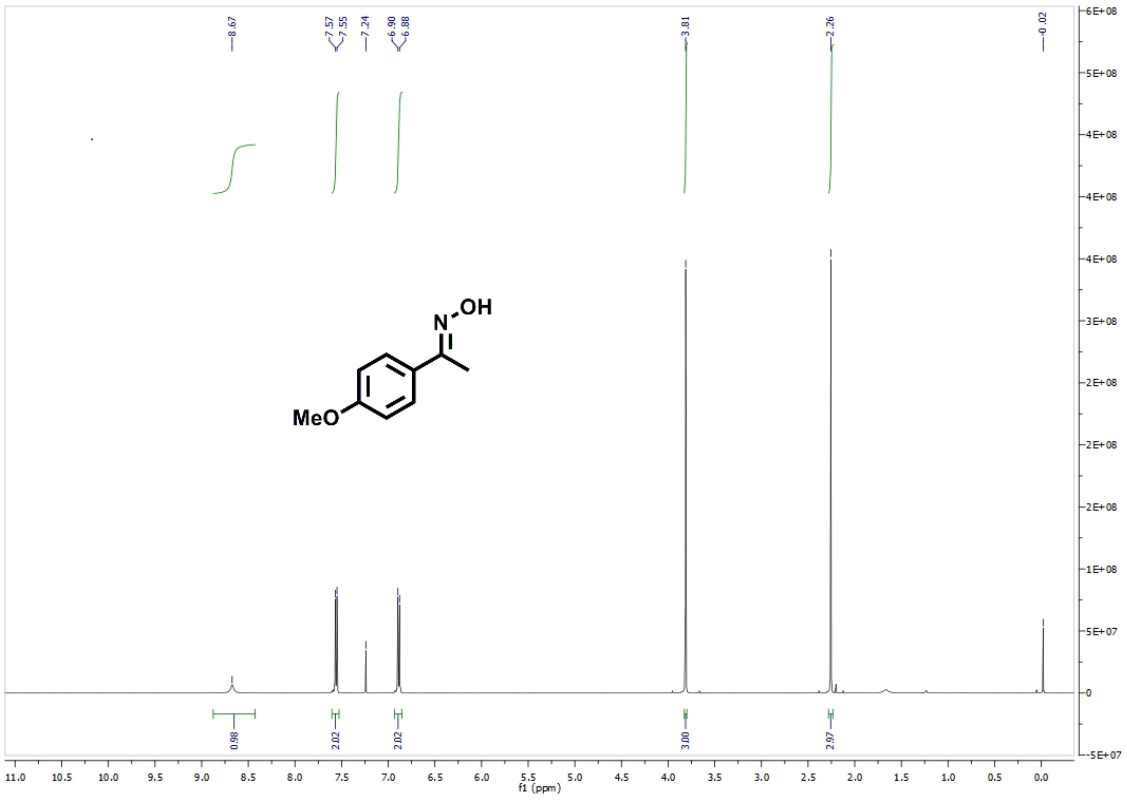
^{13}C -NMR spectrum of **7j** (300 MHz, DMSO)



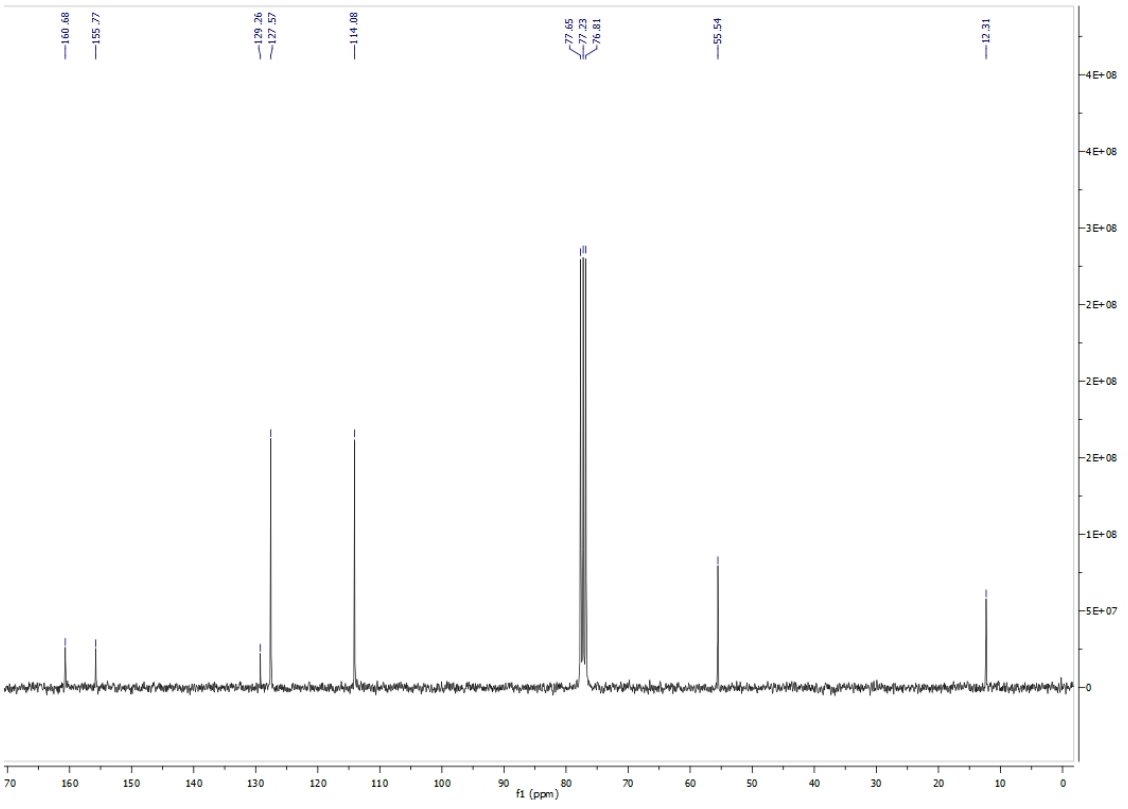
^{1}H-NMR spectrum of **7k** (300 MHz, DMSO)



