Electronic Supplementary Material (ESI) for New Journal of Chemistry.

Supporting Information

$PhI(OAc)_2$/NaX-mediated Halogenation Providing Access to Valuable Synthons 3-Haloindole derivatives

Vittam Himabindu[a,b], Sai Prathima Parvathaneni*[a], and Vaidya Jayathirth Rao*[a,b]

[a]Fluoro Agro Chemicals(Org.Chem. II) Division and [b]AcSIR, Indian Institute of Chemical Technology, Uppal Road Tarnaka, Hyderabad-500007, India, Tel: (+) 91 40 27193933

saiprathimaiict@gmail.com; vaidya.opv@gmail.com

Contents

1. General Information

The starting materials and reagents were purchased from various commercial sources and used without further purification. The reactions were performed at room temperature. ACME silica gel (60-120 mesh) was used for column chromatography. Analytical thin-layer chromatography (TLC) was performed on pre-coated TLC plates with silica gel 60-F_{254} plates and visualized by UV-light. ^{1}H NMR and ^{13}C NMR spectra were recorded, using tetramethylsilane (TMS) in the solvent of $CDCl_3$+DMSO as the internal standard on a 300, 500 MHz spectrometer (^{1}H NMR: TMS at 0.00 ppm, $CDCl_3$ at 7.26 ppm; ^{13}C NMR: $CDCl_3$ at 77.0 ppm, DMSO at 39.43). Chemical shifts (δ) were recorded in ppm with respect to TMS as an internal standard and coupling constants are quoted in Hertz (Hz). Mass spectra were recorded on a mass spectrometer by the electron spray ionization (ESI) and the data acquired in positive ionization mode. HRMS spectra were determined on TOF type mass analyzer.

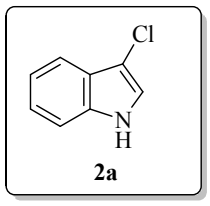
2. Halogenation of Indoles

General Procedure for Chlorination:

In a 25 mL round bottom flask, substrates **1a-1j** (1.0 mmol, 1 equiv) and NaCl (58 mg, 1.0 mmol, 1.0 equiv), $PhI(OAc)_2$ (322 mg, 1.0 mmol, 1equiv) were dissolved in 2 mL of CH_3CN:H_2O (1:1). The reaction mixture was stirred at room temperature for 1-2h as monitored by TLC. The reaction mixture was diluted with 20 mL of ethyl acetate and then treated with 10 mL of saturated Na_2S aqueous solution. The organic layer was dried over Na_2SO_4 and concentrated under vacuum. The residue was purified by column chromatography on silica gel with a gradient eluent of hexane and ethyl acetate to give the chlorinated product.

3. Characterization Data for the Products:

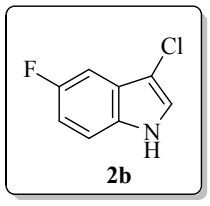
3-chloro-1H-indole (2a) [1]



2a

Isolated yield: 72%; **mp:** 58-60 °C (lit)[13] ; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.10 (s, 1H), 7.66-7.63 (d, 1H, *J* = 7.7 Hz), 7.39-7.36 (d, 1H, *J* = 7.7 Hz), 7.28-7.18 (m, 3H); **^{13}C NMR** (500 MHz, $CDCl_3$): δ 133.94, 124.38, 122.10, 119.79, 119.44, 117.26, 110.44, 105.48;**MS** (EI-MS) =151.0 (M^+), 153.0 (M+2).

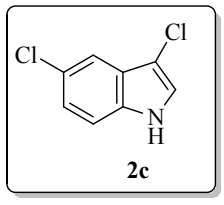
3-chloro-5-fluoro-1H-indole (2b) [1]



2b

Isolated yield: 62%; **mp:** 69-72 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.01 (s, 1H), 7.22-7.18 (m, 2H), 7.13-7.12 (d, 1H, *J* = 2.5 Hz), 6.94-6.89 (m, 1H); **^{13}C NMR** (500 MHz, $CDCl_3$): δ 159.24 (s), 157.36 (s), 131.47 (s), 125.88 (d, *J* = 10.4 Hz), 122.61 (s), 112.12 (dd, *J* = 70.7, 18.1Hz), 106.53 (s), 103.26 (d, *J*= 24.8.6 Hz);**MS** (EI-MS) = 169 (M^+).

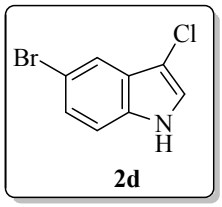
3, 5-dichloro-1H-indole (2c) [2]



2c

Isolated yield: 67%; **mp:** 97-99 °C (lit)[6]; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.09 (s, 1H), 7.61 (s, 1H,), 7.28-7.25 (m, 1H), 7.21-7.18 (m, 2H); **^{13}C NMR** (500 MHz, $CDCl_3$): δ 133.32, 126.48, 126.42, 123.64, 122.22, 117.89, 112.61, 106.21;**MS** (EI-MS) = 184 (M^+).

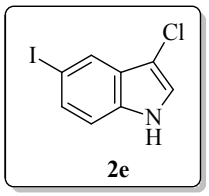
5-bromo-3-chloro-1H-indole (2d)[1, 3]



2d

Isolated yield: 64%; **mp:** 111-113 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.22 (s, 1H), 7.56 (s, 1H), 7.30-7.29 (d, 1H, *J* = 8.5 Hz), 7.26-7.25 (d, 1H, *J* = 2.5 Hz), 7.21-7.19 (dd, 1H, *J* = 8.6, 10.6 Hz); **^{13}C NMR** (500 MHz, $CDCl_3$): δ 133.59, 127.06, 126.16, 122.09, 120.96, 113.81, 113.04, 106.01; **MS** (EI-MS) = 229 (M+1).

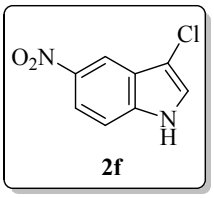
3-chloro-5-iodo-1H-indole (2e)



2e

Isolated yield: 74%; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.18 (s, 1H), 7.98 (s, 1H), 7.50-7.48 (d, 1H, *J* = 8.8 Hz), 7.15-7.13 (d, 2H, *J* = 8.0 Hz); **^{13}C NMR** (400 MHz, $CDCl_3$): 134.07, 131.57, 127.80, 127.28, 121.63, 113.42, 83.83, 60.46;MS (EI-MS) = 277 [M^+], 279 [M + 2].

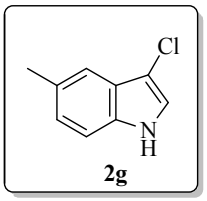
3-chloro-5-nitro-1H-indole (2f) [1]



2f

Isolated yield: 65%; **mp:** 150-152 °C; **^{1}H NMR** (300 MHz, $CDCl_3$+d_6-DMSO): δ 8.63 (s, 1H), 8.49 (s, 1H), 8.18-8.16 (dd, 1H, *J* = 8.9, 11.2 Hz), 7.45-7.42 (d, 1H, *J* = 9.0 Hz), 7.36-7.35 (d, 1H, *J* = 8.9 Hz); **^{13}C NMR** (300 MHz, $CDCl_3$+d_6-DMSO): δ 140.32, 138.49, 127.49, 126.28, 116.67, 115.84, 110.65, 103.14; **MS** (EI-MS) = 198 (M+2).

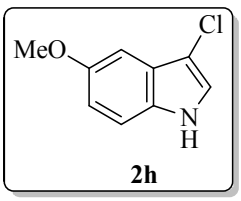
3-chloro-5-methyl-1H-indole (2g) [1]



2g

Isolated yield: 79%; **mp:** 65-67 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.00 (s, 1H), 7. 45 (s, 1H), 7.28 (s, 1H), 7.16-7.09 (m, 2H), 1.51 (s, 3H); **^{13}C NMR** (400 MHz, $CDCl_3$): δ 133.34, 129.95, 125.60, 124.84, 120.87, 117.78, 111.16, 106.04, 21.44; **MS** (EI-MS) =166 (M+1).

3-chloro-5-methoxy-1H-indole (2h) [1, 3]

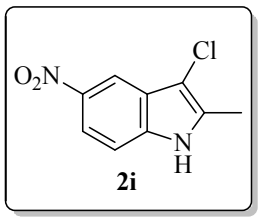


2h

Isolated yield: 78%; **mp:** 75-77 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.10 (s, 1H), 7.27-7.20 (t, 2H), 7.00-6.99 (d, 1H, *J* = 2.5 Hz), 6.91-6.89 (dd, 1H, *J* = 8.8, 11.2

Hz), 3.8 (s, 3H); **^{13}C NMR** (400 MHz$CDCl_3$): δ 154.87, 129.99, 125.79, 121.32, 113.98, 112.43, 106.04, 99.27, 29.72; **MS** (EI-MS) = 182 (M+1).

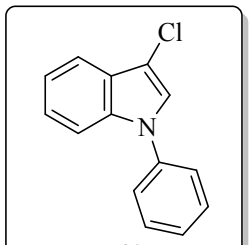
3-chloro-2-methyl-5-nitro-1H-indole (2i) [3]



2i

Isolated yield: 58%; **mp:** 170-172 °C; **^{1}H NMR** (300 MHz, $CDCl_3$+d_6-DMSO): δ 8.50 (s, 1H), 8.28 (s, 1H), 8.11-8.08 (d, 1H, *J* = 8.9 Hz), 7.33-7.31 (d, 1H, *J* = 8.9 Hz), 2.49 (s, 3H); **^{13}C NMR** (300 MHz, $CDCl_3$+d_6-DMSO): δ 140.70, 137.62, 136.58, 126.19, 116.07, 113.82, 110.49, 89.91, 11.51; **MS** (EI-MS) = 210 (M^+).

3-chloro-1-phenyl-1H-indole (2j)[4]



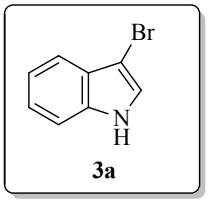
2j

Isolated yield: 64%; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.62-7.58 (m, 1H), 7.55-7.49 (m, 5H), 7.37-7.33 (m, 1H), 7.25-7.16 (m, 3H); **^{13}C NMR** (400 MHz, $CDCl_3$): δ 200.10, 164.56, 140.52, 138.28, 132.79, 132.15, 130.51, 129.33, 127.75, 127.01, 113.06, 93.59; **MS** (EI-MS)=227 (M^+).

General Procedure for bromination:

In a 25 mL round bottom flask, substrates **3a-31** (1.0 mmol, 1 equiv) and NaBr (103 mg, 1.0 mmol, 1.0 equiv), $PhI(OAc)_2$ (322 mg, 1.0 mmol, 1 equiv) were dissolved in 2 mL of CH_3CN:H_2O (1:1). The reaction mixture was stirred at room temperature for 1-2 h, monitored by TLC. The reaction mixture was diluted with 20 mL of ethyl acetate and then treated with 10 mL of saturated Na_2S aqueous solution. The organic layer was dried over Na_2SO_4 and concentrated under vacuum. The residue was purified by column chromatography on silica gel with a gradient eluent of hexane and ethyl acetate to give the brominated product.

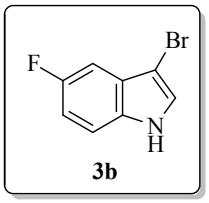
3-Bromo-1H-indole (3a) [1]



3a

Isolated yield: 78%; **mp:** 65-67 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.19 (s, 1H), 7.61-7.58 (d, 1H, *J* = 7.7 Hz), 7.39-7.37 (d, 1H, *J* = 7.1 Hz), 7.28-7.18 (m, 3H); **^{13}C NMR** (500 MHz, $CDCl_3$): δ 133.60, 127.09, 126.18, 122.03, 121.02, 113.83, 112.98, 106.09; **MS** (EI-MS) = 195 (M^+).

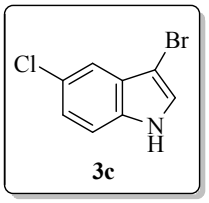
3-bromo-5-fluoro-1H-indole (3b) [1]



3b

Isolated yield: 61%; **mp:** 75-78 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.45 (s, 1H), 7.53 (s, 1H,), 7.26-7.15 (m, 3H); **^{13}C NMR** (500 MHz, $CDCl_3$): δ 139.42 (s), 134.41 (s), 131.62 (s), 129.28 (d, *J* = 102.9 Hz), 126.13 (s), 123.69 (s), 114.12 (s), 112.83 (s); **MS** (EI-MS) = 212 (M^+).

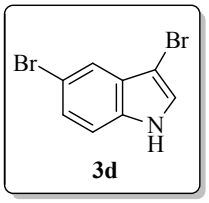
3-bromo-5-chloro-1H-indole (3c) [5]



3c

Isolated yield: 69%; **mp:** 81-83 °C (lit)[12]; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.22 (s, 1H), 7.57-7.56 (d, 1H, *J* = 8.5 Hz), 7.30-7.28 (d, 1H,*J* = 2.5 Hz), 7.25-7.19 (m, 2H,); **^{13}C NMR** (400 MHz, $CDCl_3$): δ 134.17, 128.99, 125.62, 125.49, 122.35, 120.15, 112.07, 102.43; **MS** (EI-MS) = 230 (M+2).

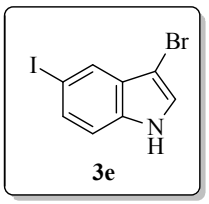
3, 5-dibromo-1H-indole (3d) [1]



3d

Isolated yield: 65%; **mp:** 91-93 °C (lit)[12]; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.21 (s, 1H), 7.72 (s, 1H), 7.34-7.31 (dd, 1H, *J* = 8.6, 10.5 Hz), 7.25-7.21 (m, 2H); **^{13}C NMR** (400 MHz, $CDCl_3$): δ 133.98, 128.59, 126.19, 124.55, 121.90, 113.99, 112.91, 90.99; **MS** (EI-MS) = 274 (M+2).

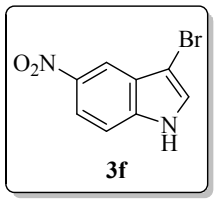
3-bromo-5-iodo-1H-indole (3e):



3e

Isolated yield: 79%; **mp:** 90-93 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.25 (s, 1H), 7.93 (s, 1H), 7.51-7.49 (dd, 1H, *J* = 8.5, 10.2 Hz), 7.20-7.14 (m, 2H); **^{13}C NMR** (500 MHz, $CDCl_3$):δ 134.45, 131.62,129.30, 128.19, 124.11, 113.31, 90.69, 84.04; **MS** (EI-MS) = 320 (M+), 321 (M+2), **HRMS** (EI-HRMS) $(M+H)^+$*m/z* calcd for C_8H_5BrIN = 320.8650, found = 320.8620.

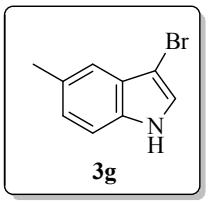
3-bromo-5-nitro-1H-indole (3f) [6]



3f

Isolated yield: 59%; **mp:** 190-192 °C; **^{1}H NMR** (300 MHz, $CDCl_3$): δ 11.31 (s, 1H), 8.19 (s, 1H), 7.83-73.79 (d, 1H, *J* = 8.5 Hz),7.28-7.16 (m, 2H);**^{13}C NMR** (300 MHz, $CDCl_3$): δ 141.20, 138.20, 126.99, 125.60, 117.04, 115.48, 111.69, 91.61; **MS** (EI-MS) = 241.

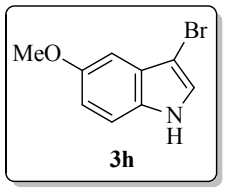
3-bromo-5-methyl-1H-indole (3g) [7]



3g

Isolated yield: 82%; **mp:** 66-68 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.14 (s, 1H), 7.36 (s, 1H), 7.27-7.25 (t, 1H), 7.19-7.18 (d, 1H, *J* = 8.6 Hz), 7.08-7.06 (dd, 1H, *J* = 8.3, 10.2 Hz), 2.47 (s, 3H); **^{13}C NMR** (500 MHz, $CDCl_3$): δ 134.15, 129.03, 128.18, 124.27, 123.65, 120.38, 110.70, 102.13, 21.48; **MS** (EI-MS) = 208 (M^+).

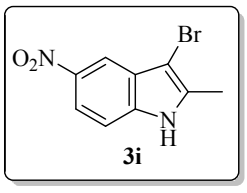
3-bromo-5-methoxy-1H-indole (3h) [1]



3h

Isolated yield: 81%; **mp:** 74-76 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.04 (s, 1H), 7.20-7.18 (t, 1H), 7.13-7.12 (d, 1H, *J* = 2.4 Hz), 6.92 (s, 1H), 6.84-6.82 (dd, 1H, *J* = 8.8, 11.2 Hz), 3.8 (s, 3H). **^{13}C NMR** (500 MHz, $CDCl_3$): δ 154.24, 131.14, 131.03, 128.34, 124.95, 112.39, 111.78, 102.40, 55.54; **MS** (EI-MS) = 226 (M+2).

3-bromo-2-methyl-5-nitro-1H-indole (3i)

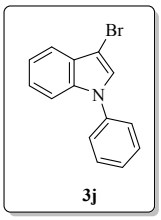


3i

Isolated yield: 62%; **mp:** 161-165 °C; **^{1}H NMR** (300 MHz, $CDCl_3$+d_6-DMSO): δ 11.60 (s, 1H), 8.31 (s, 1H), 8.01-7.97 (dd, 1H, *J* = 9.0, 11.0 Hz), 7.39-7.36 (d, 1H, *J* = 8.8 Hz), 3.14 (s, 3H); **^{13}C NMR** (300 MHz, $CDCl_3$+d_6-DMSO): δ 140.70, 137.62,

136.58, 126.19, 116.07, 114.01, 110.49, 89.91, 11.51; **MS** (EI-MS) = 254 (M+1), **HRMS** (EI-HRMS) =calcd for $C_8H_5BrN_2O_2$ = 253.9690, found = 253.9690.

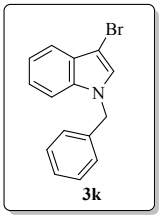
3-bromo-1-phenyl-1H-indole (3j) [12]



3j

Isolated yield: 74%; **mp:** 91-93 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.55-7.52 (t, 2H), 7.48-7.42 (m, 4H), 7.28-7.24 (m, 1H), 7.15-7.12 (m, 1H), 6.80-6.78 (s, 1H, *J* = 7.9 Hz), 5.43 (s, 1H) ; **^{13}C NMR** (400 MHz, $CDCl_3$): δ 171.73, 143.94, 133.83, 130.33, 129.78, 128.54, 126.44, 126.36, 125.98, 123.83, 110.10; **MS** (EI-MS) = 272 (M+2).

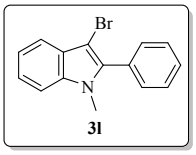
1-benzyl-3-bromo-1H-indole (3k) [8]



3k

Isolated yield: 71%; **mp:** 55-60 °C; **^{1}H NMR** (500 MHz, $CDCl_3$+d_6-DMSO): δ 7.60-7.57 (m, 1H), 7.33-7.17 (m, 7H), 7.13-7.10 (m, 2H), 5.28 (s, 2H); **^{13}C NMR** (400 MHz, $CDCl_3$+d_6-DMSO): δ 136.79, 135.94, 128.92, 127.94, 127.56, 127.08, 126.97, 122.88, 120.39, 119.47, 109.93, 90.36, 50.37; **MS** (EI-MS) = 285 (M^+), **HRMS** (EI-HRMS) =calcd for $C_{15}H_{12}BrN$= 285.0179, found = 285.0153.

3-bromo-1-methyl-2-phenyl-1H-indole (3l) [6]



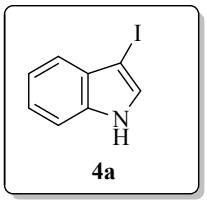
3l

Isolated yield: 94%; **^{1}H NMR** (400 MHz, $CDCl_3$+d_6-DMSO): δ 7.62-7.60 (d, 1H, *J* = 8.6 Hz), 7.50-7.44 (m, 5H), 7.34-7.27 (m, 2H), 7.24-7.22 (m, 1H), 3.63 (s, 3H); **^{13}C NMR** (400 MHz, $CDCl_3$+d_6-DMSO): δ 141.81, 137.84, 131.70, 131.00, 130.46, 128.88, 128.74, 128.51, 123.00, 121.54, 120.81, 109.95, 58.98, 32.10; **MS** (EI-MS) = 285 (M^+).

General Procedure for iodination:

In a 25 mL round bottom flask, substrates **4a-4m** (1.0 mmol, 1 equiv) and NaI (150 mg, 1.0 mmol, 1.0 equiv), $PhI(OAc)_2$ (322 mg, 1.0 mmol, 1 equiv) were dissolved in 2 mL of $CH_3CN:H_2O$ (1:1). The reaction mixture was stirred at room temperature for 1-2 has monitored by TLC. The reaction mixture was diluted with 20 mL of ethyl acetate and then treated with 10 mL of saturated Na_2S aqueous solution. The organic layer was dried over Na_2SO_4 and concentrated under vacuum. The residue was purified by column chromatography on silica gel with a gradient eluent of hexane and ethyl acetate to give the iodinated product.

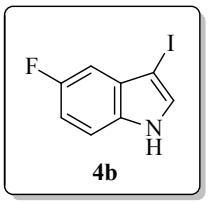
3-Iodo-1H-indole (4a)



4a

Isolated yield: 91%; **mp:** 66 °C (lit)[16]; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.28 (s, 1H), 7.47-7.45 (d, 1H, *J* = 7.6 Hz), 7.35-7.34 (d,1H, *J* = 7.9 Hz) 7.26-7.19 (m, 3H); **^{13}C NMR** (500 MHz, $CDCl_3$): δ 135.65, 129.83, 128.42, 123.23, 121.05, 120.85, 111.28, 57.64; **MS** (EI-MS) = 242 (M^+).7

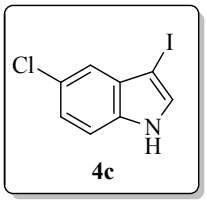
3-Iodo-5-Fluoro-1H-indole (4b) [10]



4b

Isolated yield: 75%; **mp:** 73-75 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.34 (s, 1H), 7.32-7.28 (m, 2H), 7.14-7.12 (d, 1H, *J* = 9.3 Hz), 7.01-6.97 (m, 1H); **^{13}C NMR** (500 MHz, $CDCl_3$): δ 159.57 (s), 157.69 (s), 132.14 (s), 130.57 (d, *J* = 10.5 Hz), 130.11 (s), 111.98 (dd, *J* = 34.6, 18.1 Hz), 106.17 (d, *J* = 24.6 Hz), 57.03 (d, *J* = 4.5 Hz); **MS** (EI-MS) = 261 (M+1)

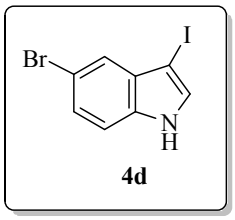
3-Iodo-5-Chloro-1H-indole (4c) [10]



4c

Isolated yield: 82%; **mp:** 81-84 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.38 (s, 1H) , 7.45-7.44 (d, 1H, *J* = 1.9 Hz), 7.31-7.28 (m, 2H) 7.21-7.18 (dd, 1H, *J* = 8.6, 10.6 Hz); **^{13}C NMR** (500 MHz,$CDCl_3$): δ 134.08, 131.06, 129.75, 126.75, 123.66, 120.66, 112.37, 56.75; MS (EI-MS) = 277 [M^+], 279 [M + 2].

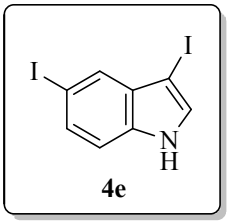
3-Iodo-5-Bromo-1H-indole (4d) [6]



4d

Isolated yield: 85%;**mp:** 106-108 °C (lit) [6];**^{1}H NMR** (500 MHz, $CDCl_3$): δ 10.60 (s, 1H), 7.28-7.23 (m, 1H), 7.15-7.09 (m, 2H), 6.88-6.81 (m, 1H);**^{13}C NMR** (500 MHz, $CDCl_3$): δ 131.46, 130.97, 128.87, 125.94, 122.59, 114.09, 112.34, 103.50; **MS** (EI-MS) = 323 (M+2), 321 (M^+).

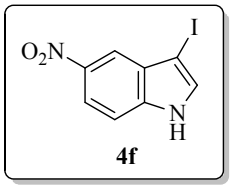
3, 5-diiodo-1H-indole (4e) [6, 8]



4e

Isolated yield: 89%; **mp:** 110-112 °C ; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.36 (s, 1H), 7.32-7.29 (dd, 1H, J = 8.3, 10.0 Hz), 7.14-7.12 (d, 1H, J = 2.5 Hz), 7.01-6.97 (d, 1H, J = 8.3 Hz); **^{13}C NMR** (400 MHz, $CDCl_3$): δ 134.84, 132.30, 131.64, 129.98, 129.20, 113.22, 84.28, 56.33; **MS** (EI-MS) = 368 (M^+), **HRMS** (EI-HRMS) =calcd for $C_8H_5BrN_2O_2$ = 368.8511, found = 368.8510.

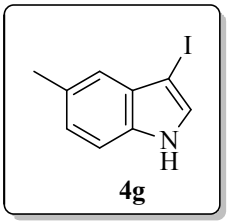
3-Iodo-5-nitro-1H-indole (4f) [9]



4f

Isolated yield: 68%; **mp:** 199-201 °C; **^{1}H NMR** (300 MHz, $CDCl_3$+d_6-DMSO): δ 11.73 (s, 1H), 8.38 (s, 1H), 8.12-8.08 (dd, 1H, J = 8.8, 11.0 Hz), 7.54-7.51 (m, 2H); **^{13}C NMR** (300 MHz, $CDCl_3$+d_6-DMSO): δ 143.91, 140.79, 138.45, 131.88, 128.26, 116.51, 111.27, 56.87; **MS** (EI-MS) = 230.5.

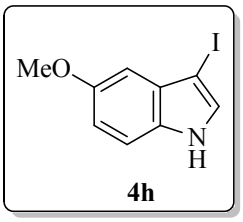
3-Iodo-5-methyl-1H-indole (4g) [9]



4g

Isolated yield: 94%; **mp:** 70-72 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.28 (s, 1H), 7.29-7.26 (m, 3H), 7.11-7.08 (dd, 1H, J = 8.2, 9.6 Hz), 2.51 (s, 3H); **^{13}C NMR** (500 MHz, $CDCl_3$): δ 133.94, 130.33, 129.97, 128.43, 124.88, 120.58, 110.98, 57.07, 21.44; **MS** (EI-MS) = 257 (M+1).