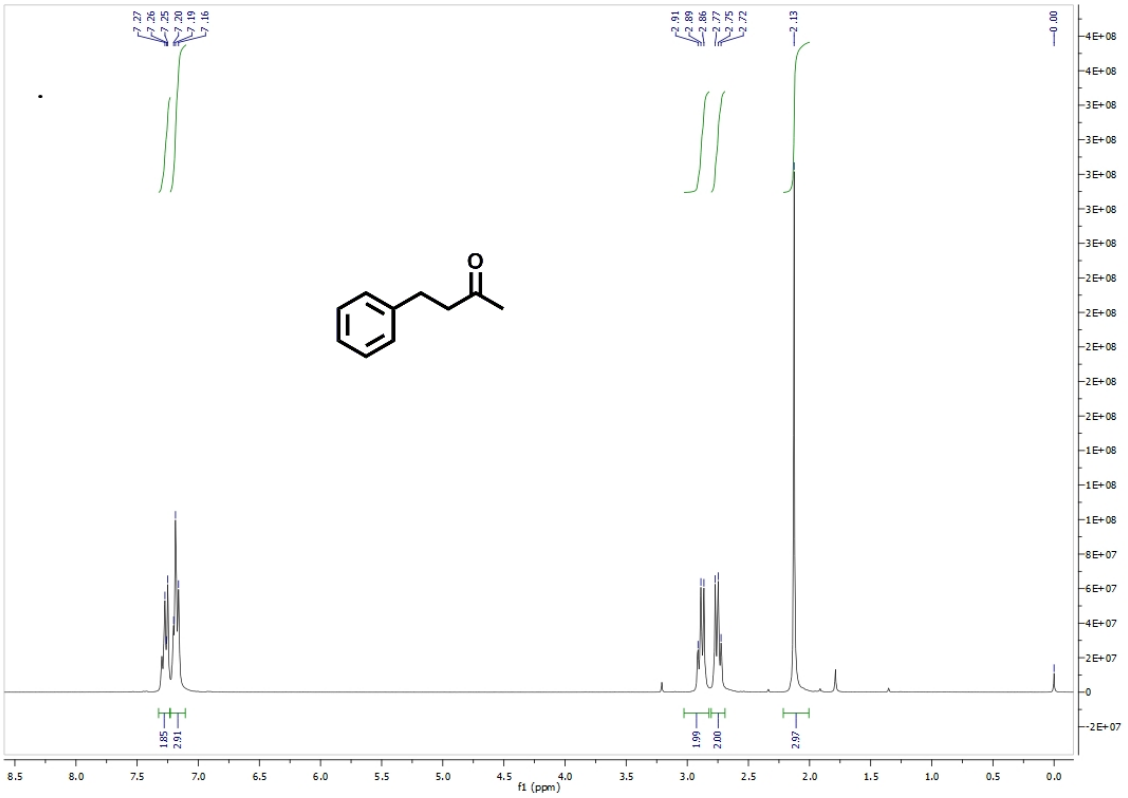
^{13}C -NMR spectrum of **7k** (300 MHz, DMSO)



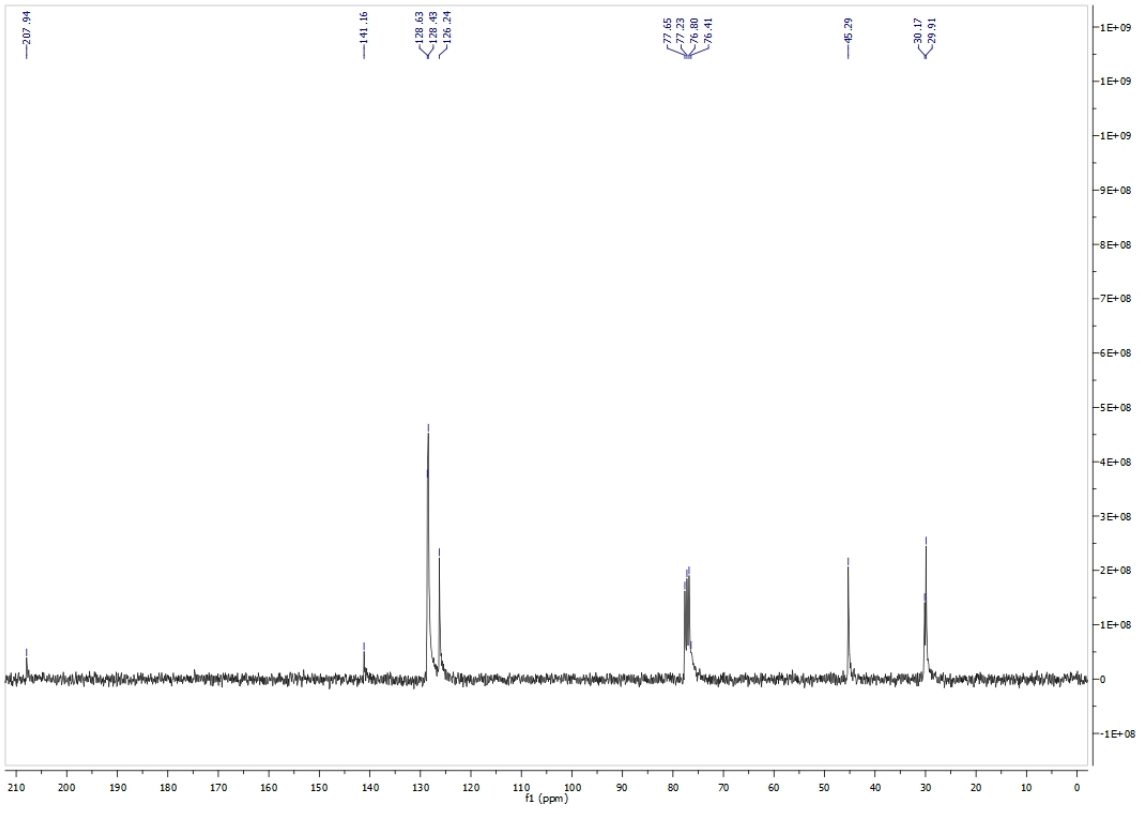
^{1}H-NMR spectrum of **2a** (300 MHz, $CDCl_3$)