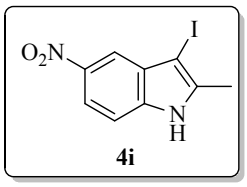
3-Iodo-5-methoxy-1H-indole (4h) [9]



4h

Isolated yield: 92%; **mp:**106-108 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.98 (s, 1H), 7.25-7.04 (m, 3H), 6.92-6.88 (dd, 1H, *J* = 8.8, 11.2 Hz), 3.88 (s, 3H). **^{13}C NMR** (500 MHz, $CDCl_3$): δ 154.23, 130.99, 128.32, 124.90, 112.39, 111.74, 102.41, 55.90, 30.99; **MS** (EI-MS) = 272 (M^+).

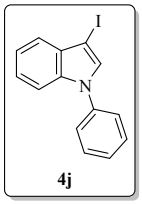
3-Iodo-2-methyl-5-nitro-1H-indole (4i)



4i

Isolated yield: 71%; **mp:** 180-182 °C; **^{1}H NMR** (300 MHz, $CDCl_3$+d_6-DMSO): δ 11.58 (s, 1H), 8.23-8.22 (d, 1H, *J* = 2.2 Hz), 8.02-7.98 (dd, 1H, *J* = 8.8, 11.2 Hz), 7.36-7.33 (d, 1H, *J* = 8.8 Hz), 2.49 (s, 3H); **^{13}C NMR** (300 MHz, $CDCl_3$+d_6-DMSO): δ 140.91, 140.59, 139.14, 129.58, 116.31, 115.93, 110.45, 58.65, 13.60; **MS** (EI-MS) = 301.95500.

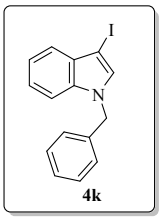
3-iodo-1-phenyl-1H-indole (4j)



4j

Isolated yield: 90%; **mp:** 99-102 °C; **^{1}H NMR** (400 MHz, $CDCl_3$+d_6-DMSO): δ 7.62-7.48 (m, 7H), 7.57 (s, 1H), 7.35-7.30 (m, 1H), 7.25-7.16 (m, 2H),; **^{13}C NMR** (400 MHz, $CDCl_3$+d_6-DMSO): δ 168.49, 139.44132.89, 129.80, 128.81, 127.73, 126.87, 122.59, 120.45, 119.61, 117.70, 117.30, 109.74, 50.15; **MS** (EI-MS) = 318 (M^+), **HRMS** (EI-HRMS) =calcd for $C_{14}H_{10}BrIN$= 318.9850, found = 318.9857.

1-benzyl-3-iodo-1H-indole (4k) [11]

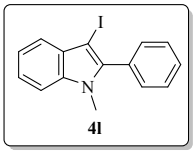


4k

Isolated yield: 82%; **mp:** 77-80 °C; **^{1}H NMR** (500 MHz, $CDCl_3$+d_6-DMSO): δ 7.58-7.56 (d, 1H, *J* = 7.8 Hz), 7.33 (s, 1H), 7.29-7.24 (m, 5H), 7.20-7.17 (m, 1H), 7.13-7.10 (m, 3H), 5.26 (s, 2H); **^{13}C NMR** (400 MHz, $CDCl_3$+d_6-DMSO): δ 168.58, 137.25, 133.39, 129.80,

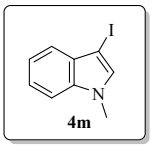
128.81, 127.73, 126.87, 122.59, 120.45, 119.61, 117.70, 117.30, 109.74, 50.15, 29.73; **MS** (EI-MS): 333 (M^+).

3-iodo-1-methyl-2-phenyl-1H-indole (4l) [6]



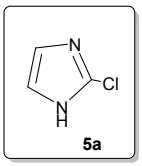
Isolated yield: 94%; **^{1}H NMR** (500 MHz, $CDCl_3$+d_6-DMSO): δ 7.51-7.43 (m, 6H), 7.30-7.28 (m, 2H), 7.24-7.19 (m, 1H), 3.64 (s, 3H); **^{13}C NMR** (400 MHz, $CDCl_3$+d_6-DMSO): δ 141.81, 137.84, 131.70, 131.00, 130.65, 130.46, 128.88, 128.74, 128.51, 123.00, 121.54, 120.81, 109.95, 58.98, 32.10; **MS**(EI-MS) = 333(M^+).

3-iodo-1-methyl-1H-indole (4m) [13]



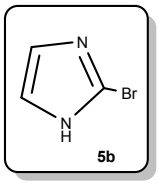
Isolated yield: 94%; **^{1}H NMR** (500 MHz, $CDCl_3$+d_6-DMSO): δ 7.43-7.41 (d, 1H, *J* = 7.8 Hz), 7.24-7.23 (m, 2H), 7.19-7.15 (m, 1H), 7.03 (s, 1H), 3.69 (s, 3H); **^{13}C NMR** (500 MHz, $CDCl_3$+d_6-DMSO): δ 136.82, 132.77, 130.46, 122.68, 121.18, 120.31, 109.47, 54.81, 33.15; **MS** (EI-MS) = 256 (M^+).

2-chloro-1H-imidazole (5a) [14]



Isolated yield: 88%; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 11.81 (s, 1H), 7.84 (s, 1H), 7.09 (s, 1H); **^{13}C NMR** (400 MHz, $CDCl_3$): δ 177.74, 134.60, 120.99; **MS** (EI-MS) =102 (M^+).

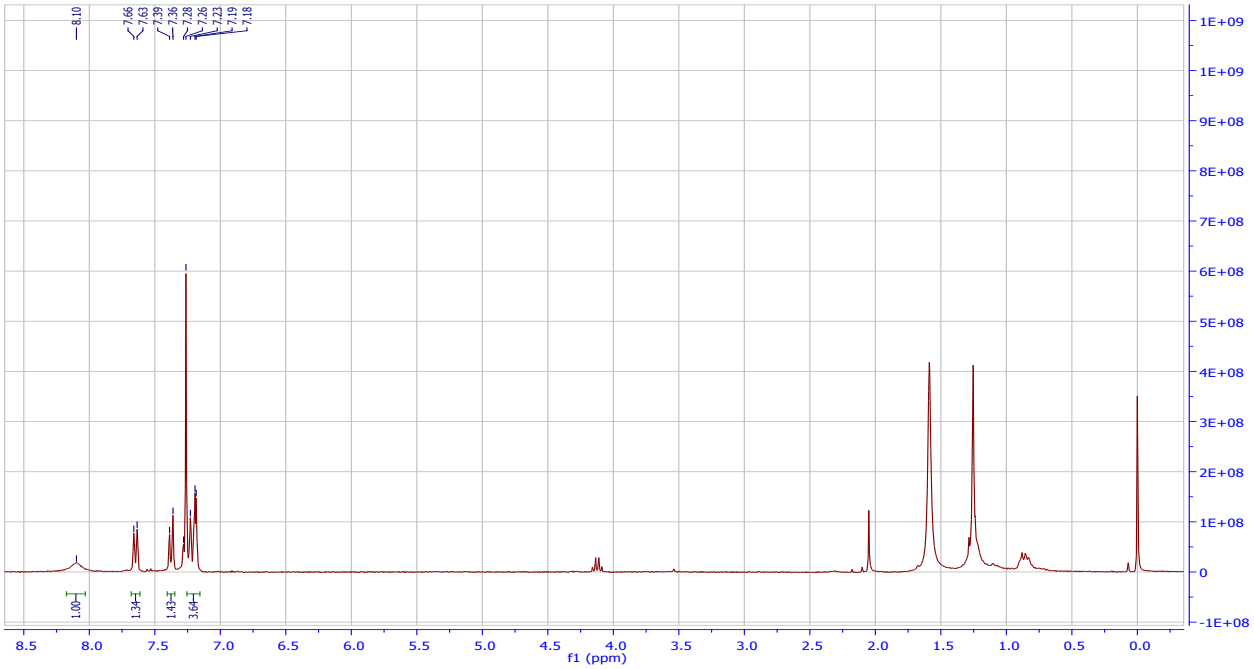
2-chloro-1H-imidazole (5b) [15]

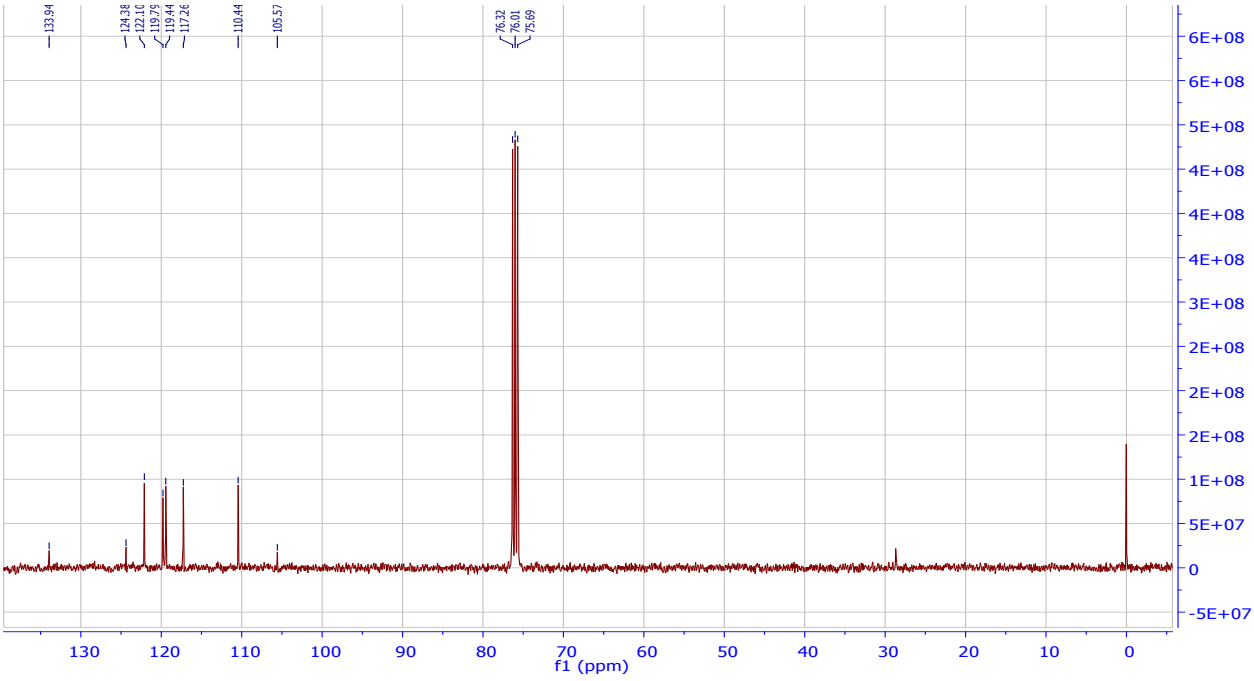


Isolated yield: 90%; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 11.69 (s, 1H), 7.78 (s, 1H), 7.09 (s, 1H); **^{13}C NMR** (400 MHz, $CDCl_3$): δ 177.82, 134.80, 121.28; **MS** (EI-MS) =145 (M^+).

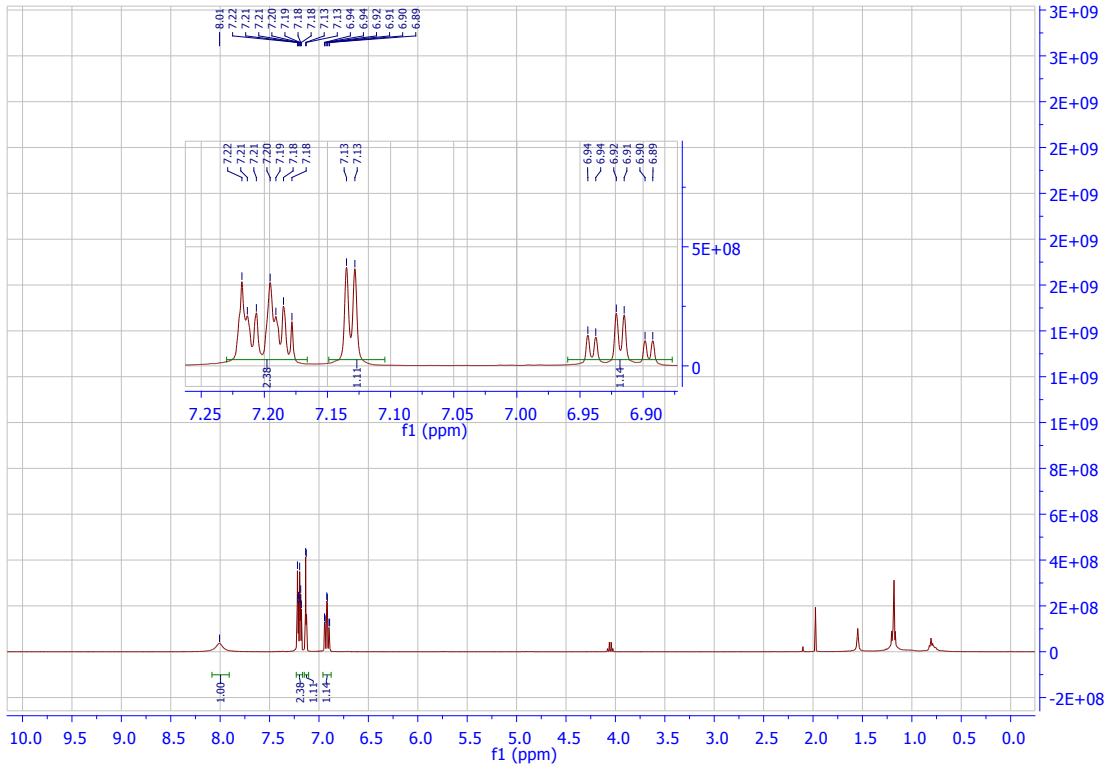
4. ^{1}H NMR and ^{13}C NMR Spectra of the Products

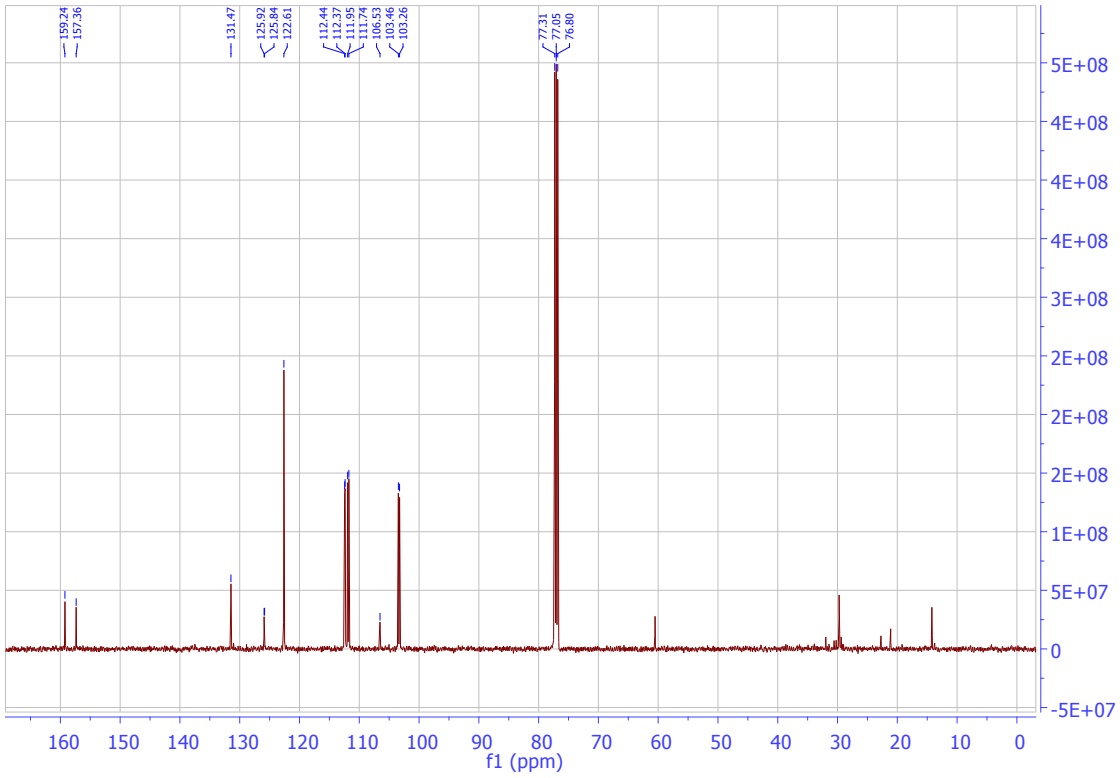
^{1}H NMR and ^{13}C NMR Spectra of Compound 2a



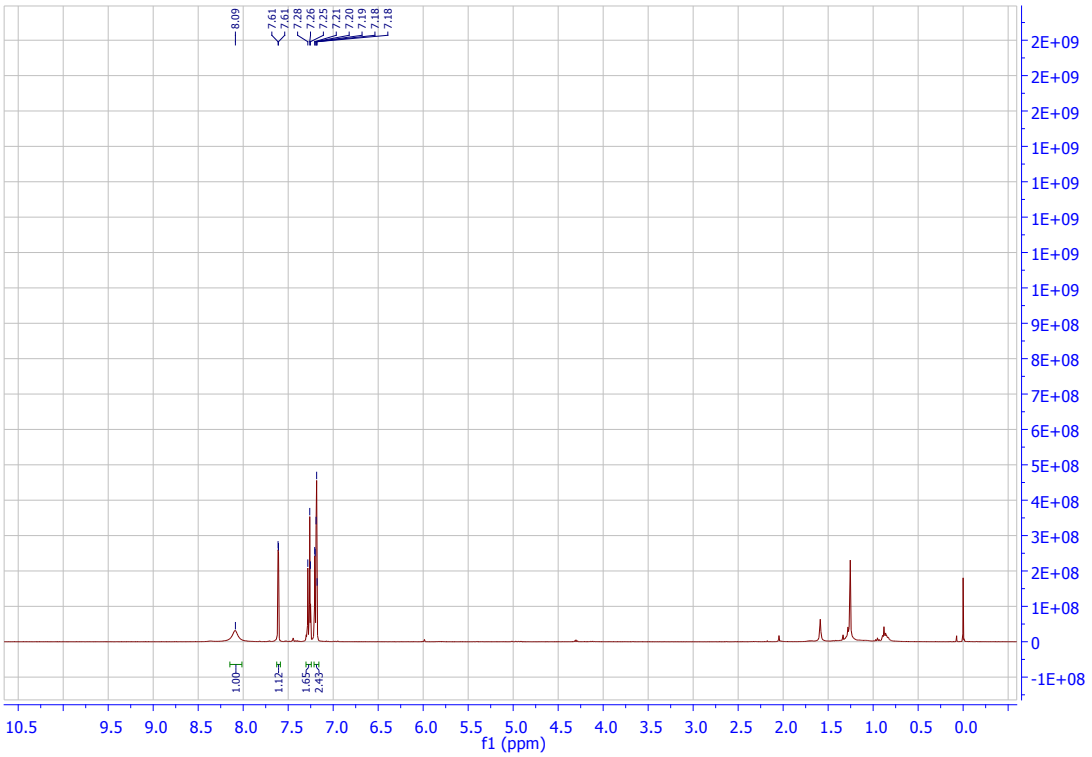


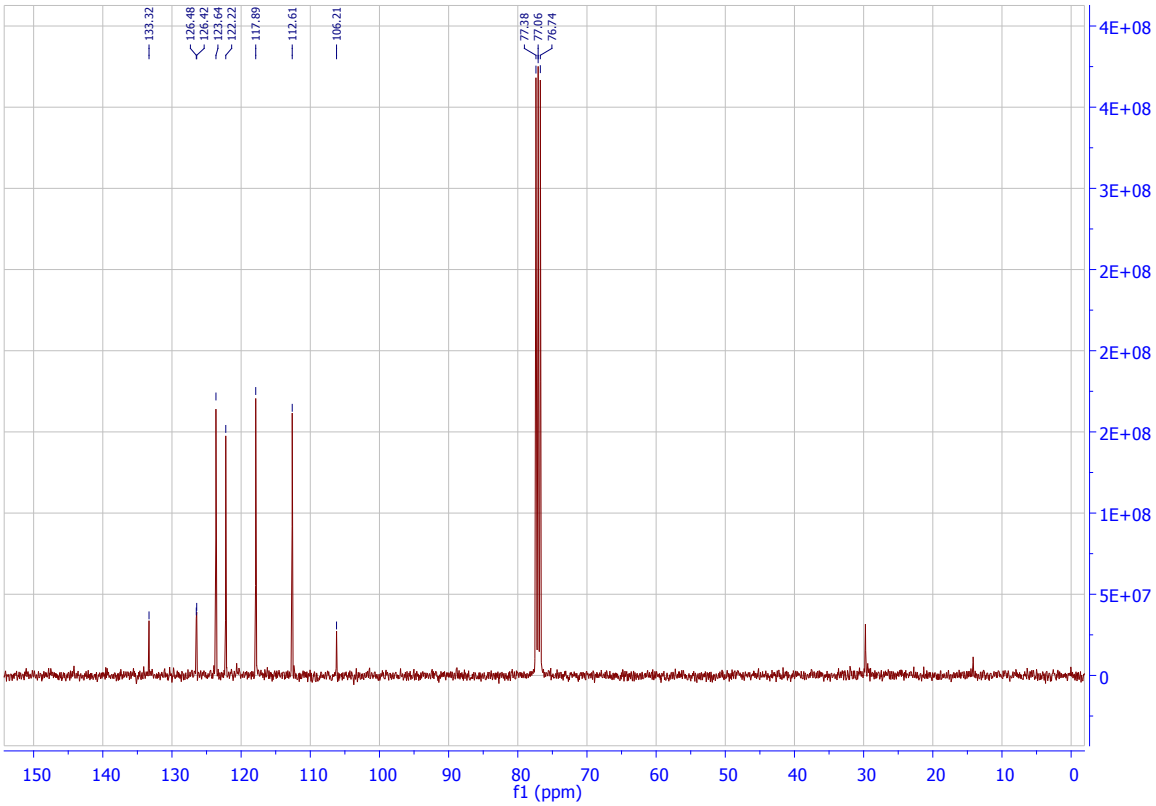
^{1}H NMR and ^{13}C NMR Spectra of Compound 2b



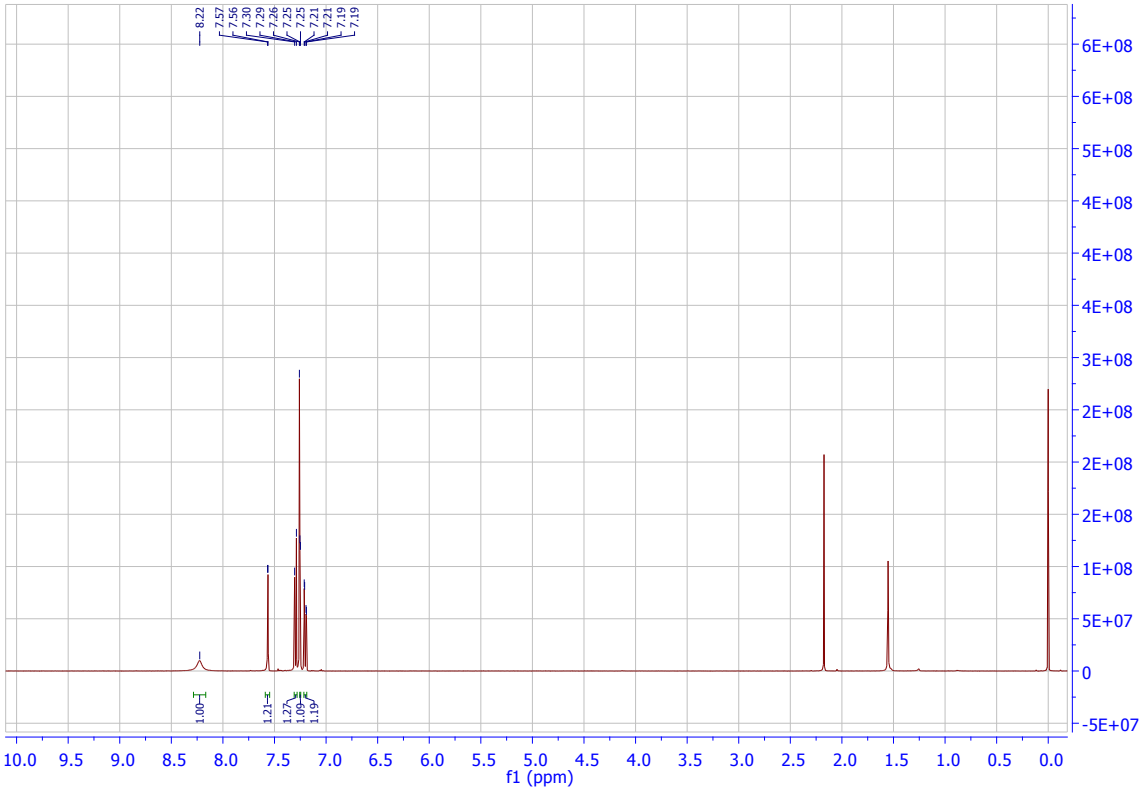


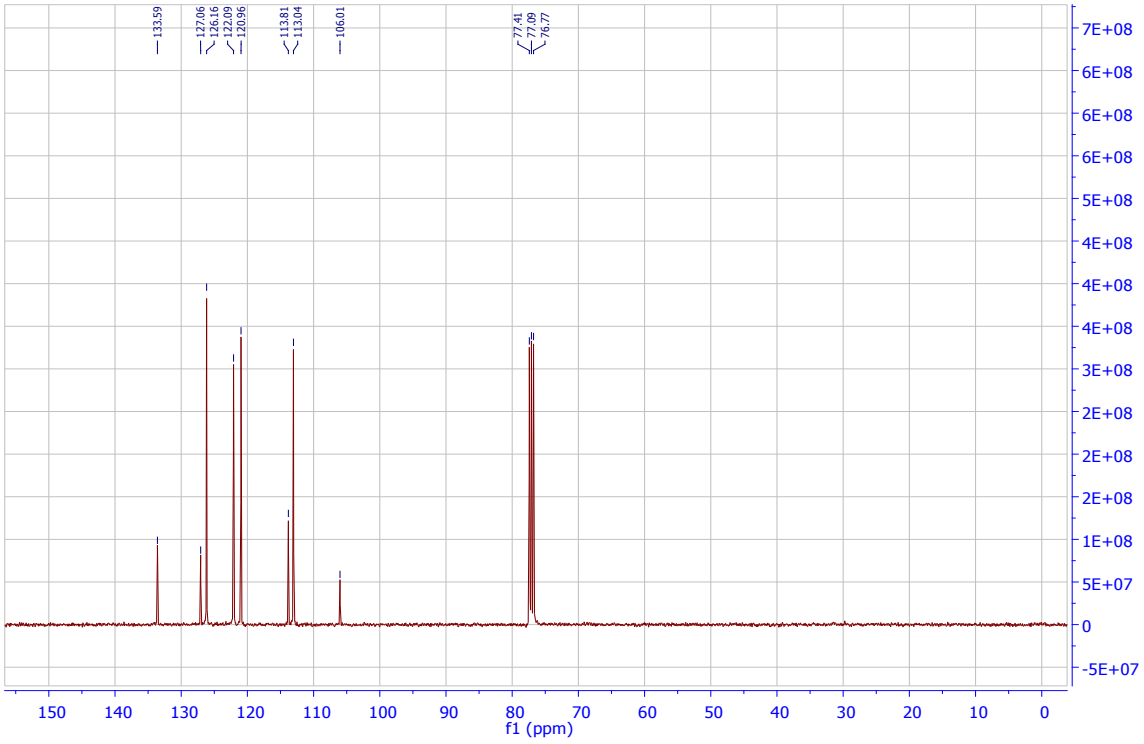
^{1}H NMR and ^{13}C NMR Spectra of Compound 2c



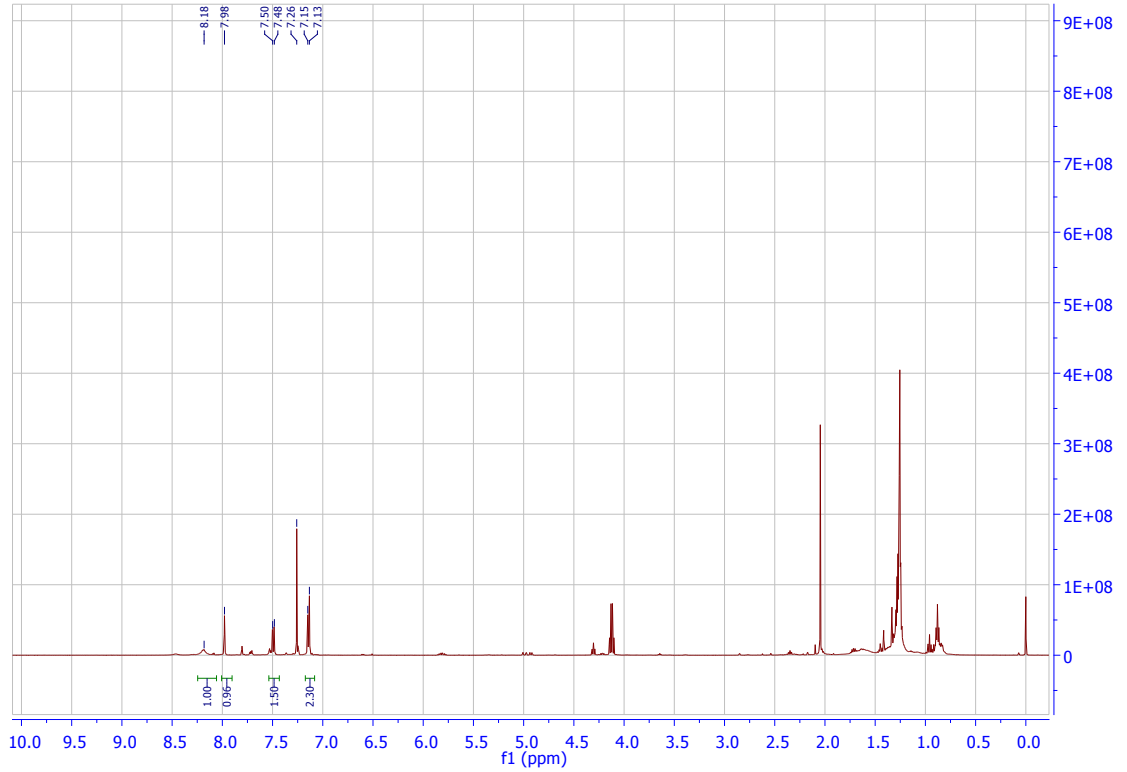


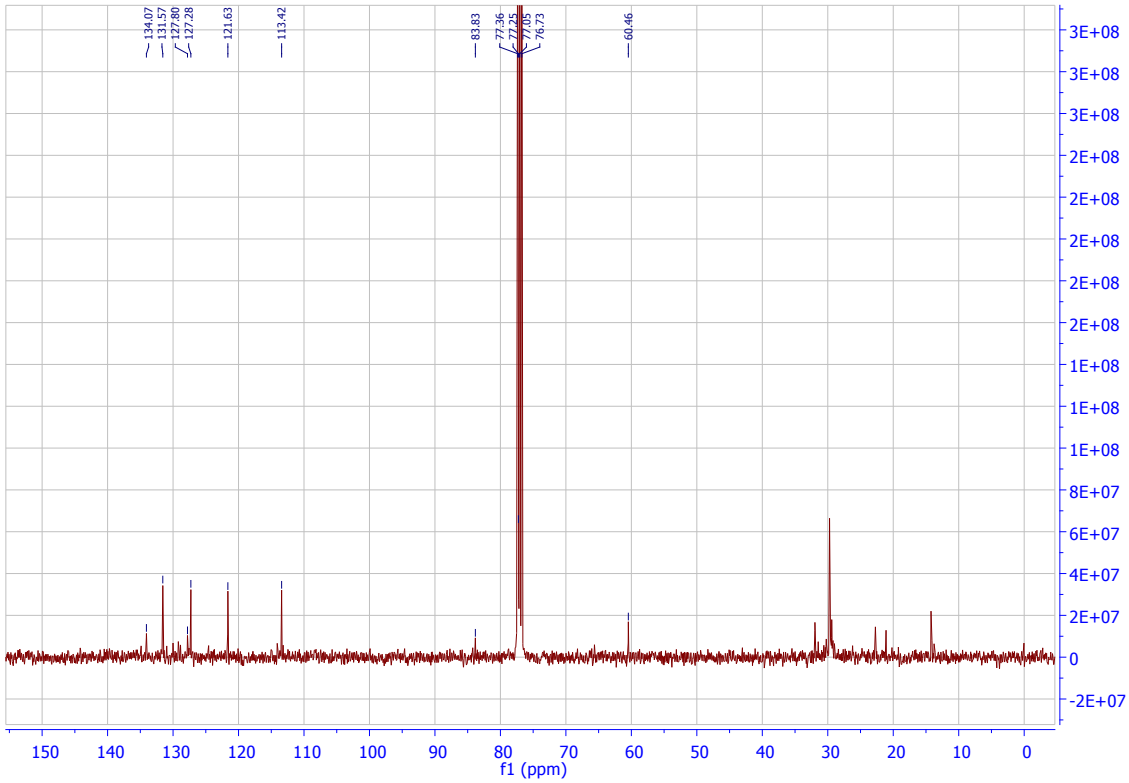
^{1}H NMR and ^{13}C NMR Spectra of Compound 2d



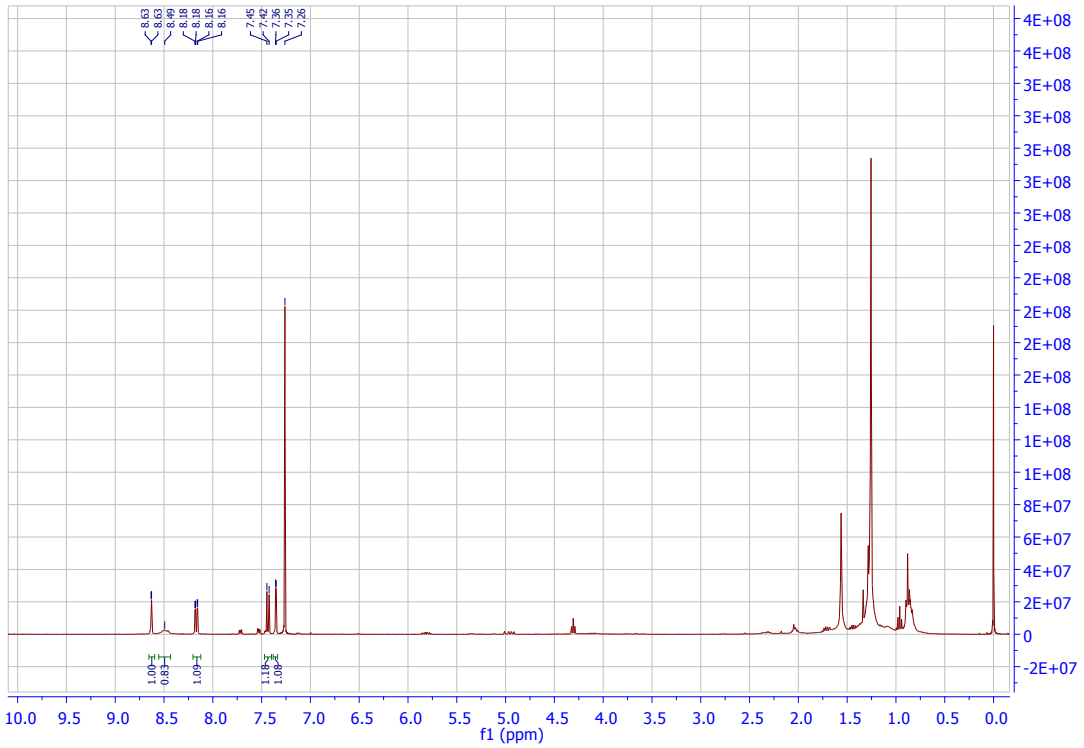


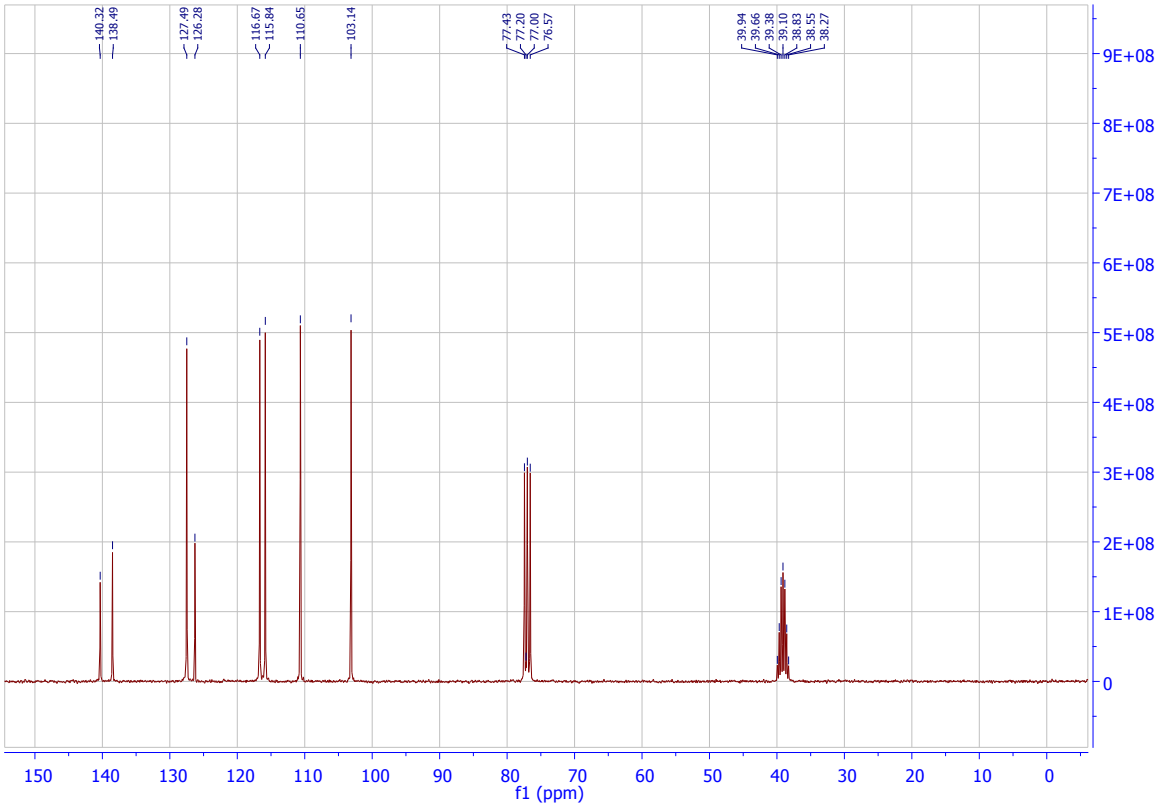
^{1}H NMR and ^{13}C NMR Spectra of Compound 2e



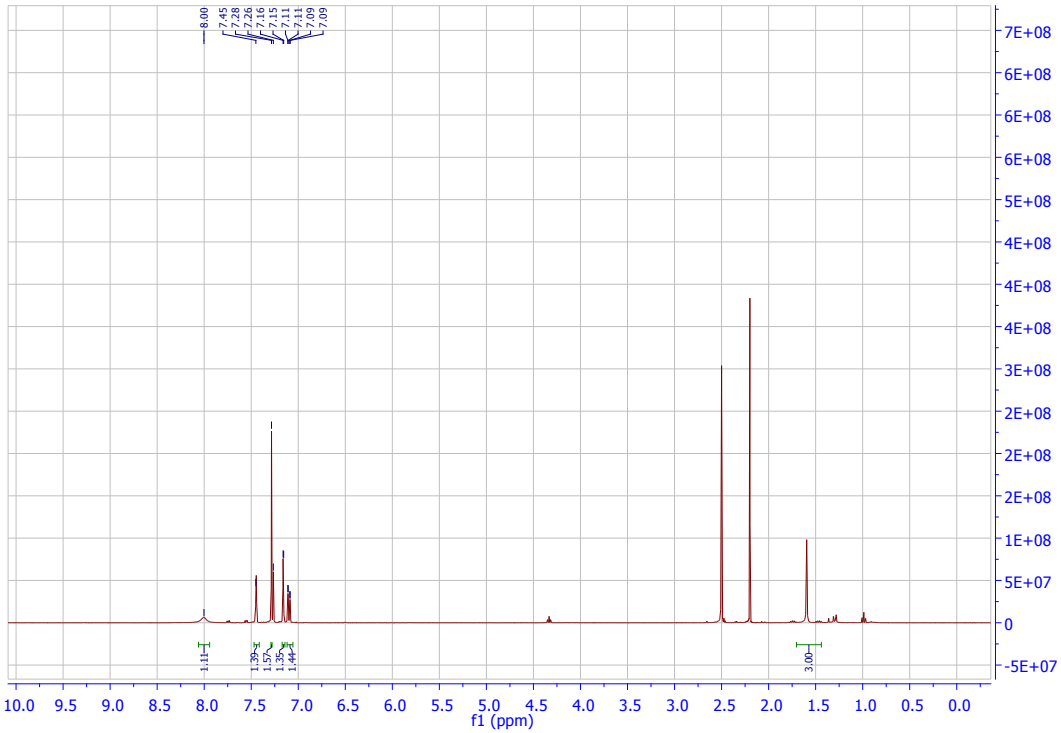


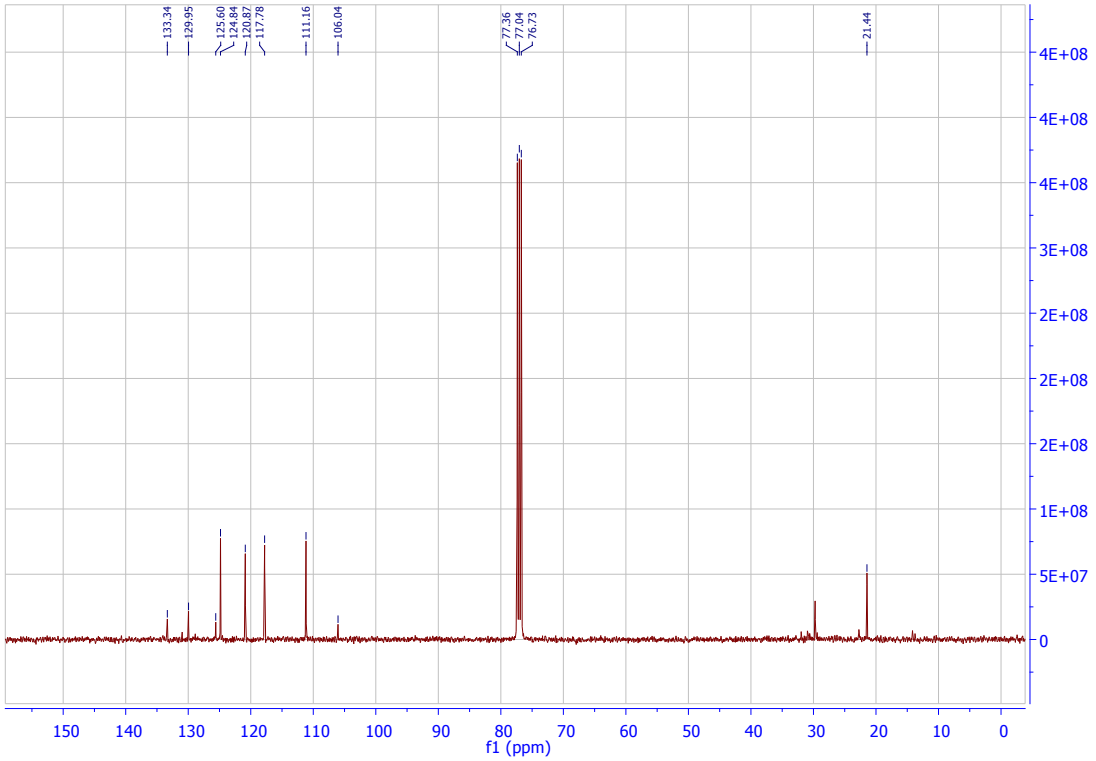
^{1}H NMR and ^{13}C NMR Spectra of Compound 2f



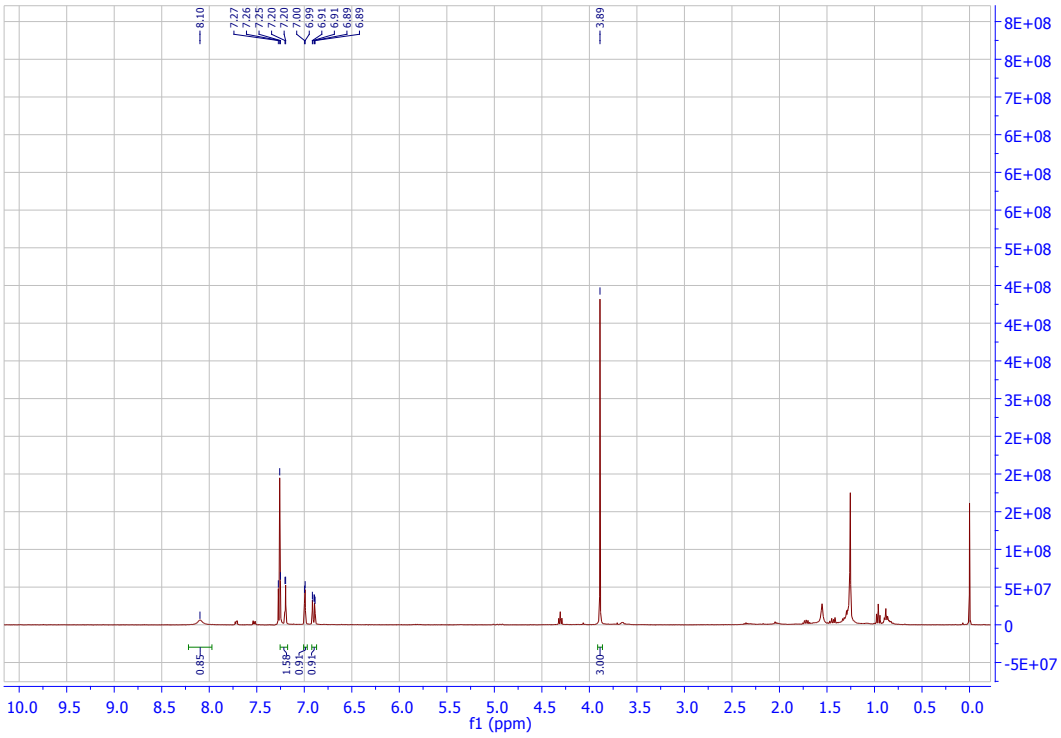


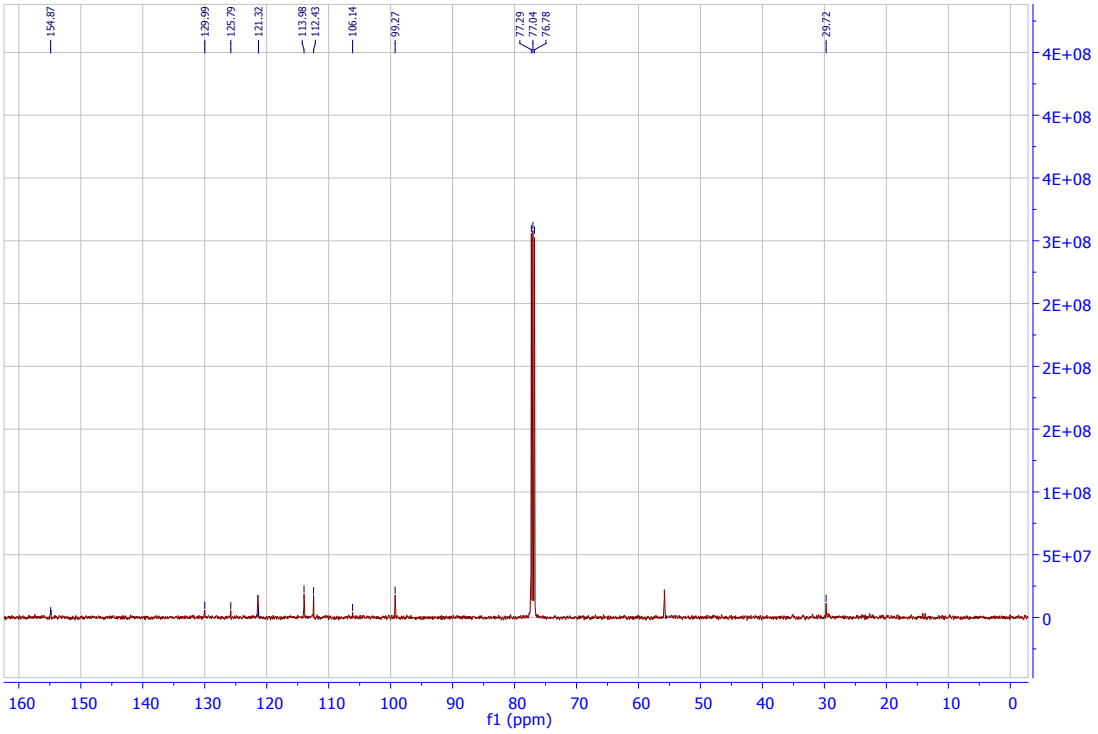
^{1}H NMR and ^{13}C NMR Spectra of Compound 2g



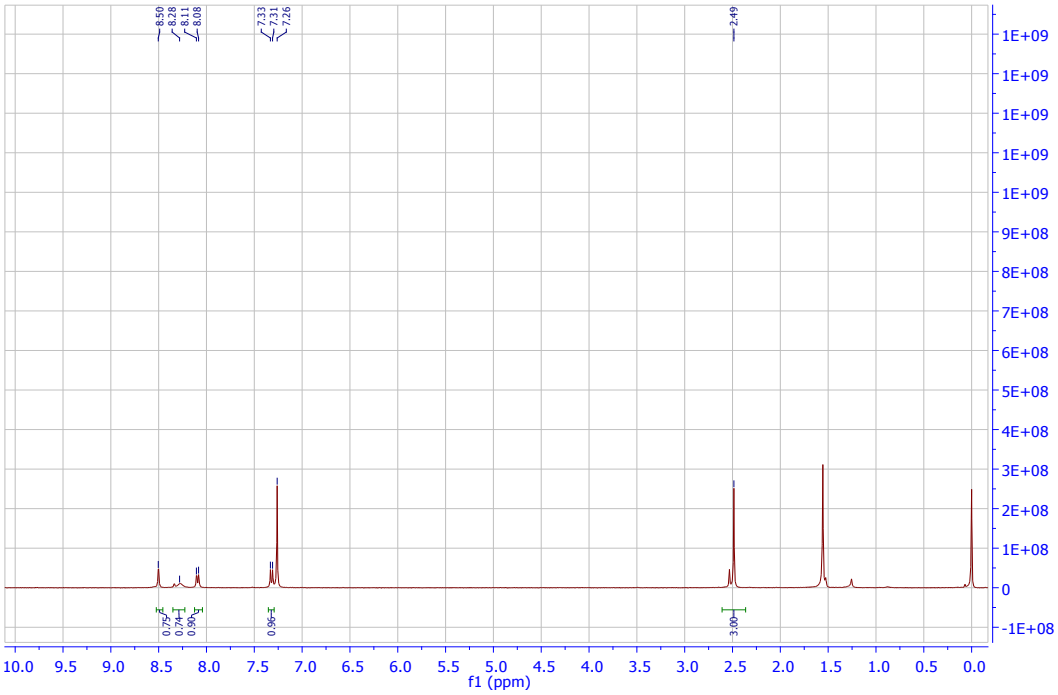


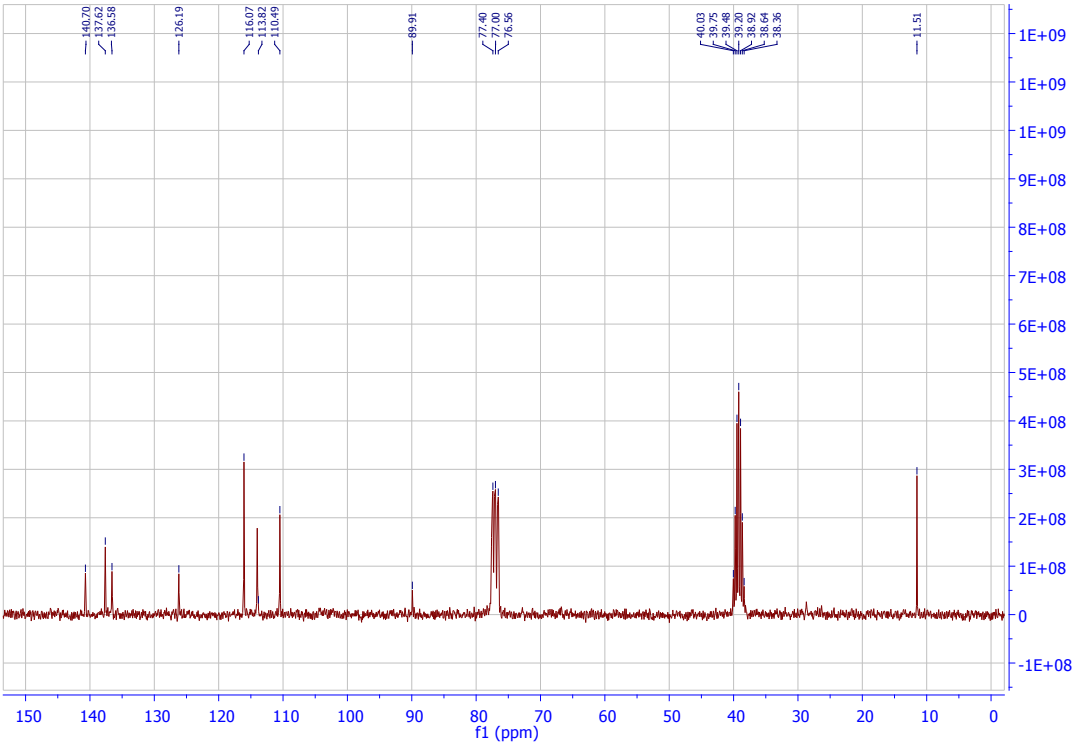
^{1}H NMR and ^{13}C NMR Spectra of Compound 2h