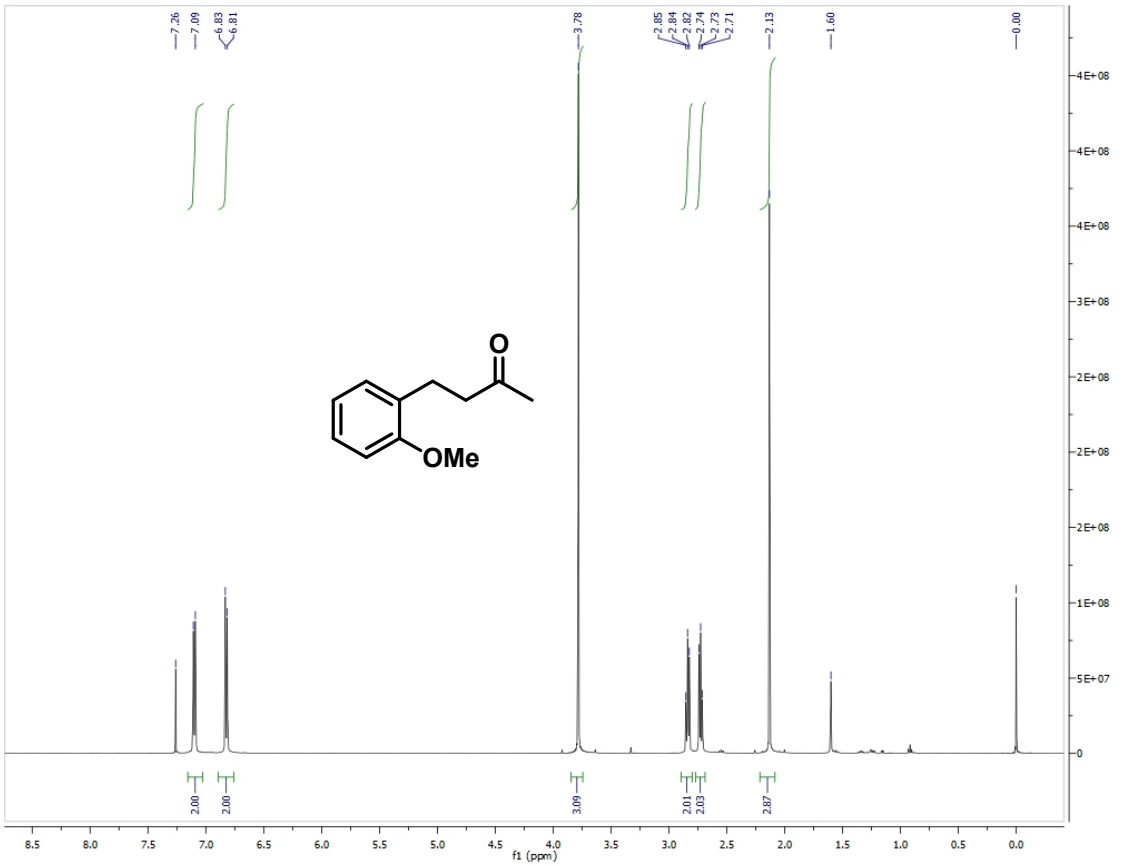
^{13}C -NMR spectrum of **2a** (300 MHz, $CDCl_3$)



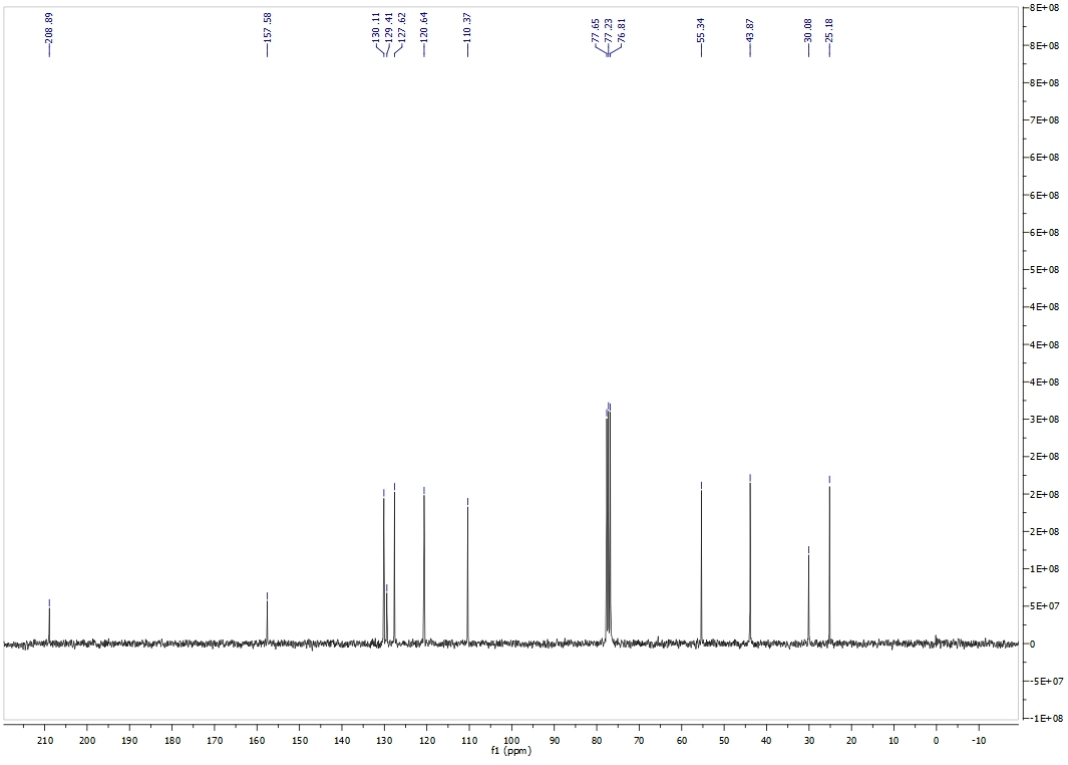
^{1}H-NMR spectrum of **5a** (300 MHz, $CDCl_3$)