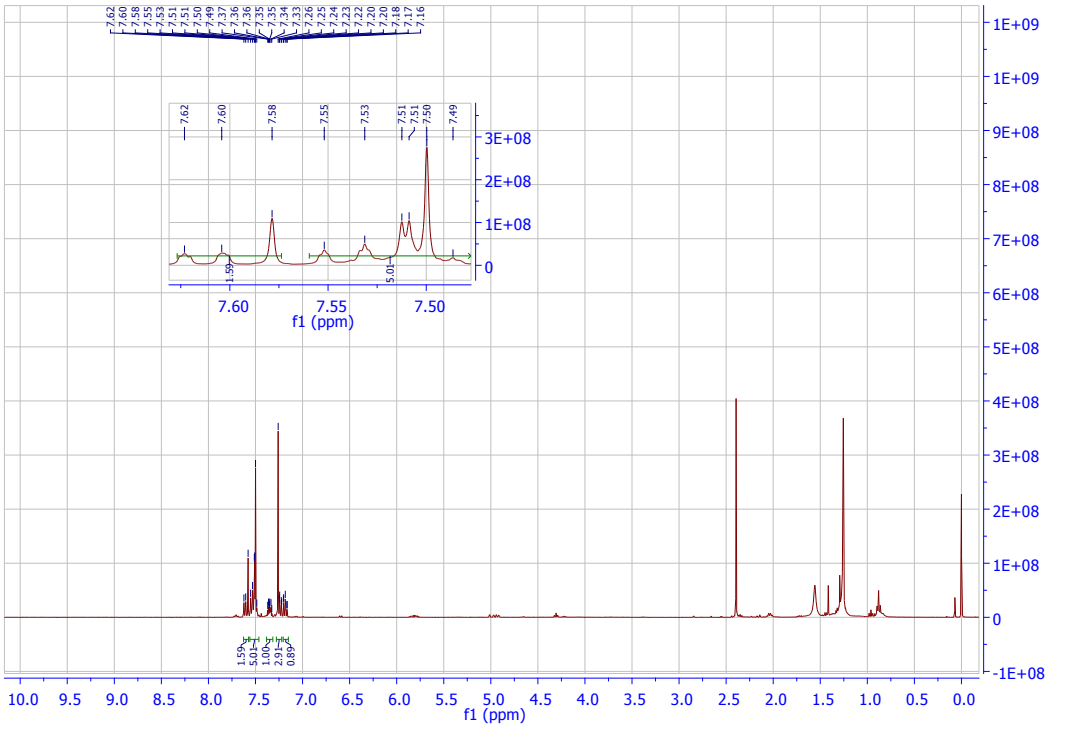


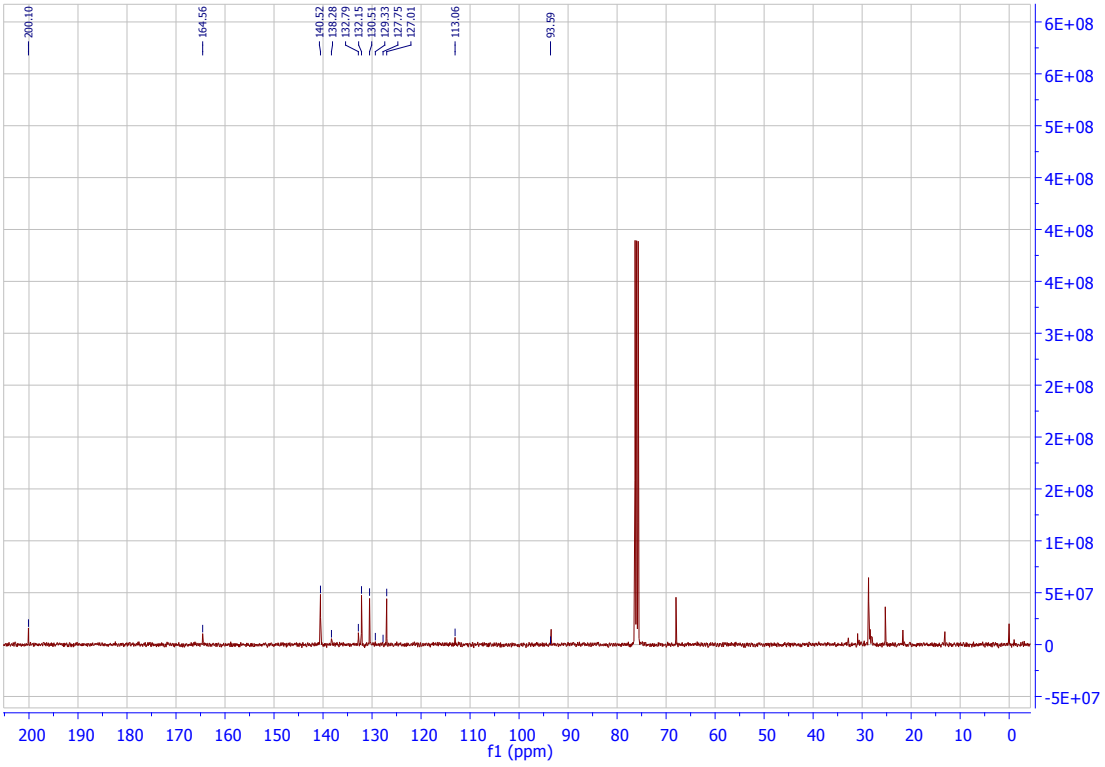
^{1}H NMR and ^{13}C NMR Spectra of Compound 2i



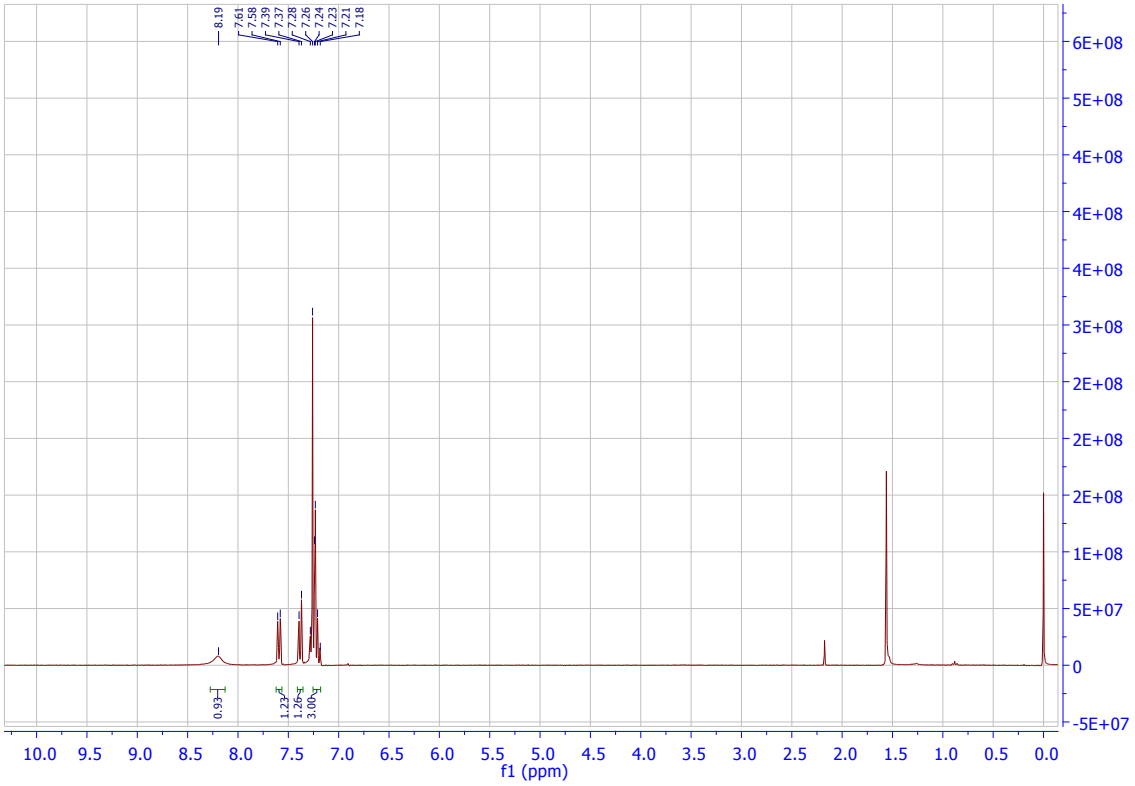


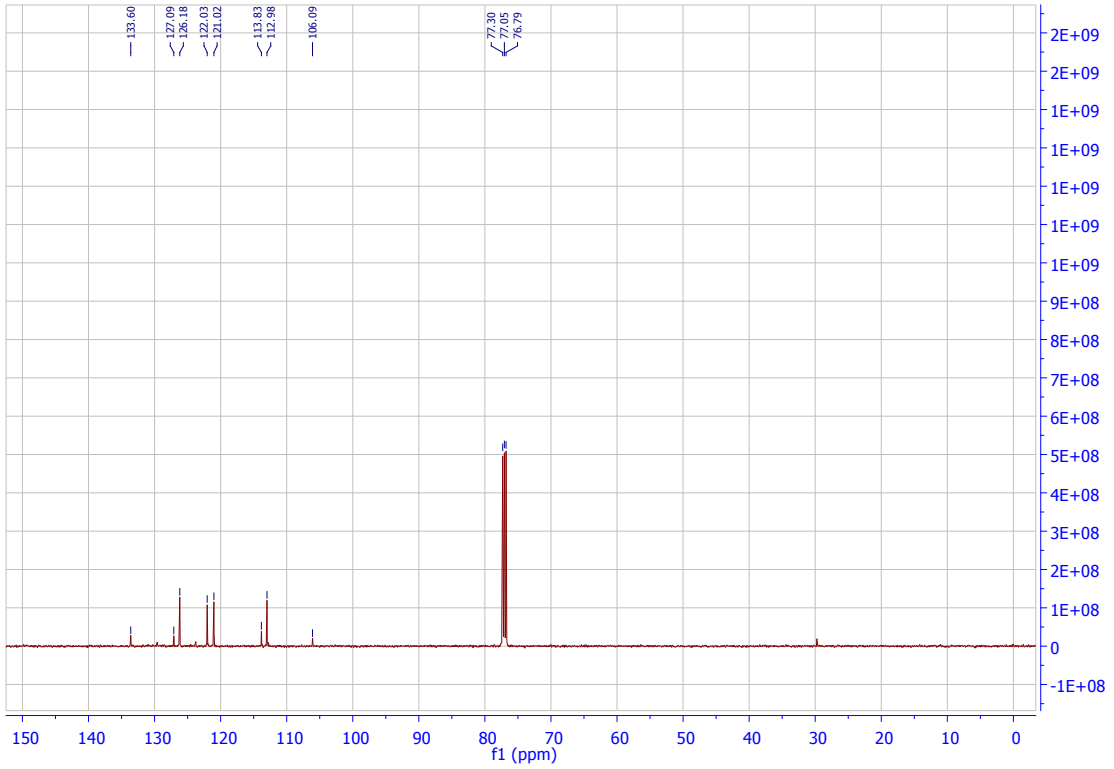
^{1}H NMR and ^{13}C NMR Spectra of Compound 2j



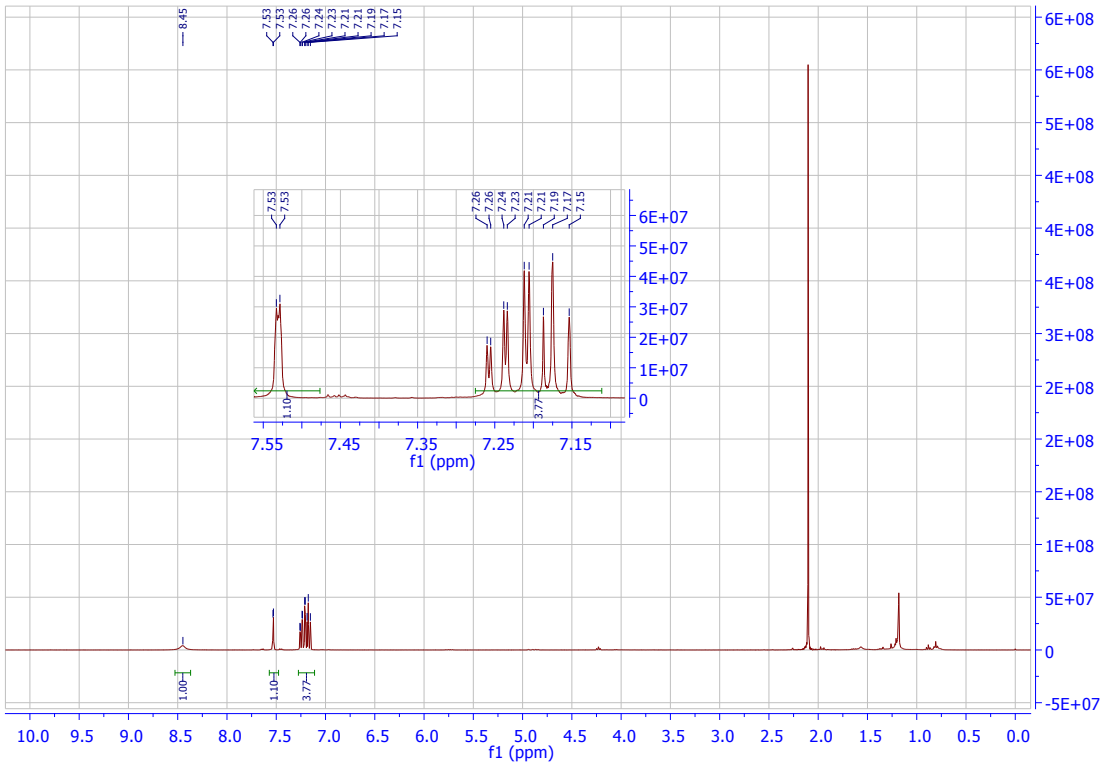


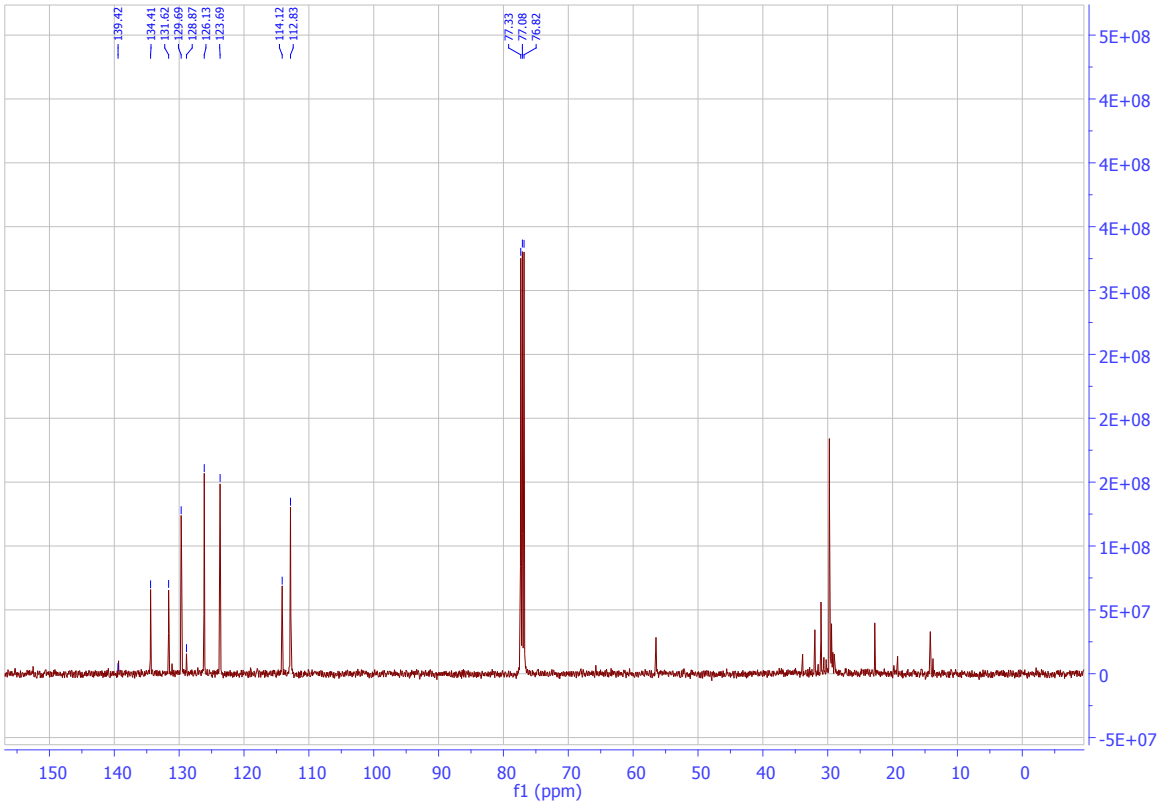
^{1}H NMR and ^{13}C NMR Spectra of Compound 3a



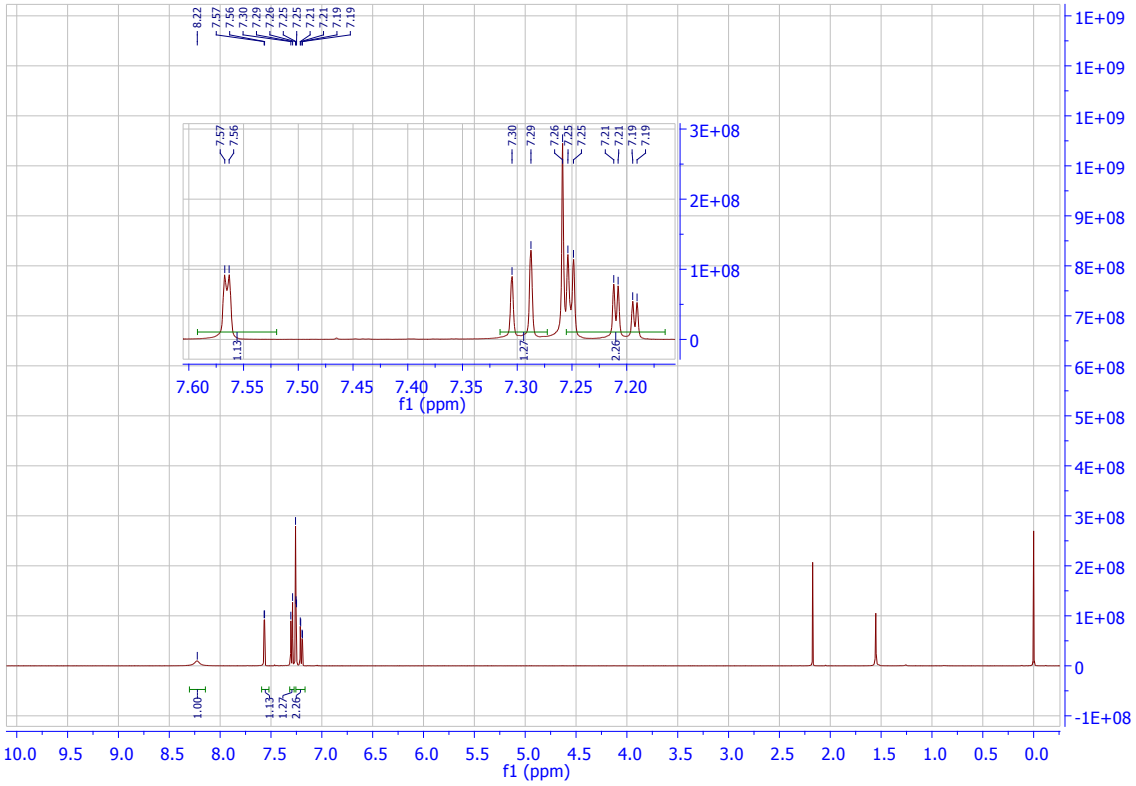


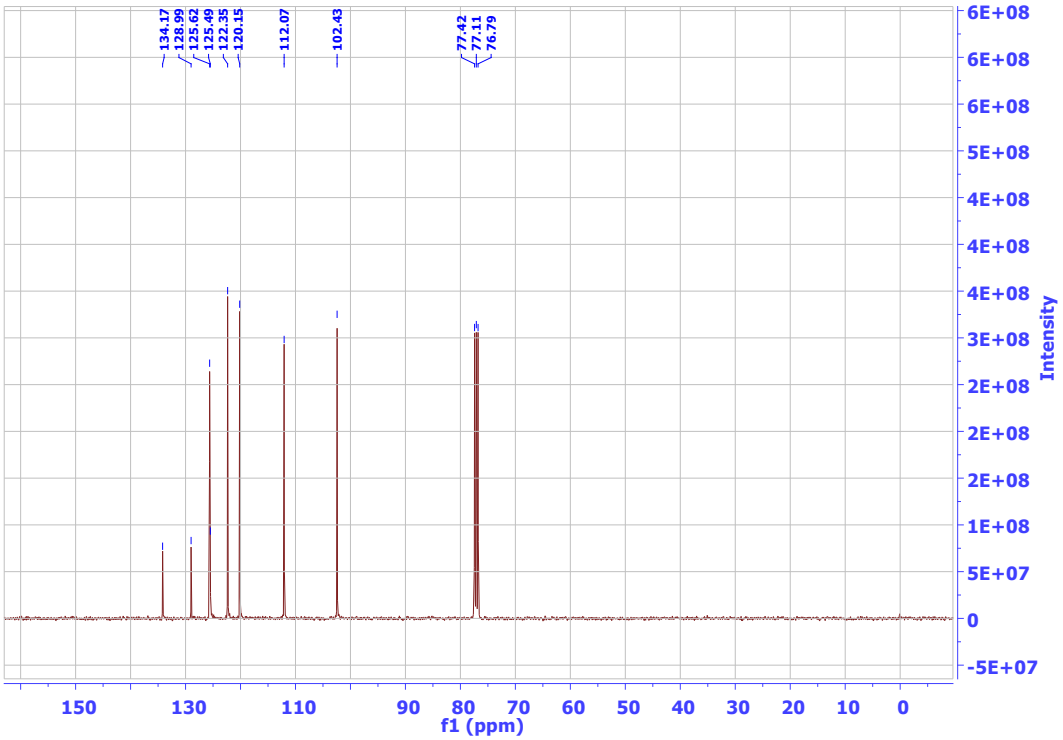
^{1}H NMR and ^{13}C NMR Spectra of Compound 3b



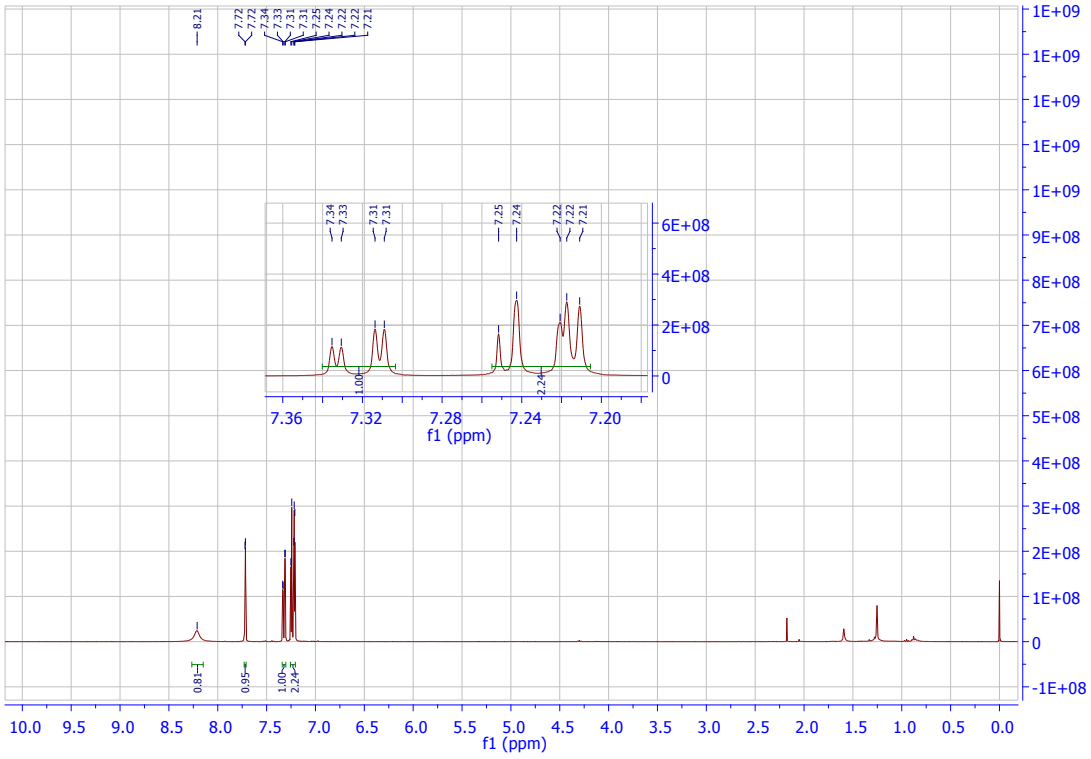


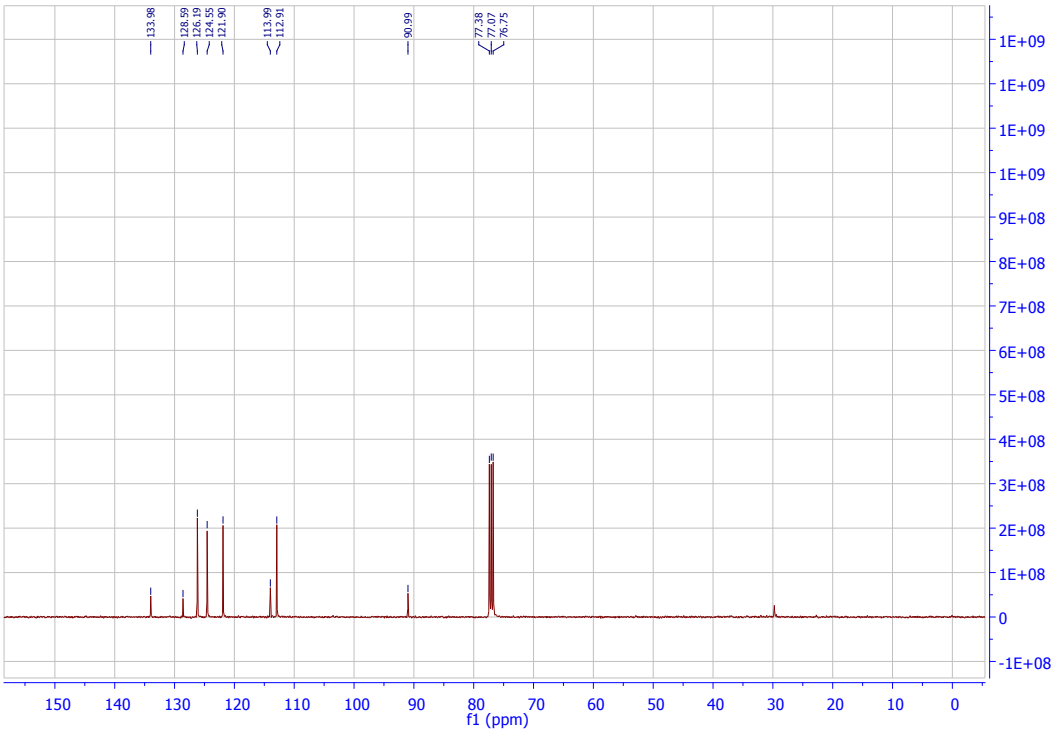
^{1}H NMR and ^{13}C NMR Spectra of Compound 3c



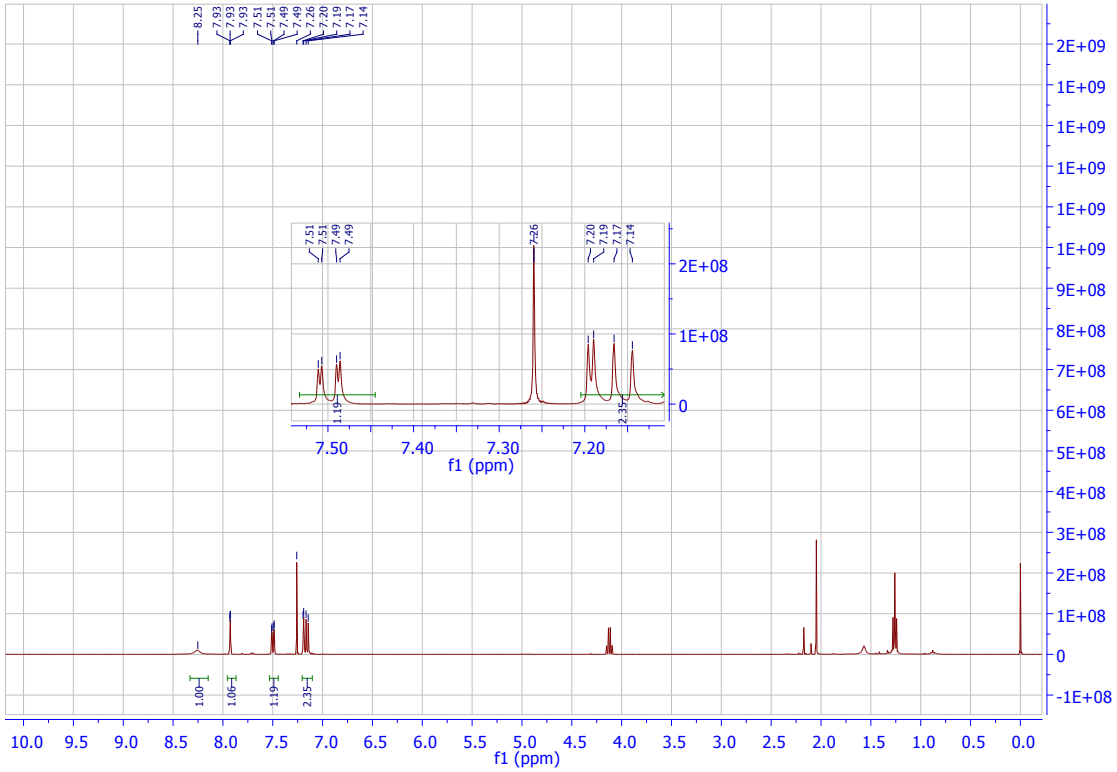


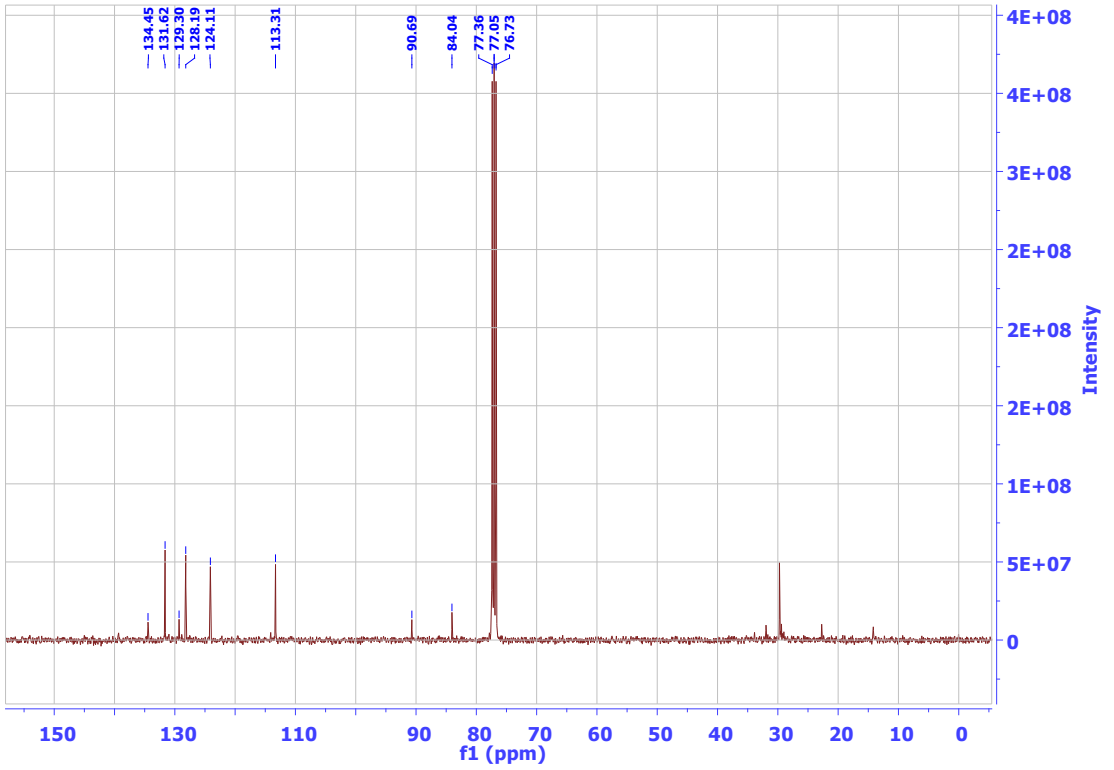
^{1}H NMR and ^{13}C NMR Spectra of Compound 3d



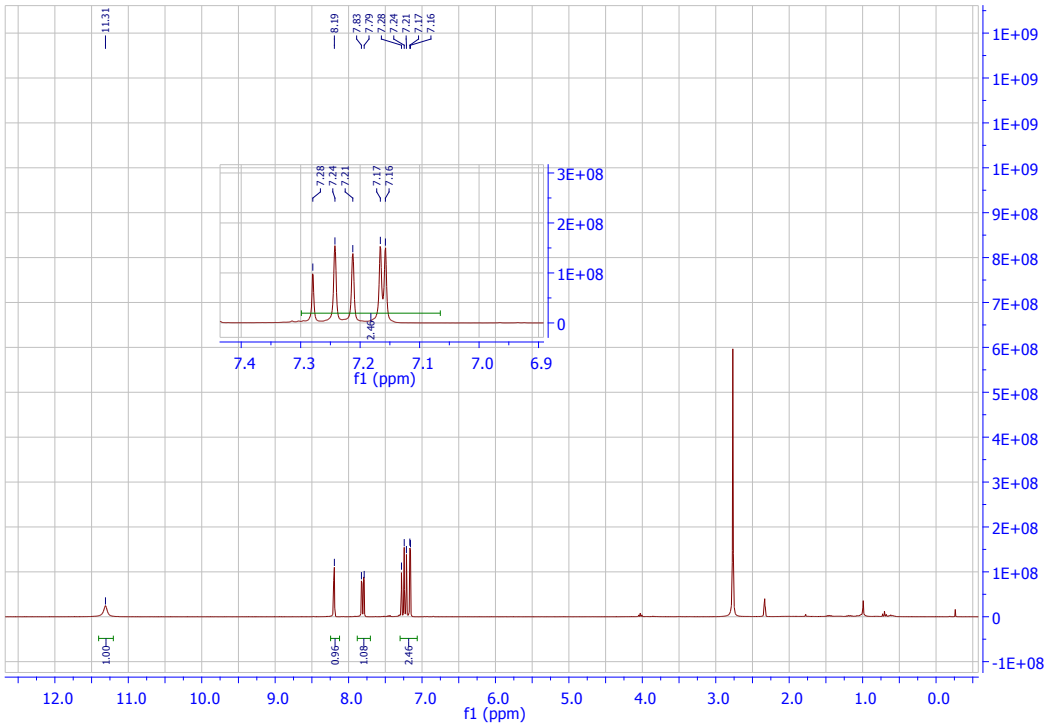


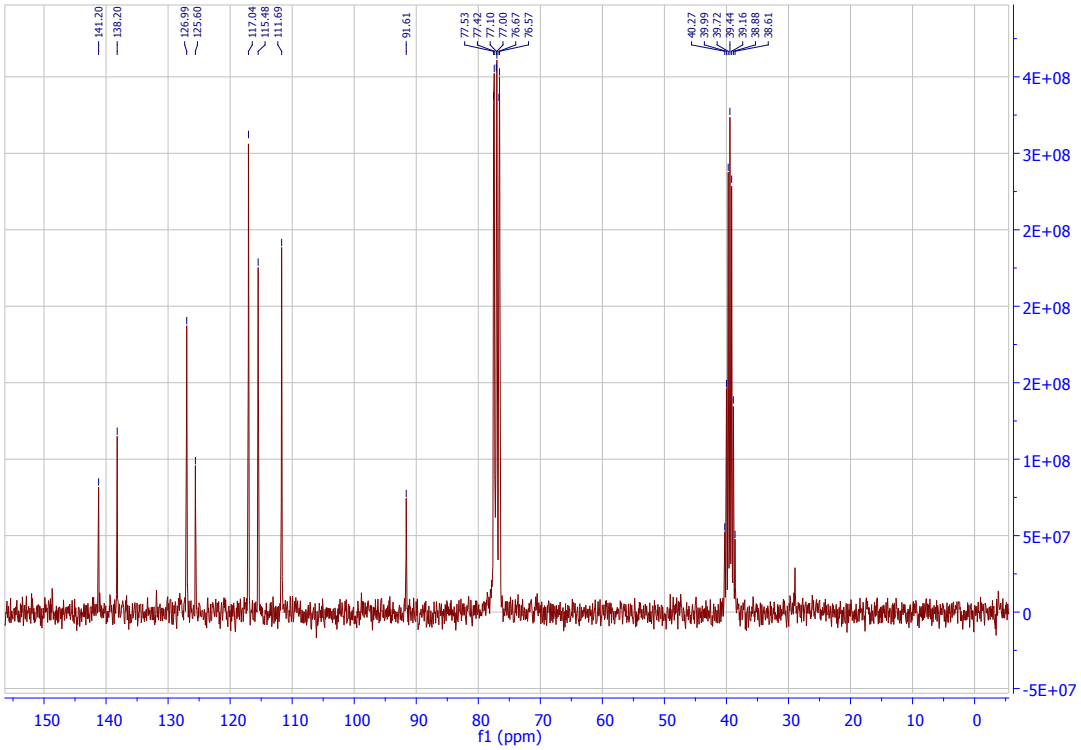
^{1}H NMR and ^{13}C NMR Spectra of Compound 3e



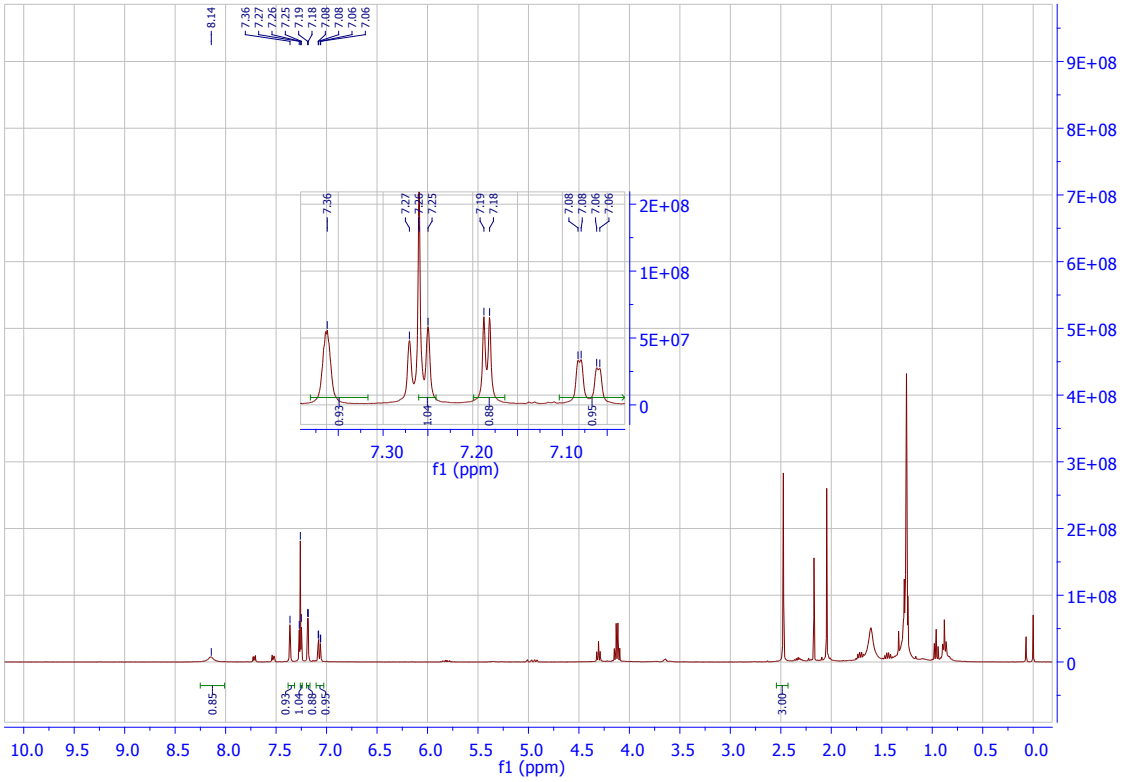


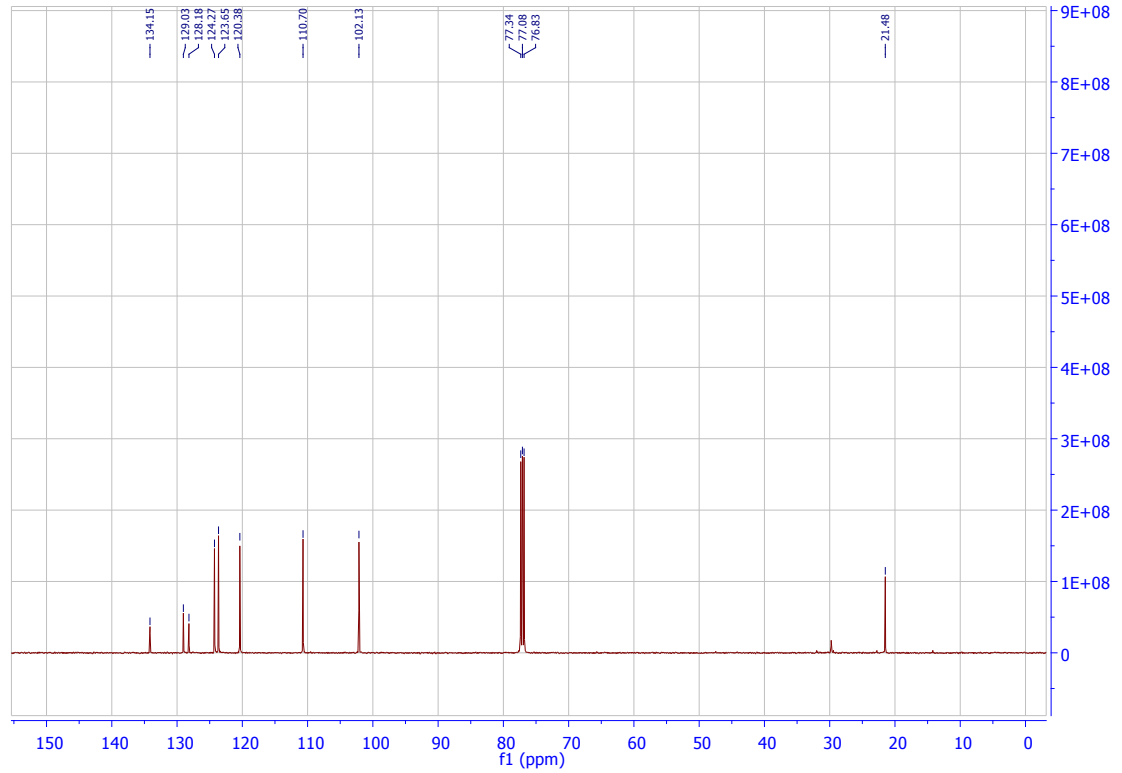
^{1}H NMR and ^{13}C NMR Spectra of Compound 3f



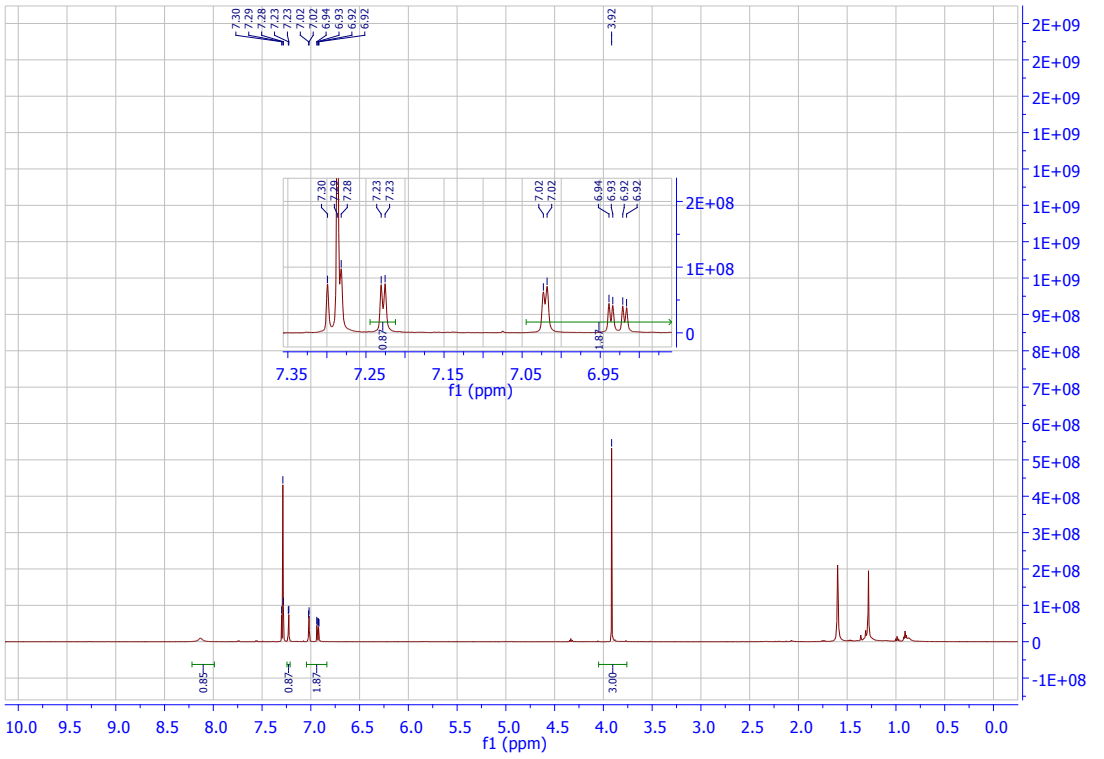


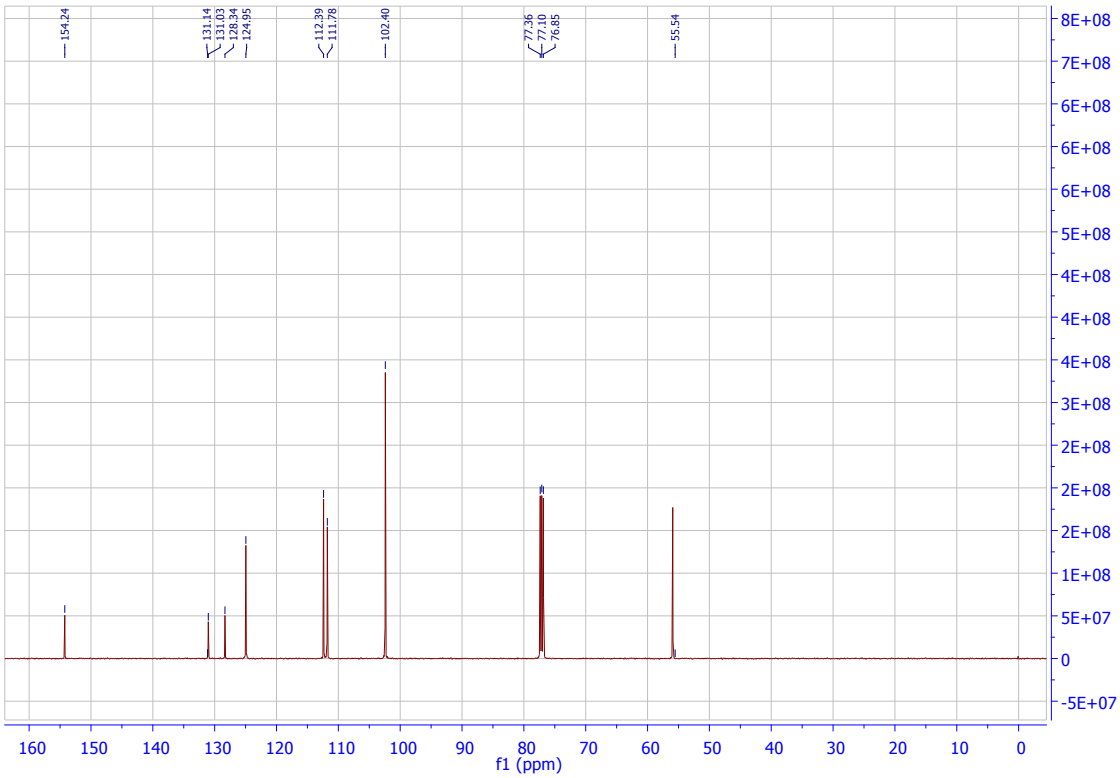
^{1}H NMR and ^{13}C NMR Spectra of Compound 3g