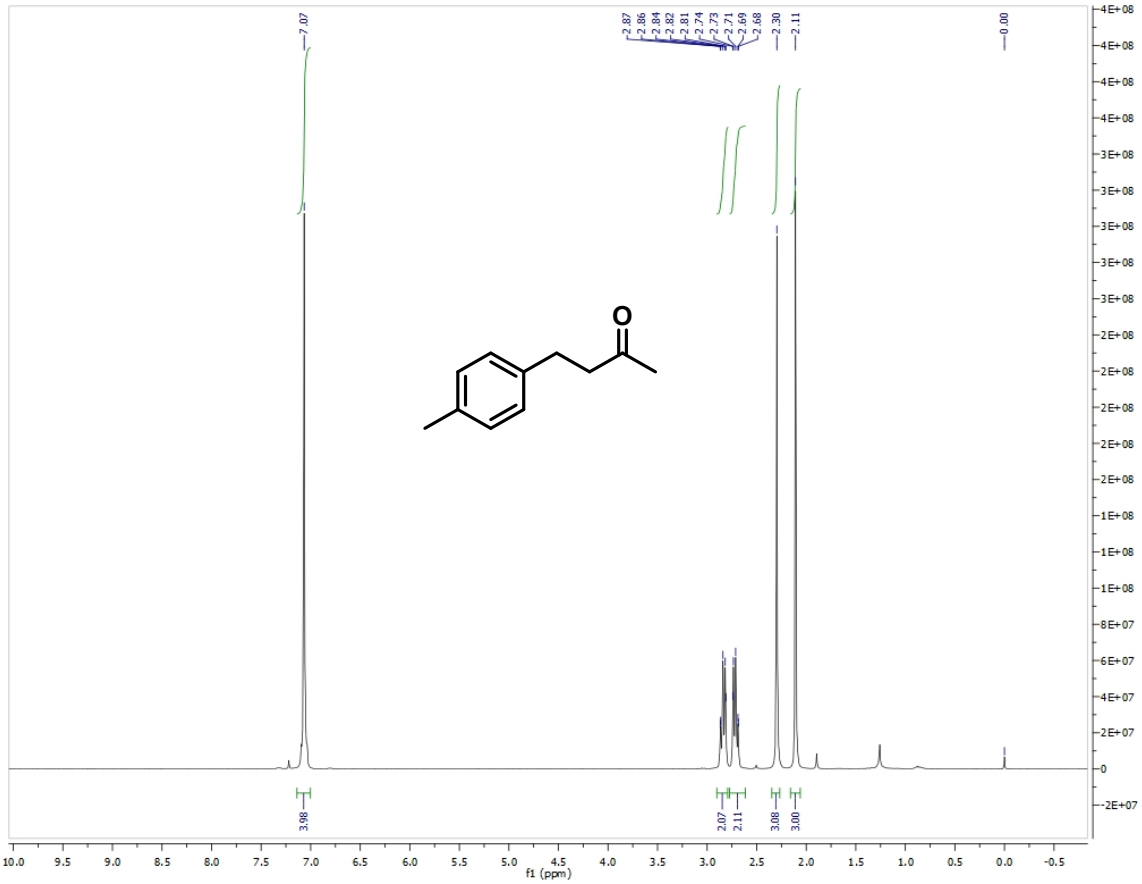
^{13}C -NMR spectrum of **5a** (300 MHz, $CDCl_3$)