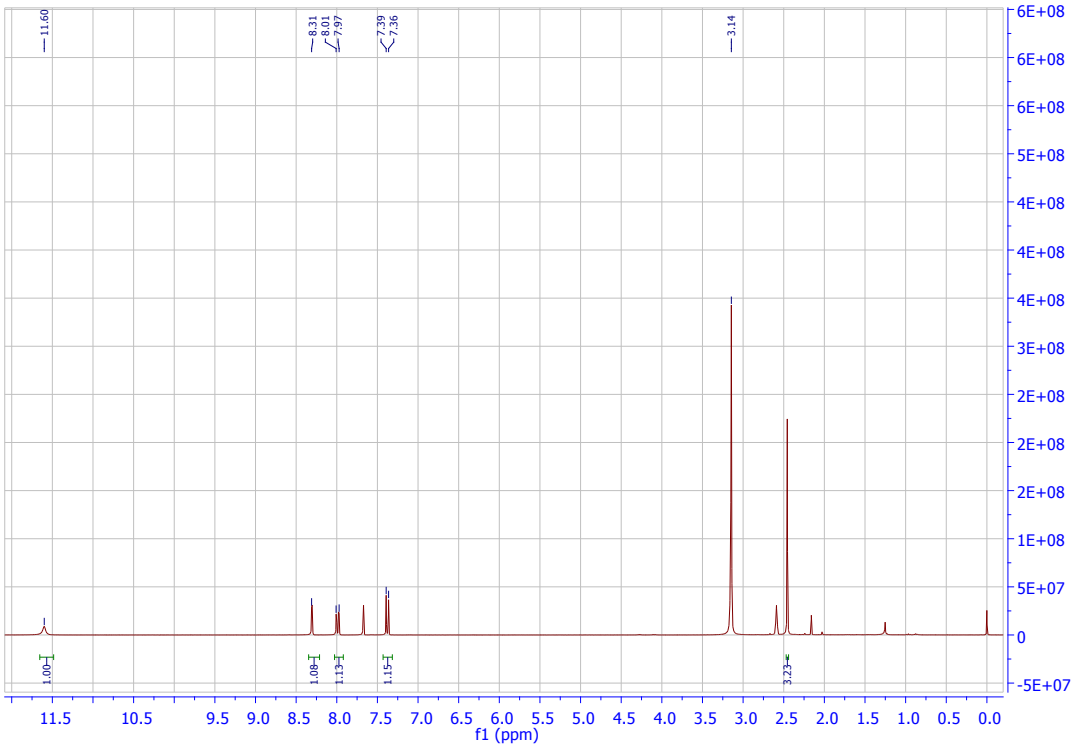


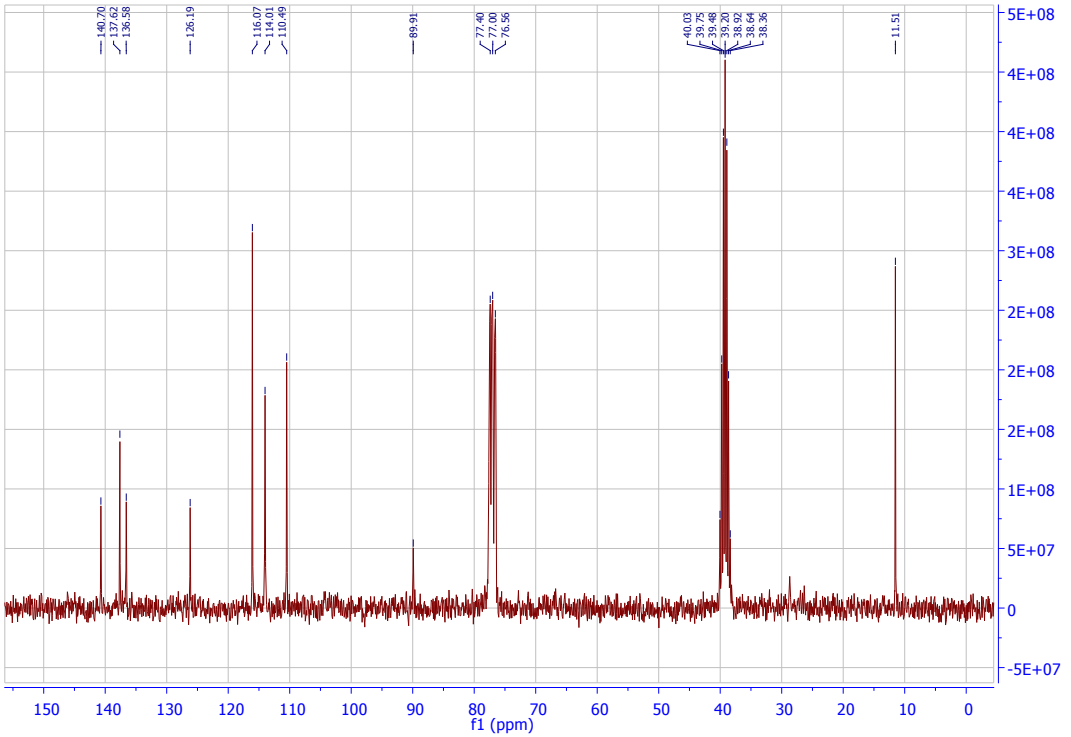
^{1}H NMR and ^{13}C NMR Spectra of Compound 3h



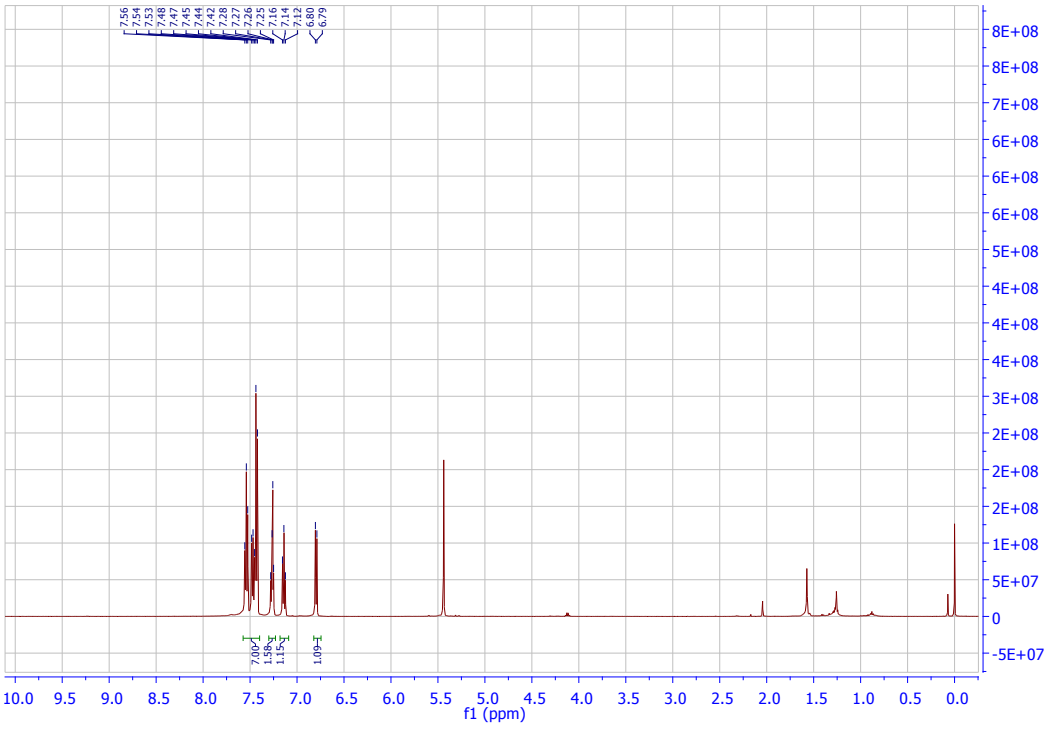


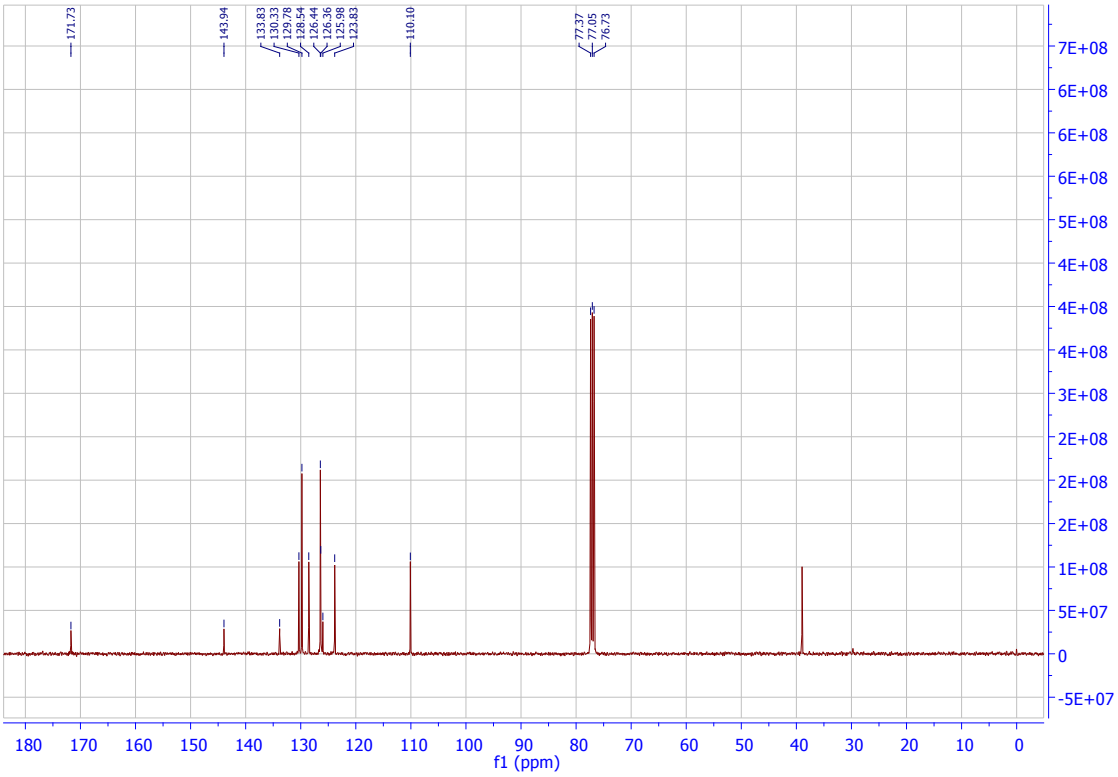
^{1}H NMR and ^{13}C NMR Spectra of Compound 3i



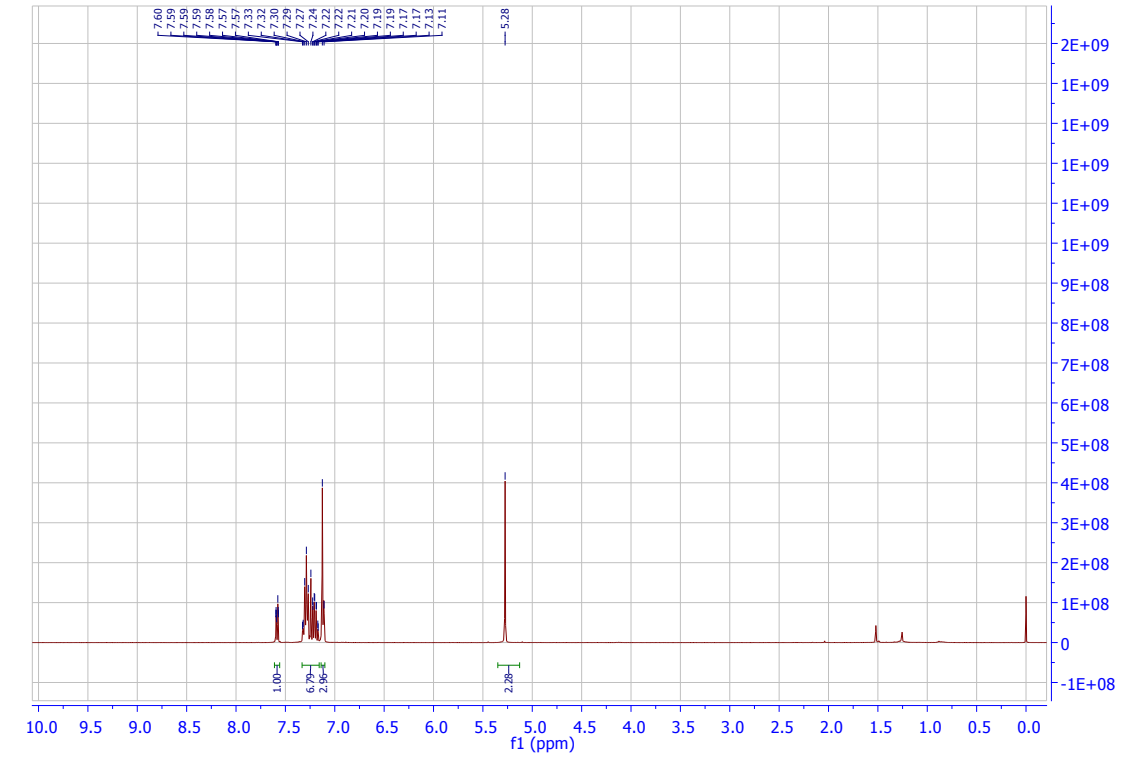


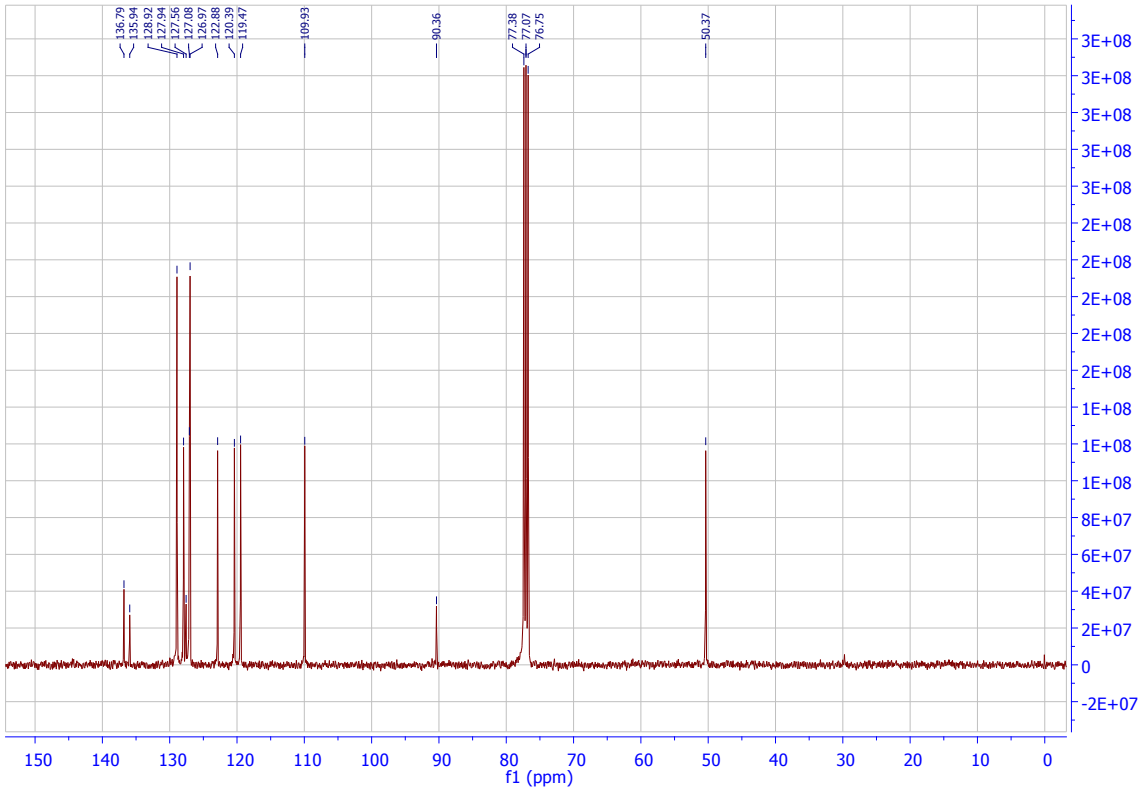
^{1}H NMR and ^{13}C NMR Spectra of Compound 3j



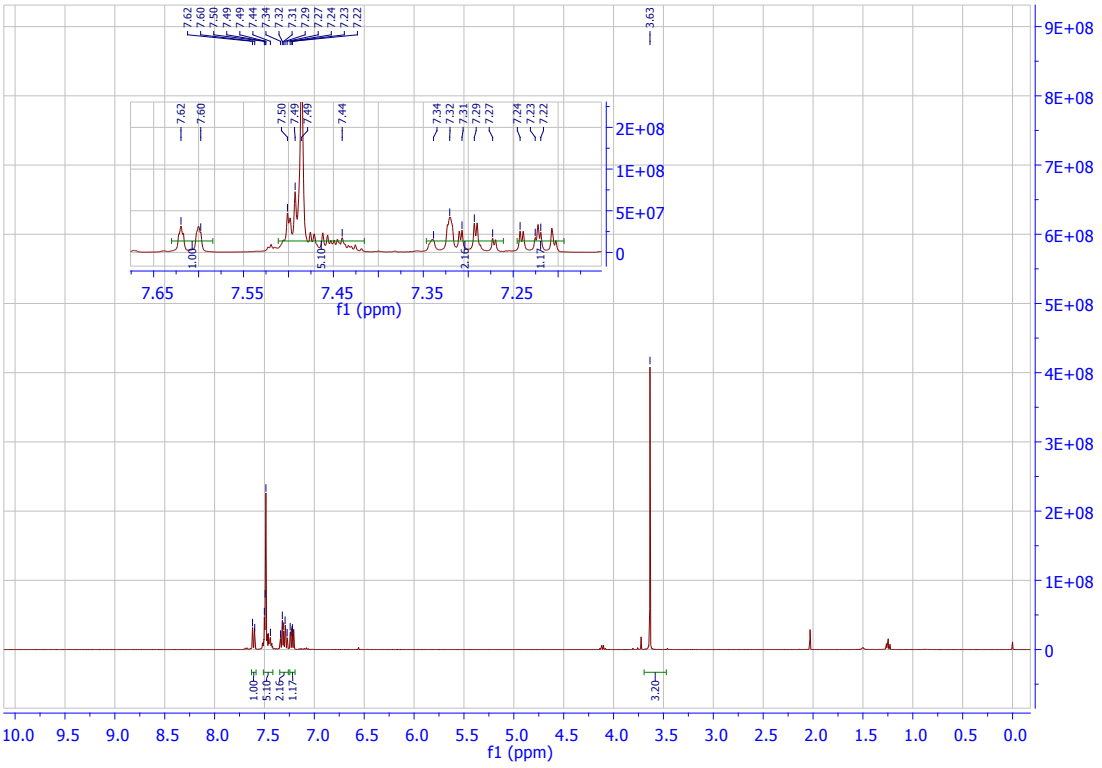


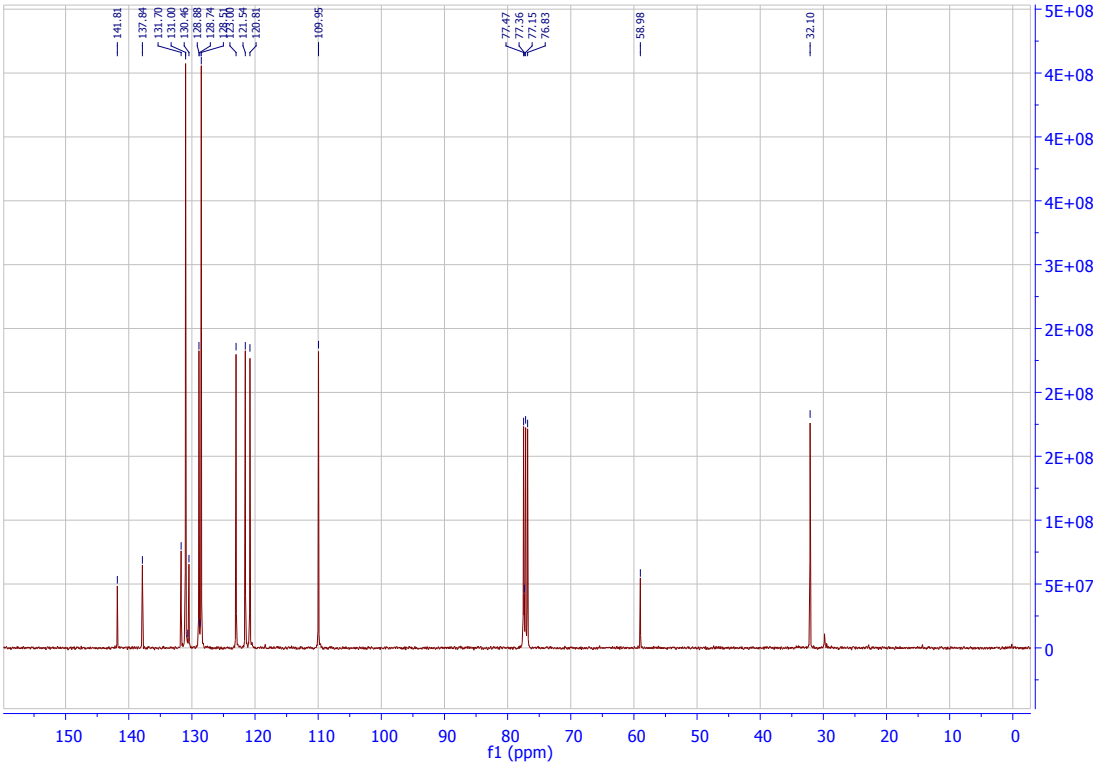
^{1}H NMR and ^{13}C NMR Spectra of Compound 3k



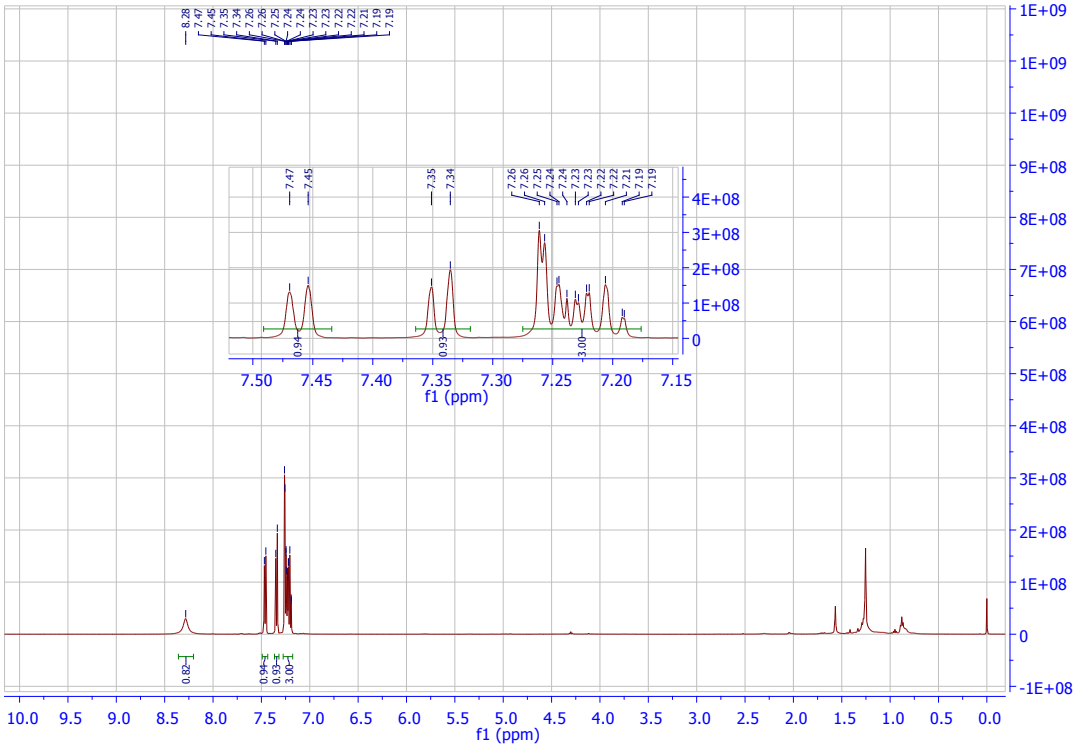


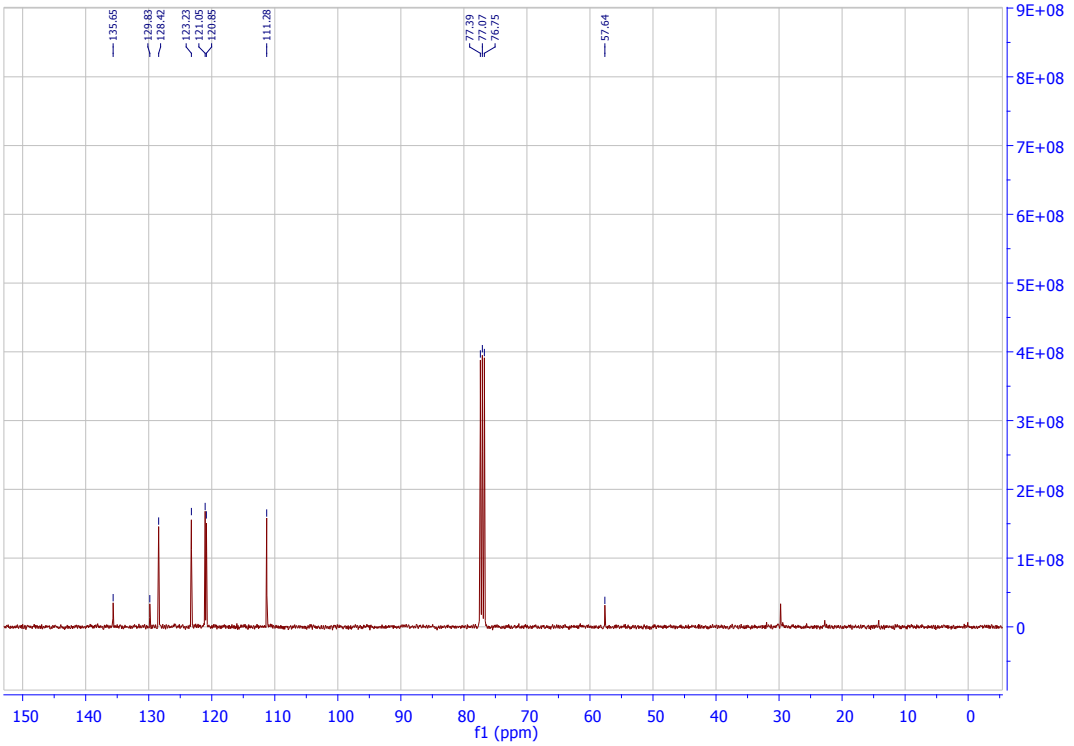
^{1}H NMR and ^{13}C NMR Spectra of Compound 3l



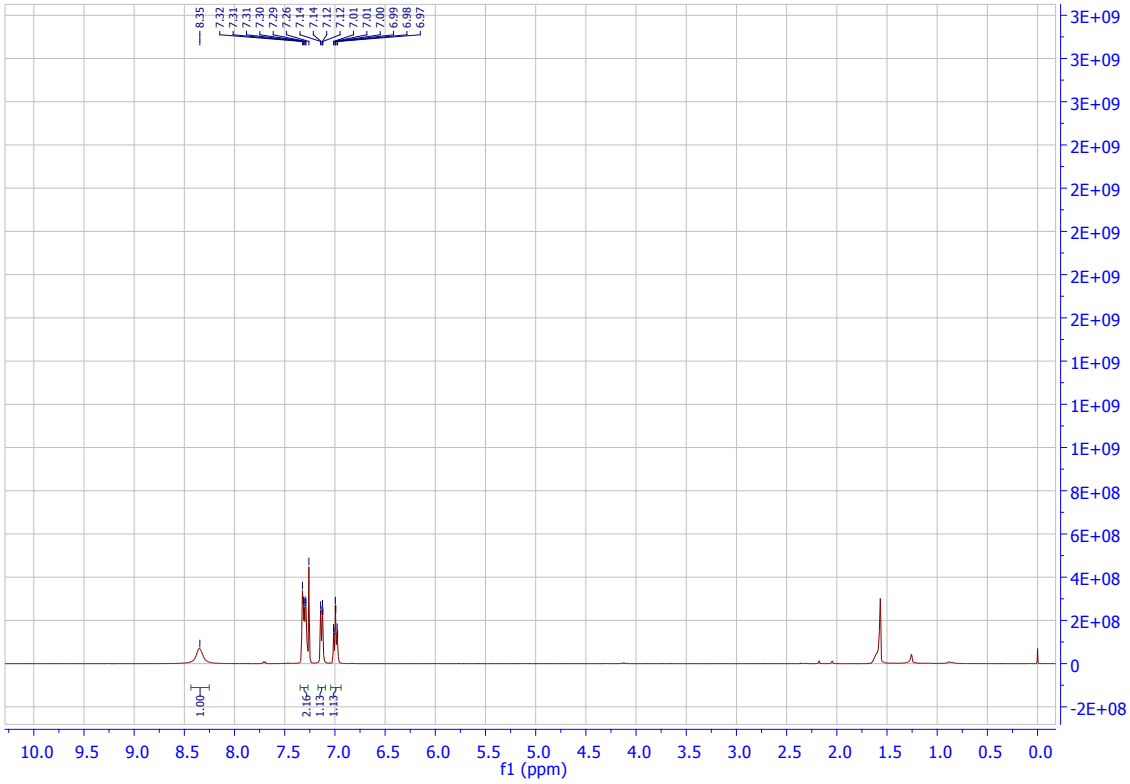


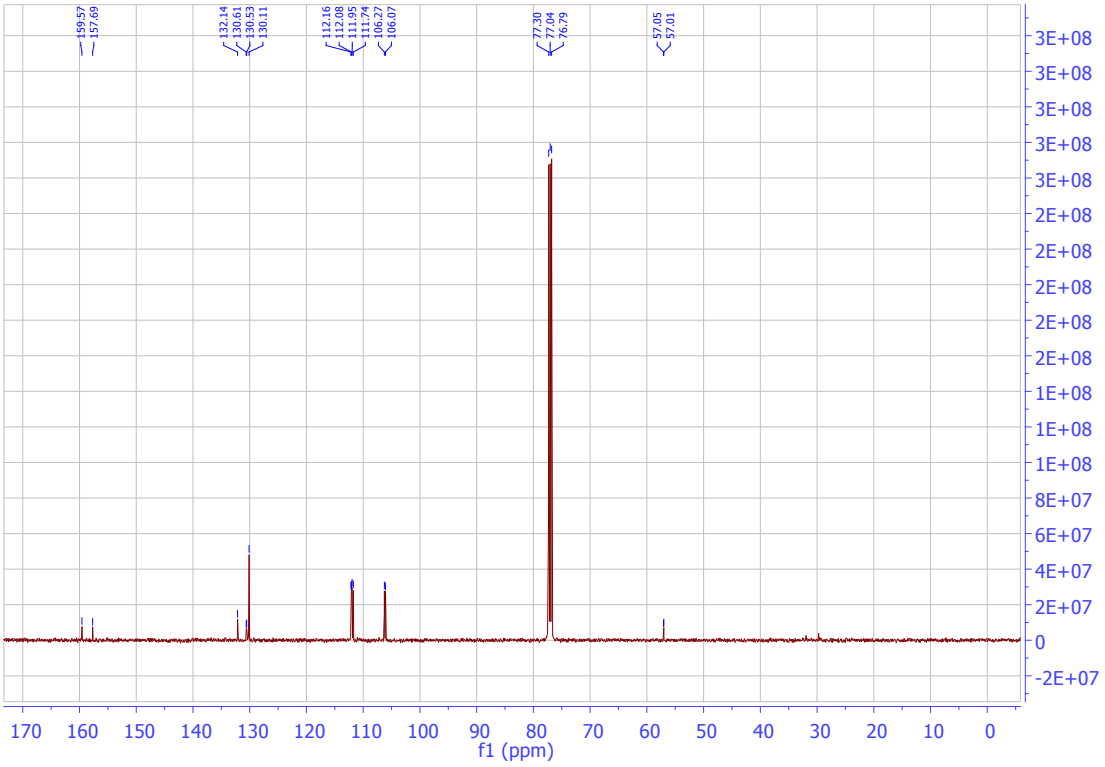
^{1}H NMR and ^{13}C NMR Spectra of Compound 4a



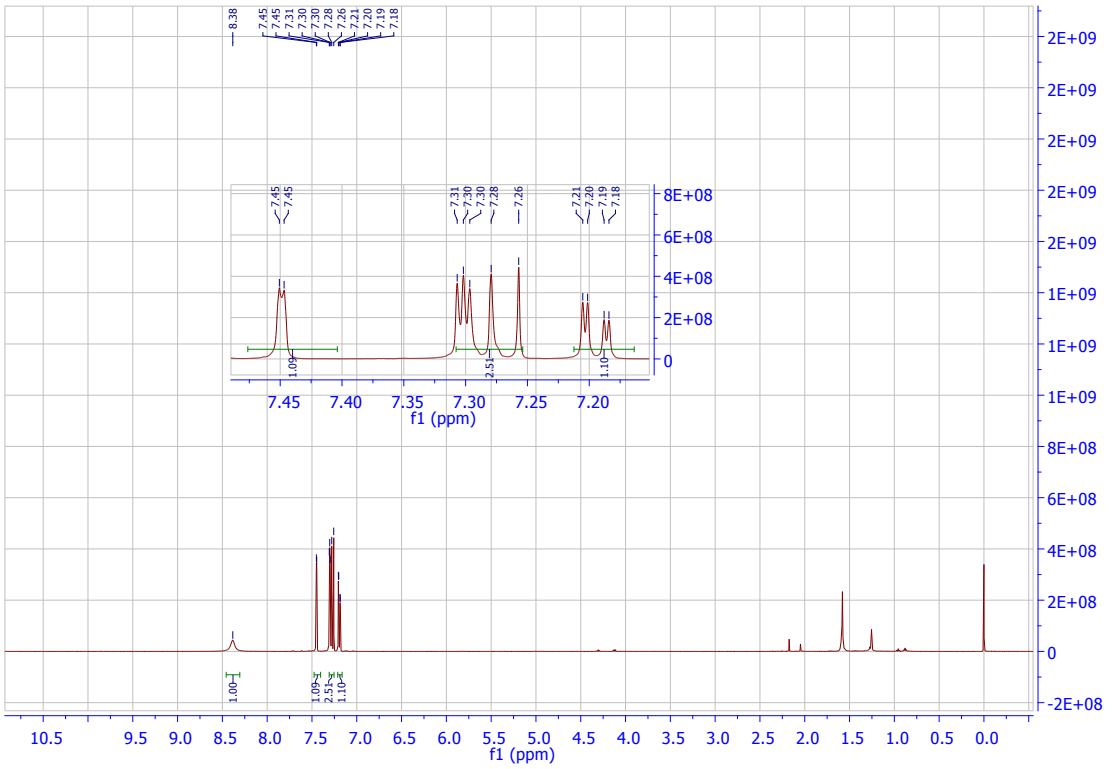


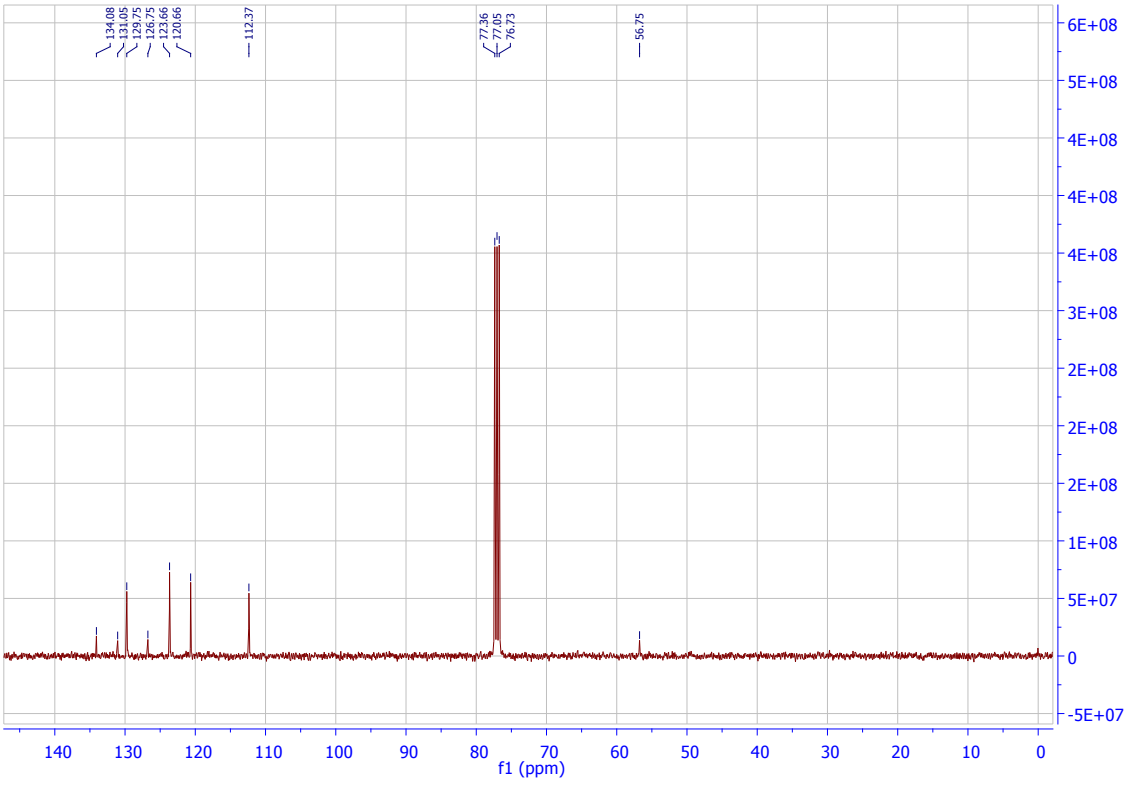
^{1}H NMR and ^{13}C NMR Spectra of Compound 4b



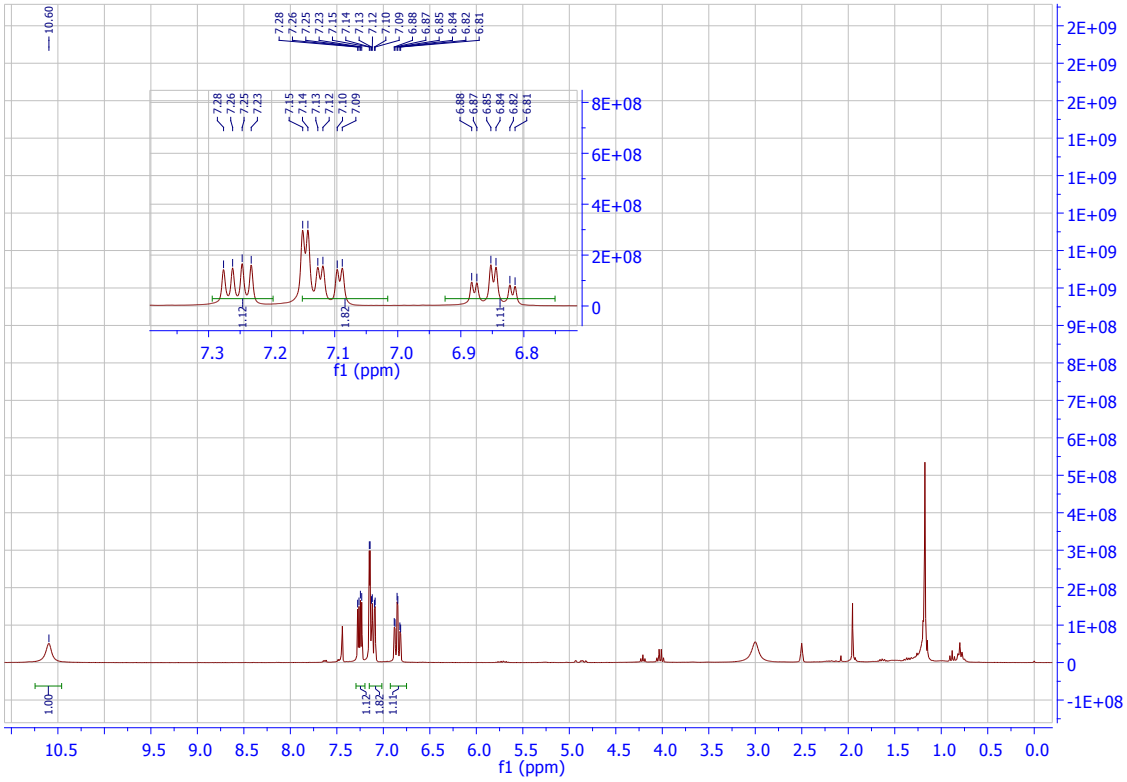


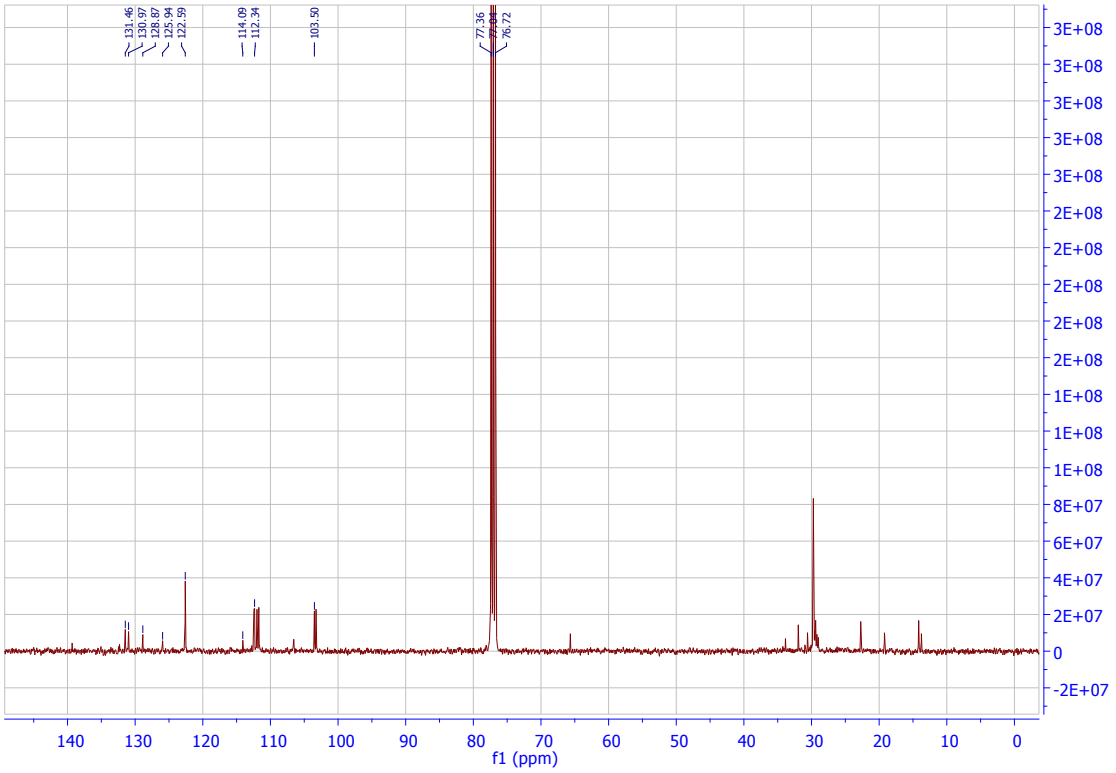
^{1}H NMR and ^{13}C NMR Spectra of Compound 4c



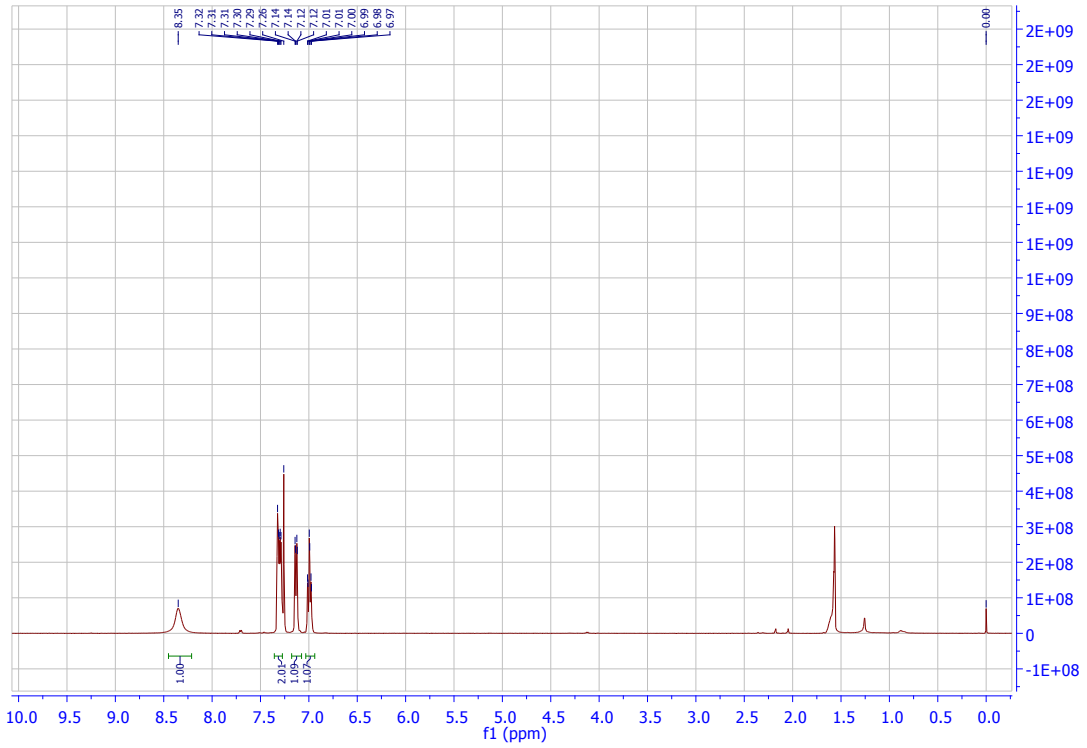


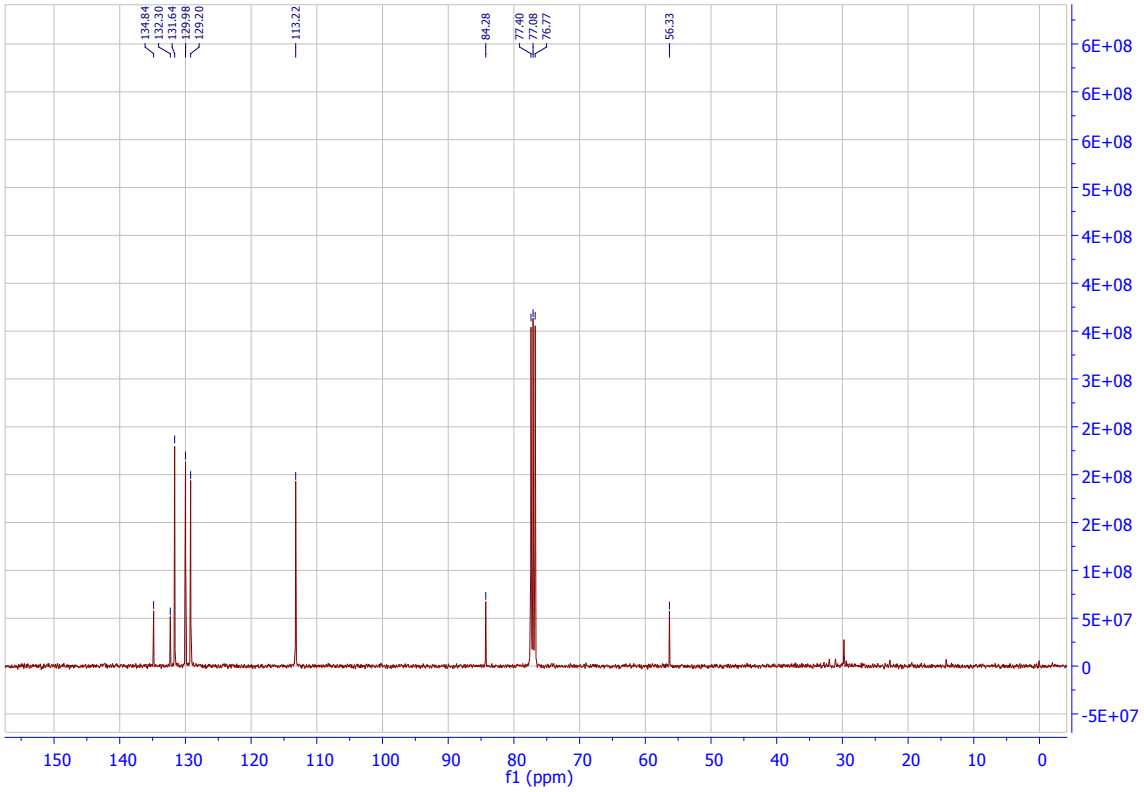
^{1}H NMR and ^{13}C NMR Spectra of Compound 4d



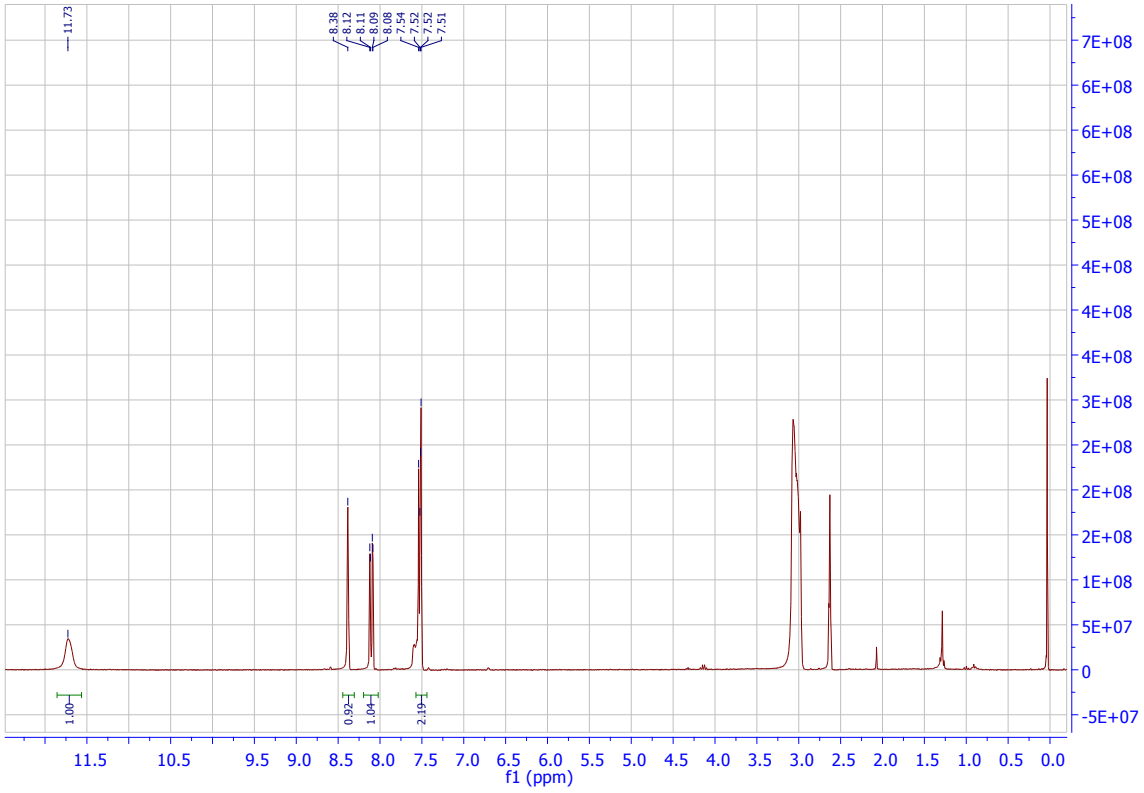


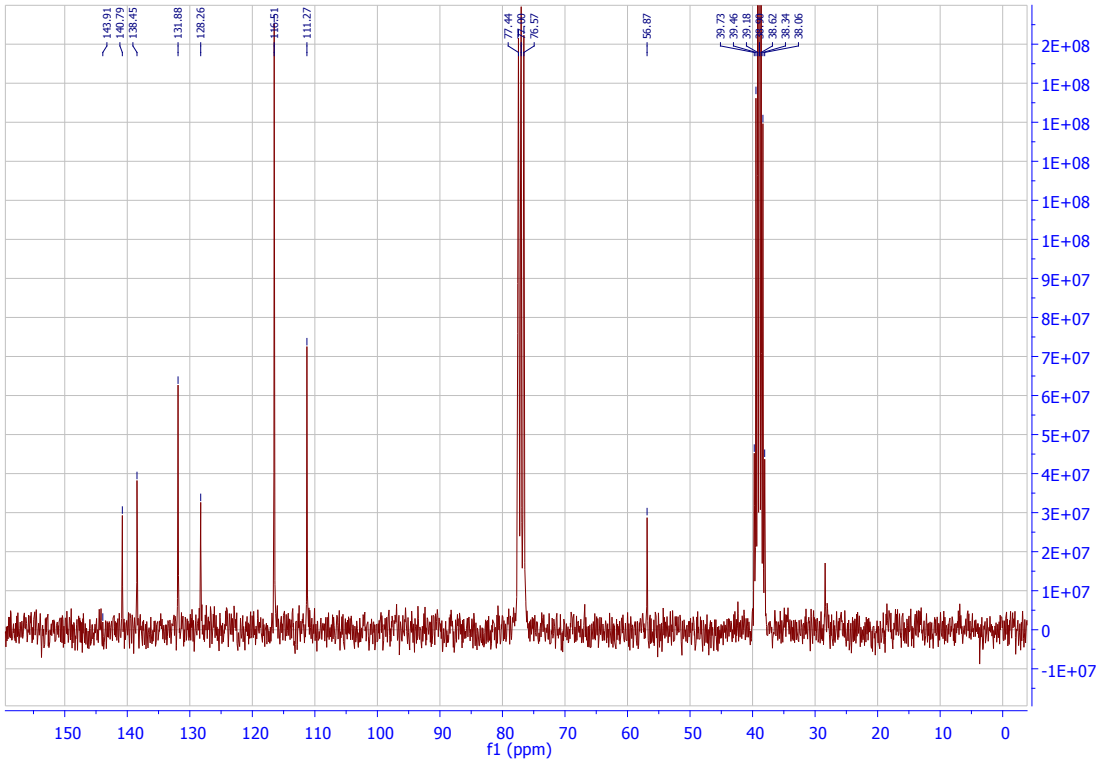
^{1}H NMR and ^{13}C NMR Spectra of Compound 4e