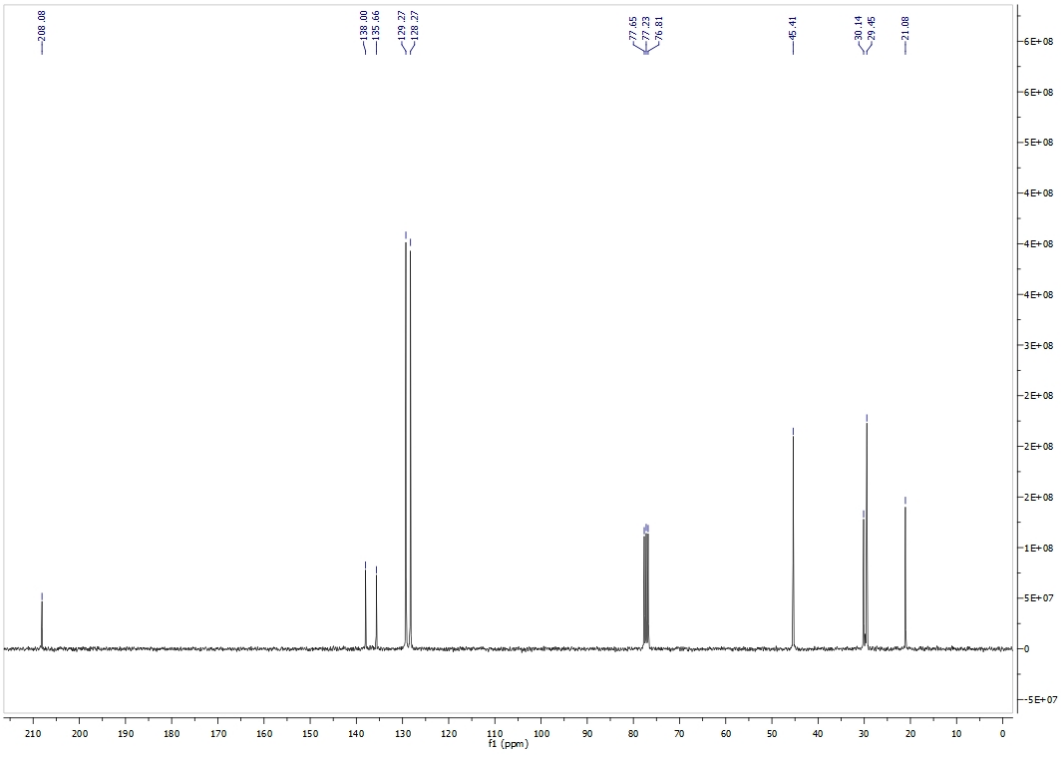
^{1}H-NMR spectrum of **5b** (300 MHz, $CDCl_3$)



^{13}C -NMR spectrum of **5b** (300 MHz, $CDCl_3$)

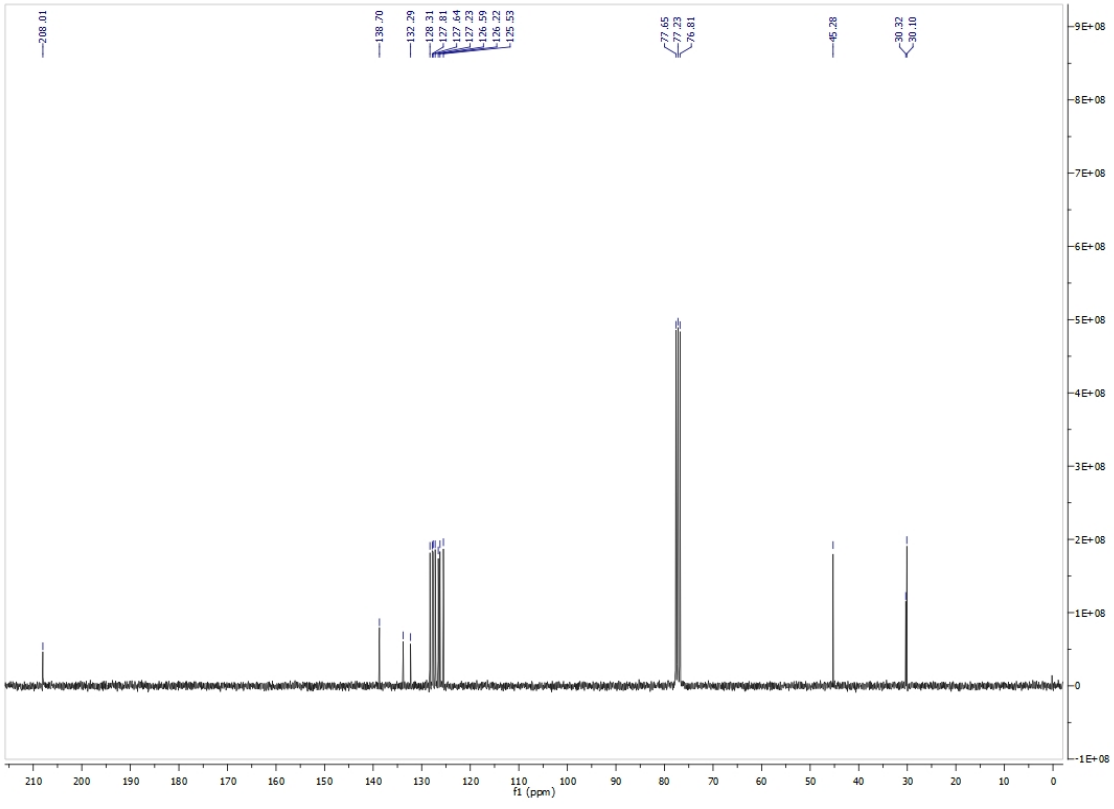


^{1}H-NMR spectrum of **5c** (300 MHz, $CDCl_3$)

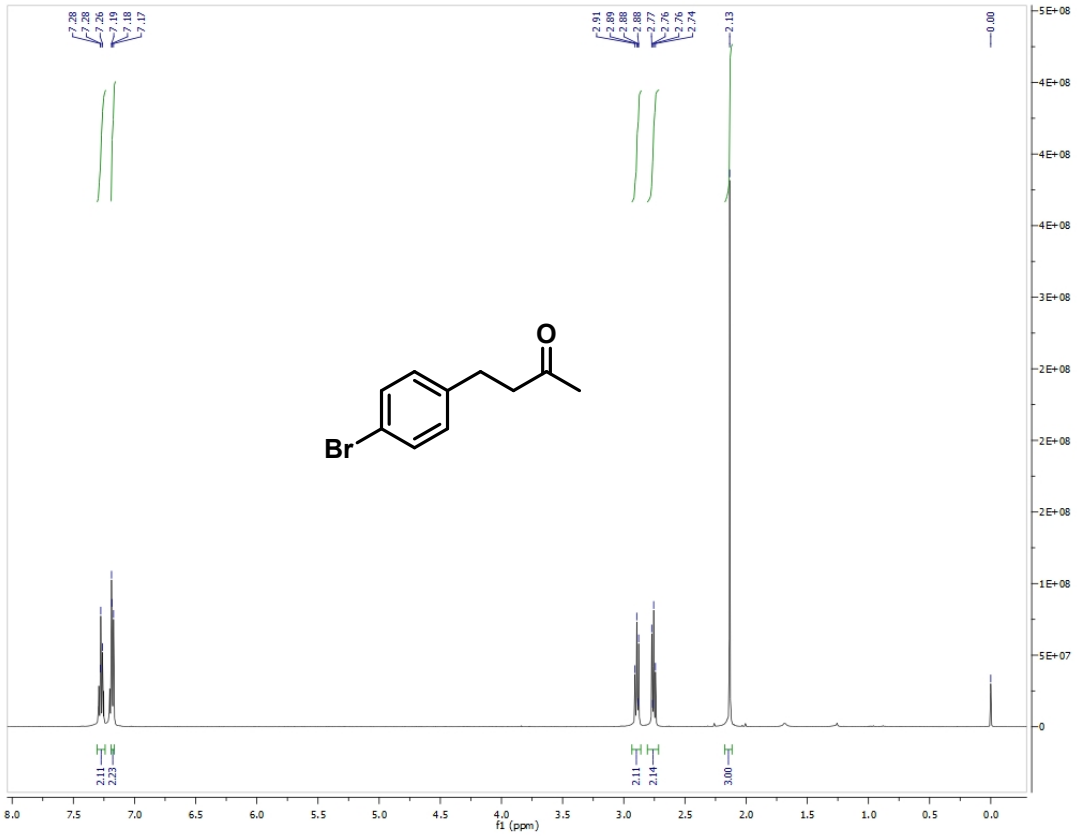


^{13}C -NMR spectrum of **5c** (300 MHz, $CDCl_3$)

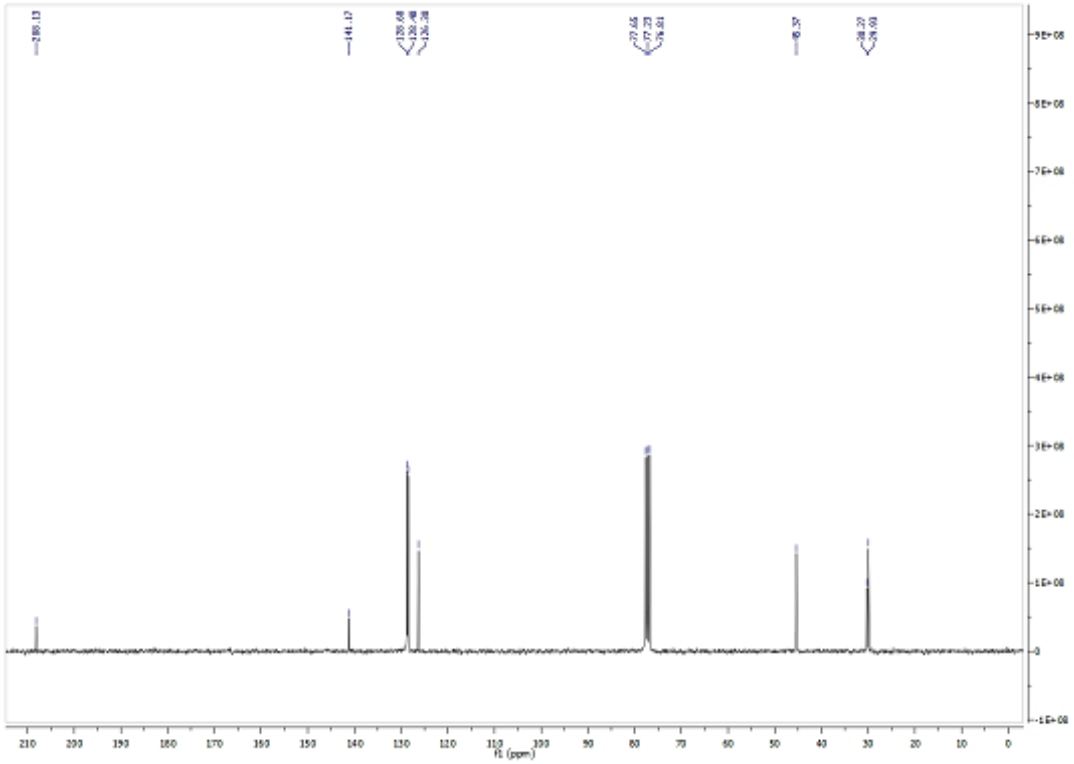
^{1}H-NMR spectrum of **5d** (300 MHz, $CDCl_3$)



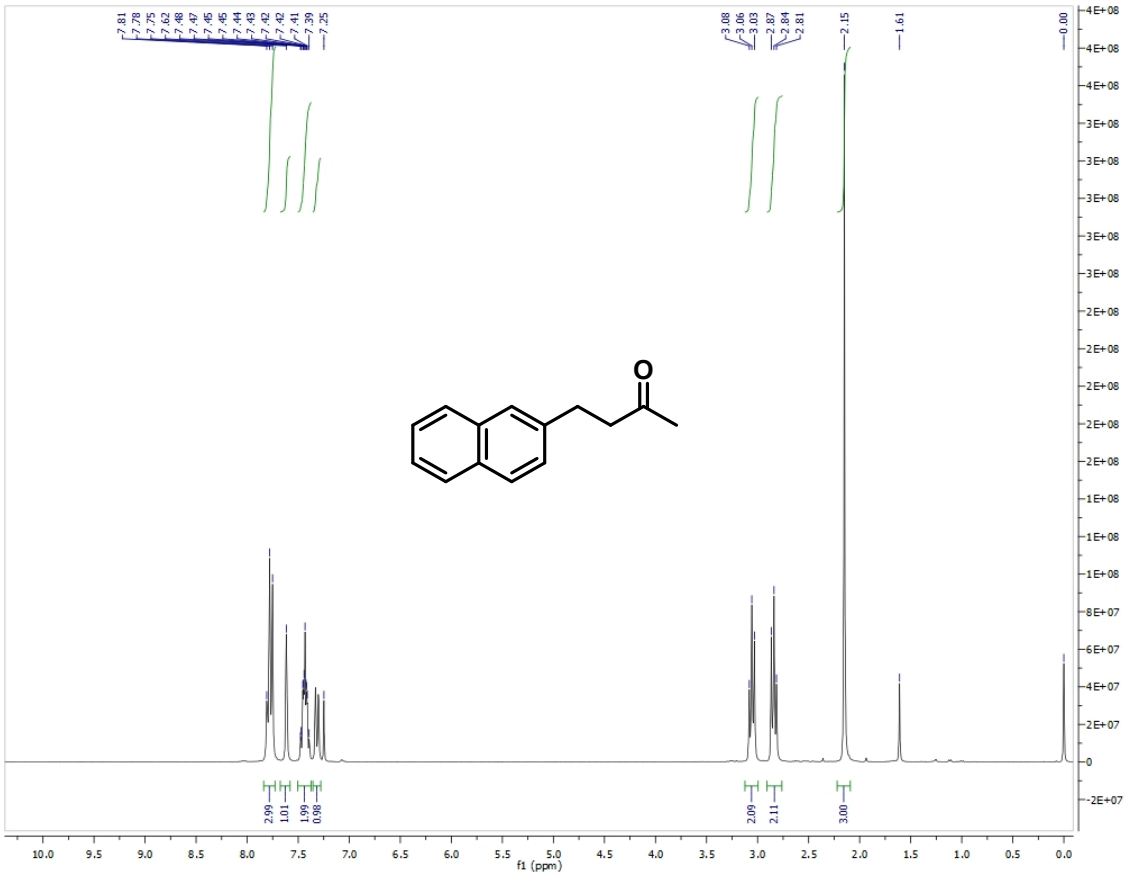
^{13}C -NMR spectrum of **5d** (300 MHz, $CDCl_3$)



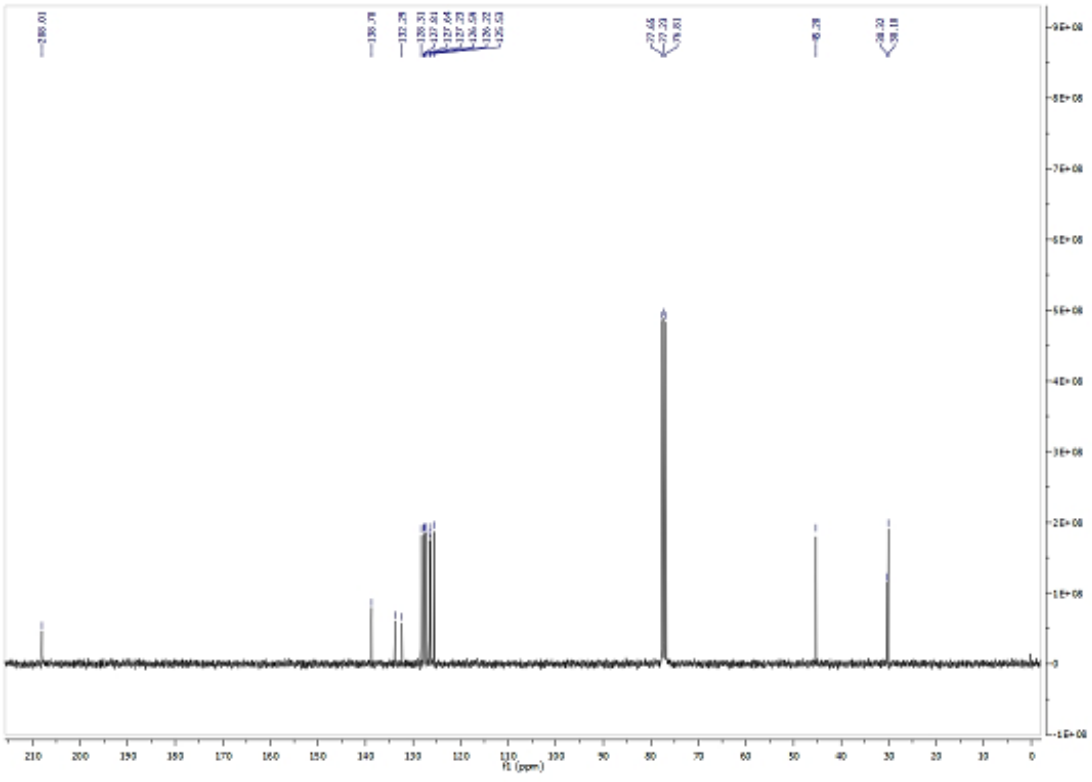
^{1}H-NMR spectrum of **5e** (300 MHz, $CDCl_3$)



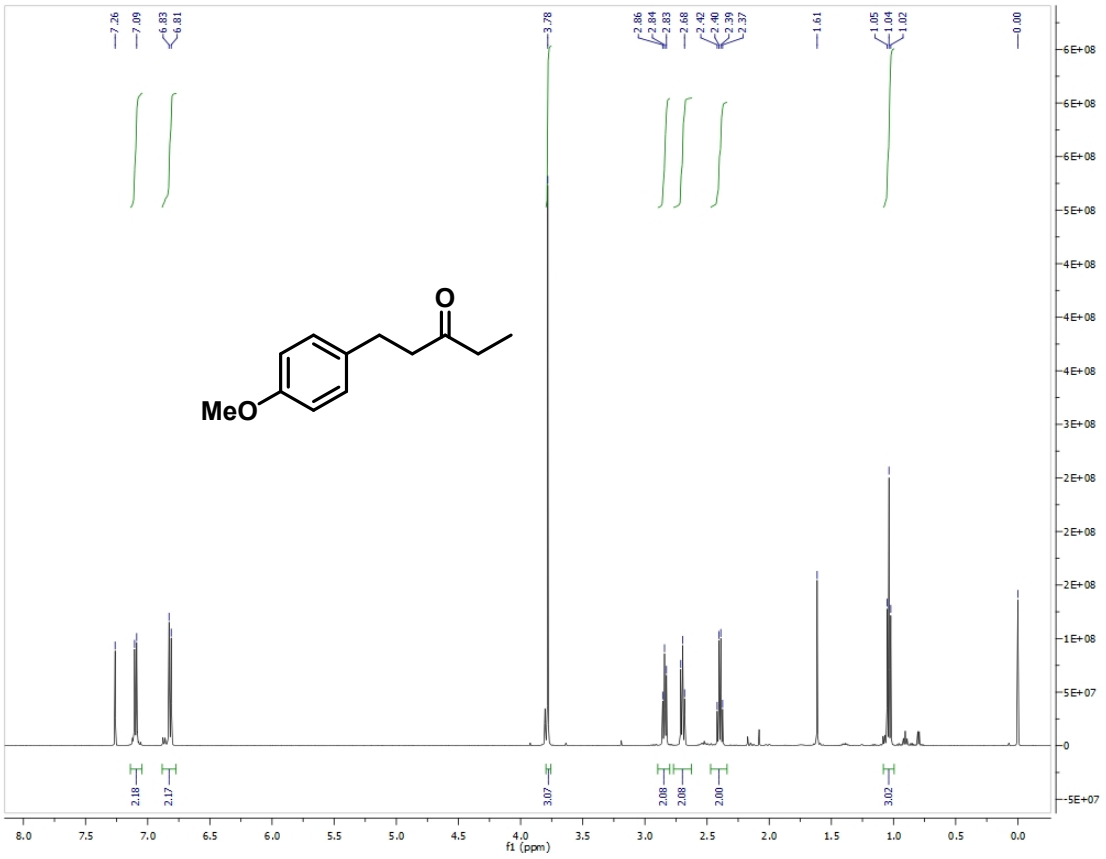
^{13}C -NMR spectrum of **5e** (300 MHz, $CDCl_3$)



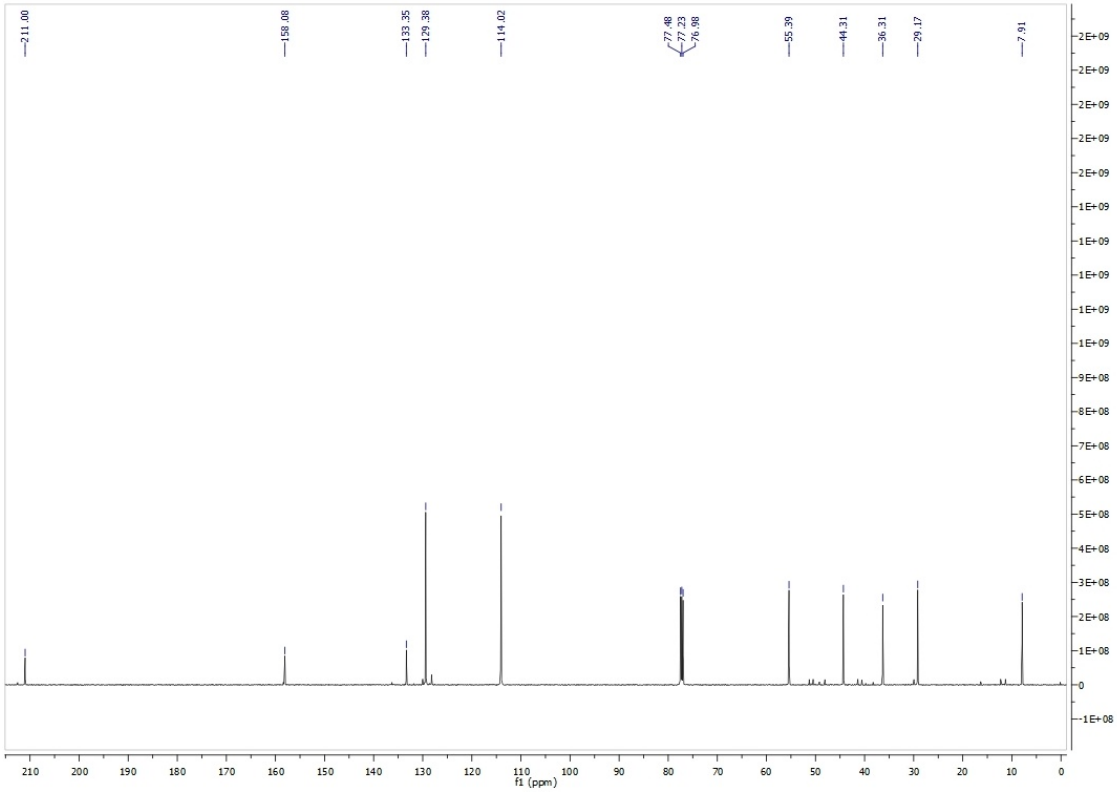
^{1}H-NMR spectrum of **5f** (300 MHz, $CDCl_3$)



^{13}C -NMR spectrum of **5f** (300 MHz, $CDCl_3$)



^{1}H-NMR spectrum of **5g** (300 MHz, $CDCl_3$)



^{13}C -NMR spectrum of **5g** (300 MHz, $CDCl_3$)

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