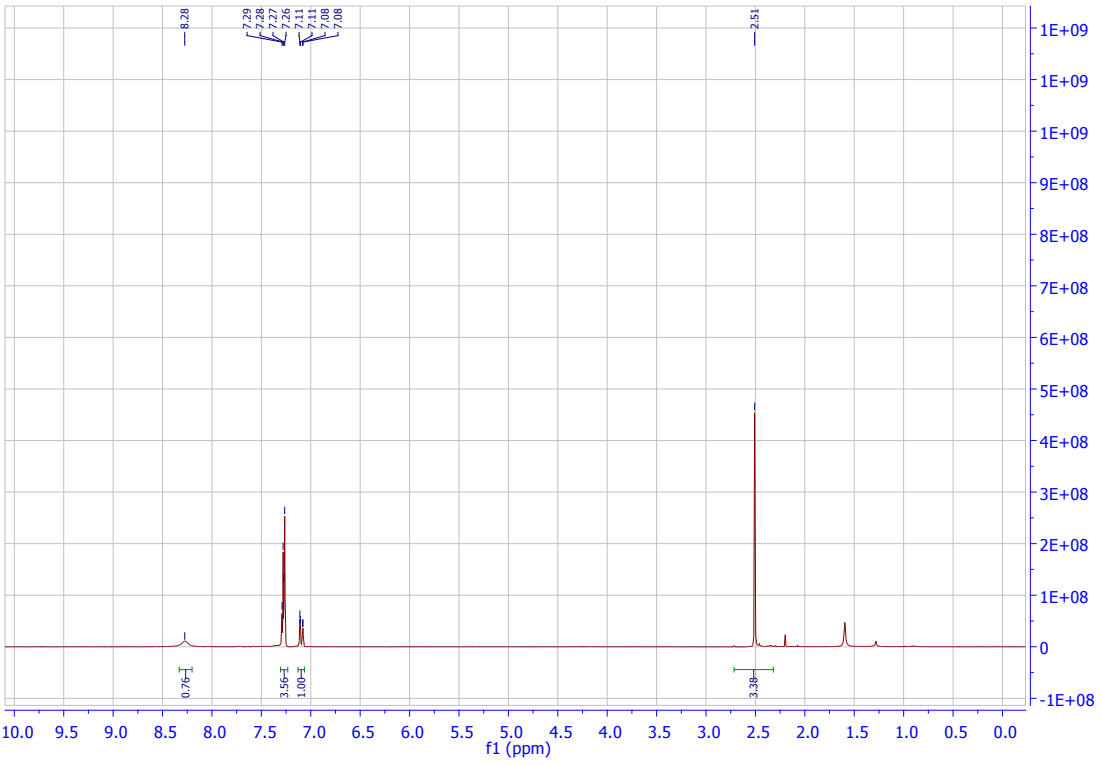


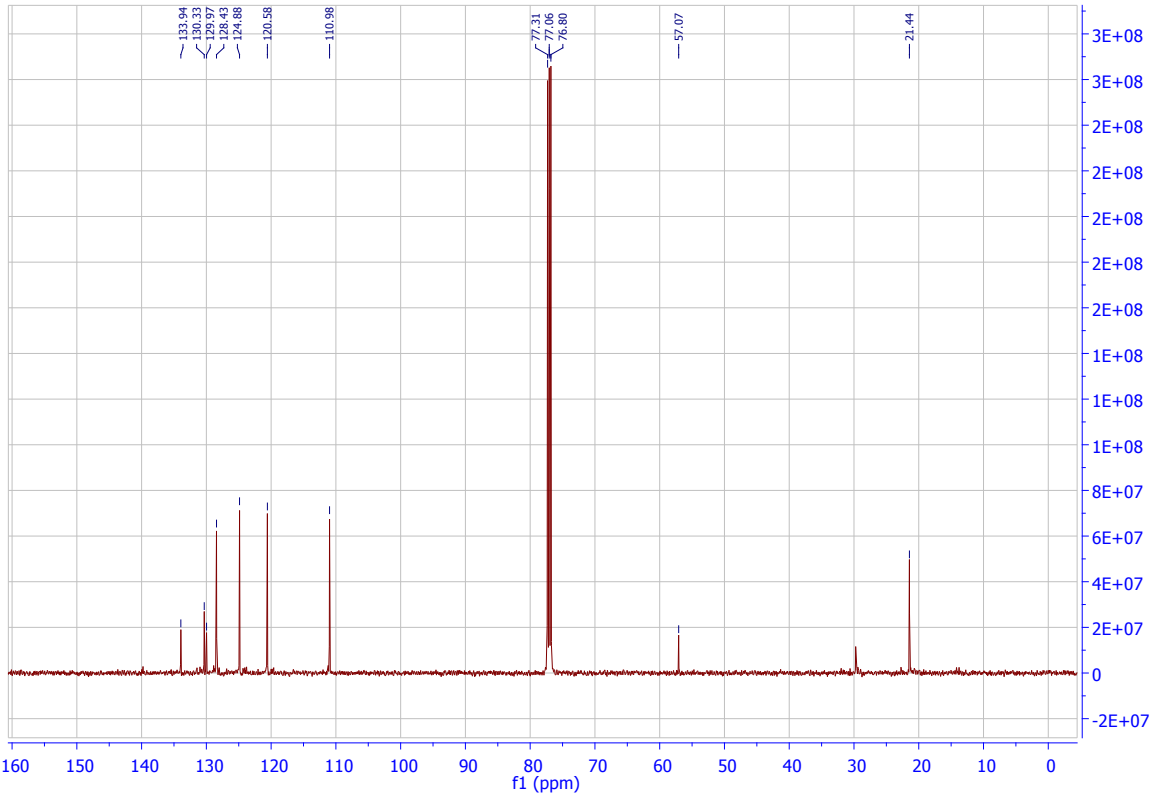
^{1}H NMR and ^{13}C NMR Spectra of Compound 4f



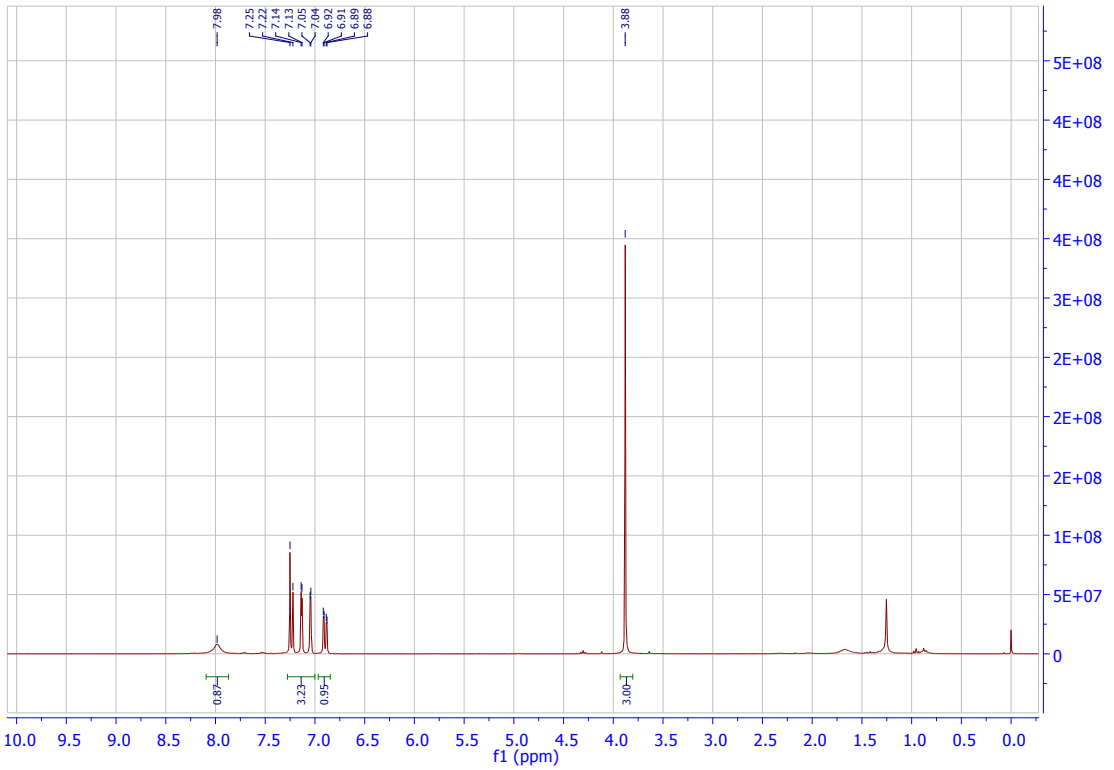


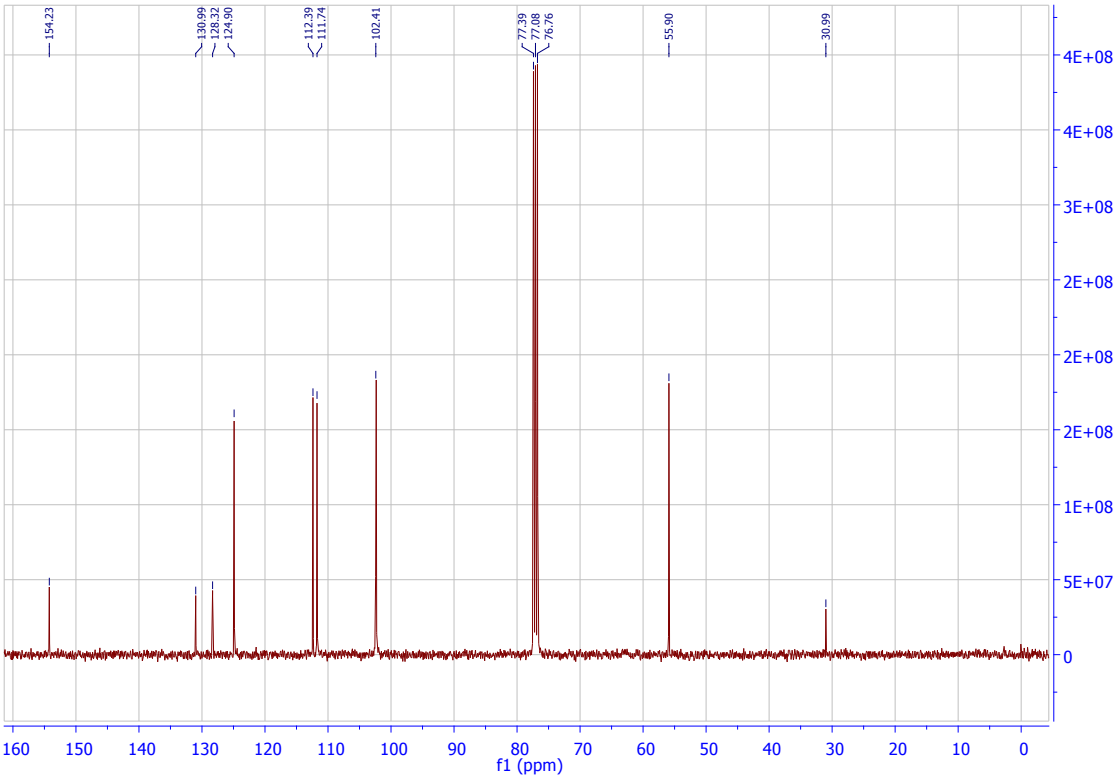
^{1}H NMR and ^{13}C NMR Spectra of Compound 4g



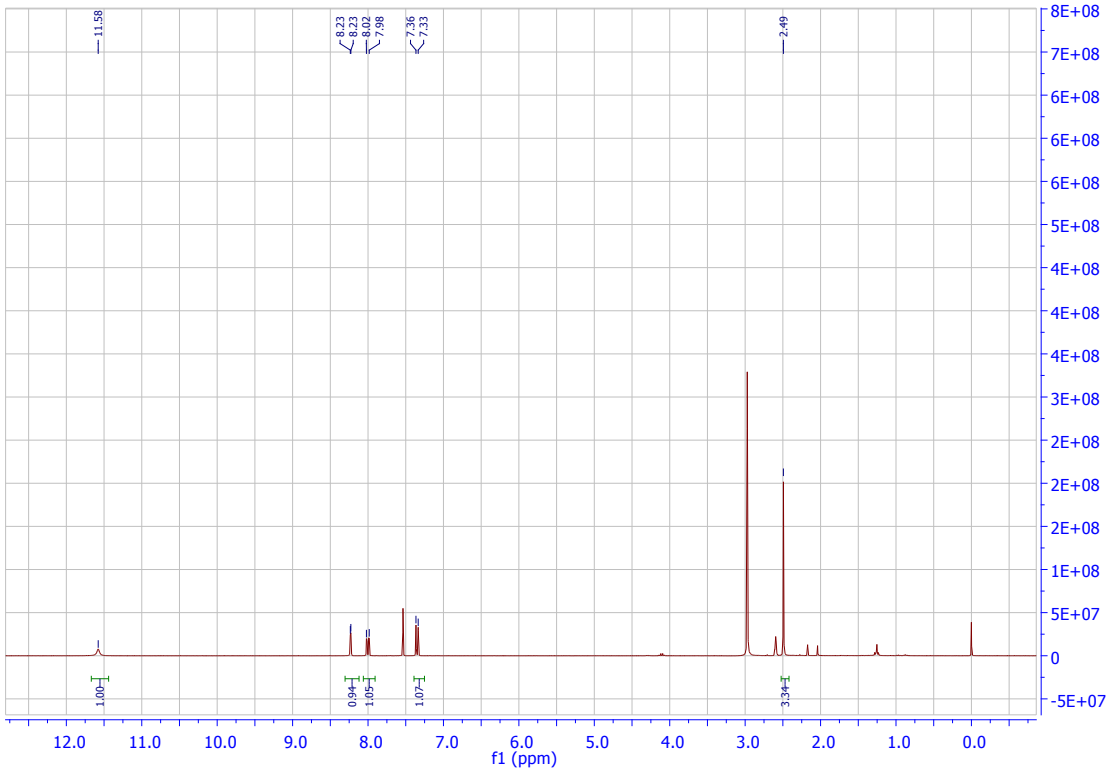


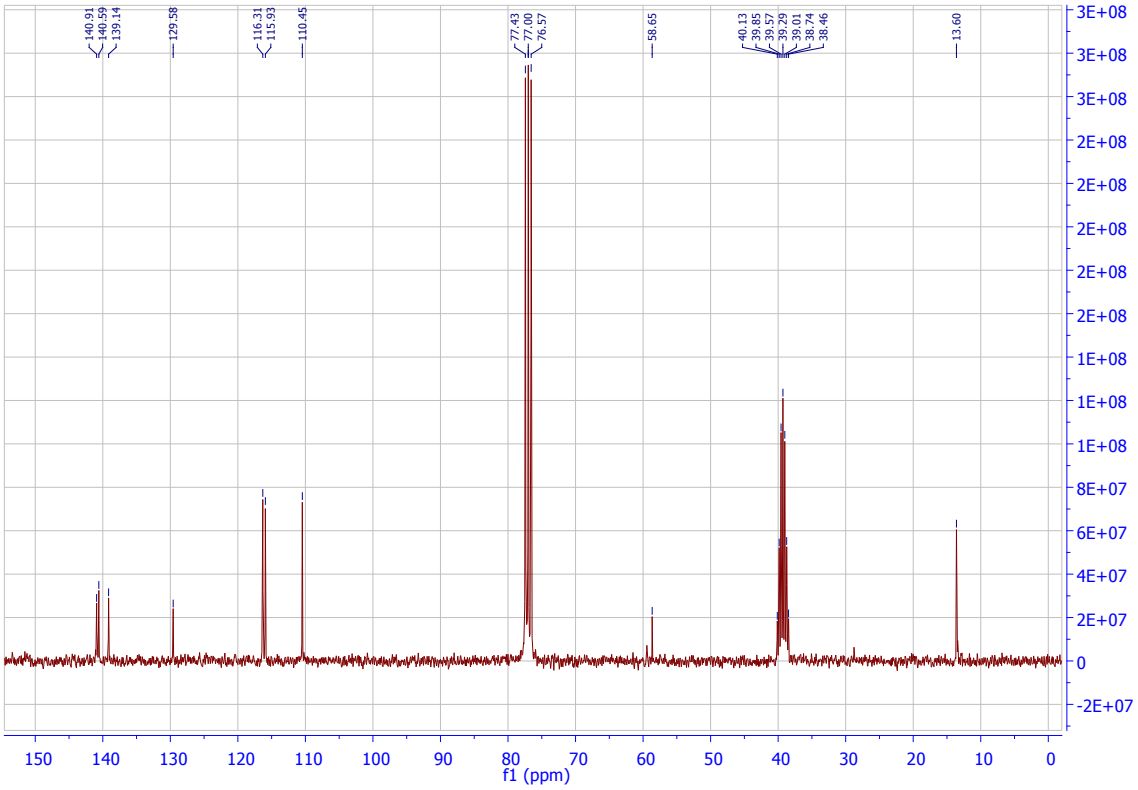
^{1}H NMR and ^{13}C NMR Spectra of Compound 4h



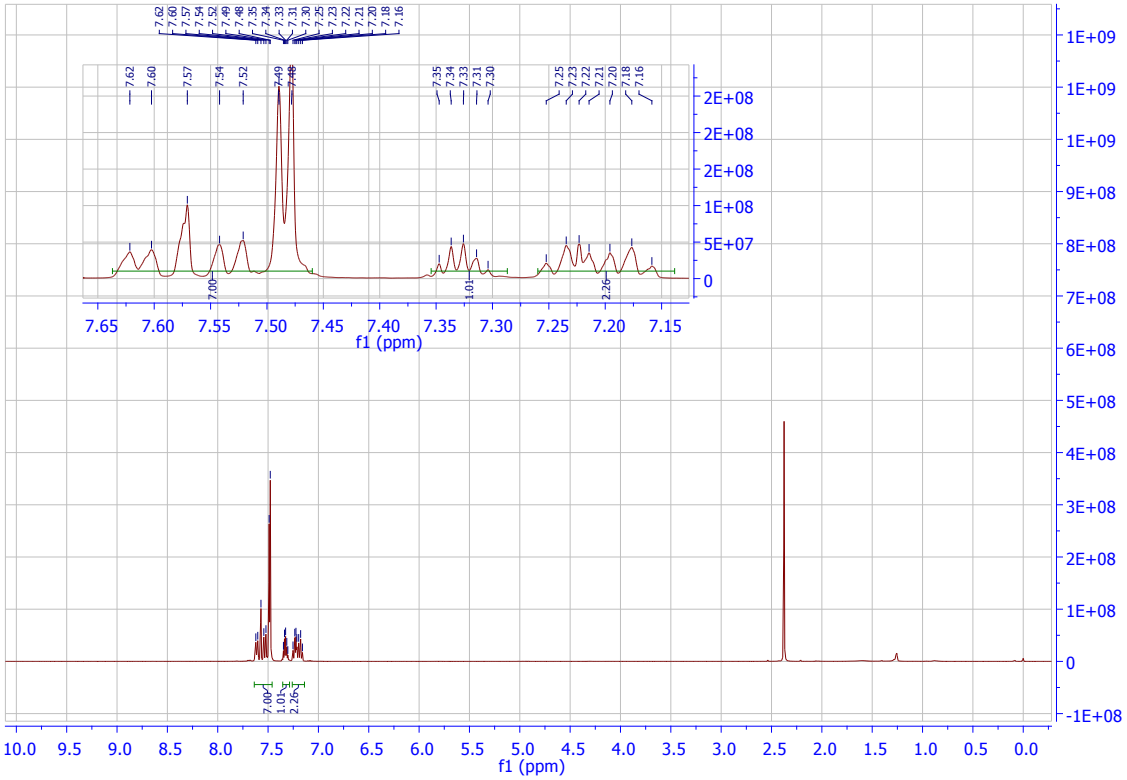


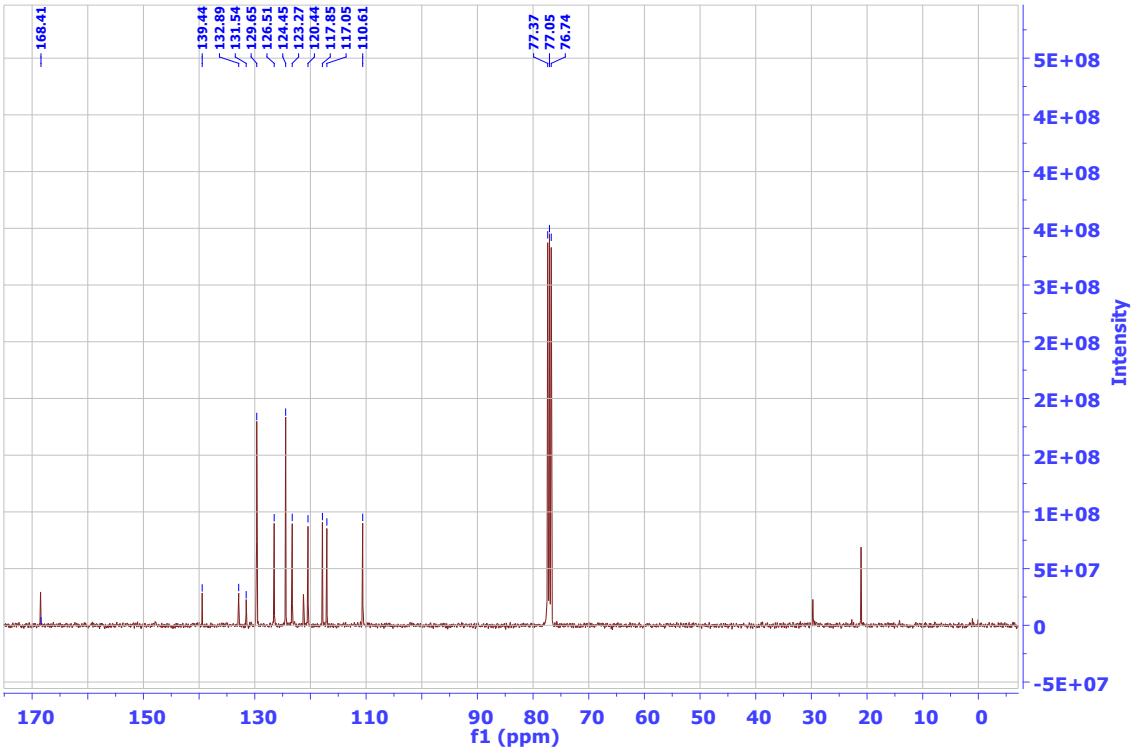
^{1}H NMR and ^{13}C NMR Spectra of Compound 4i



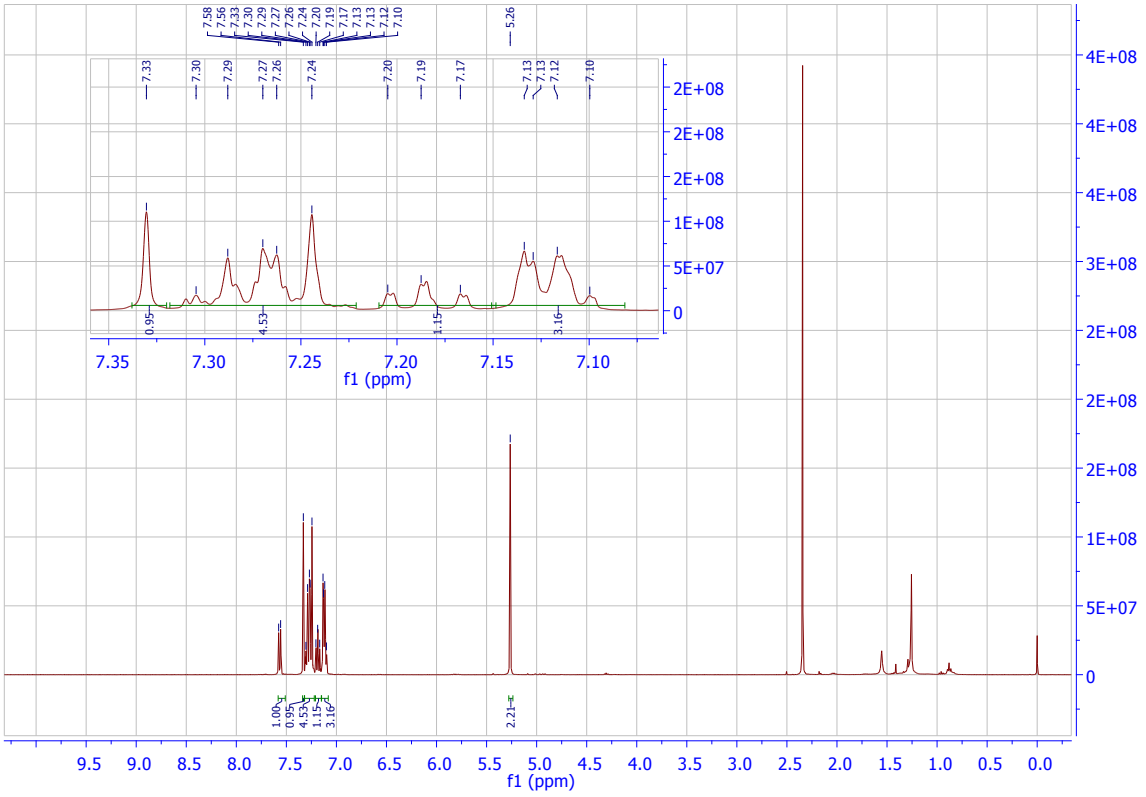


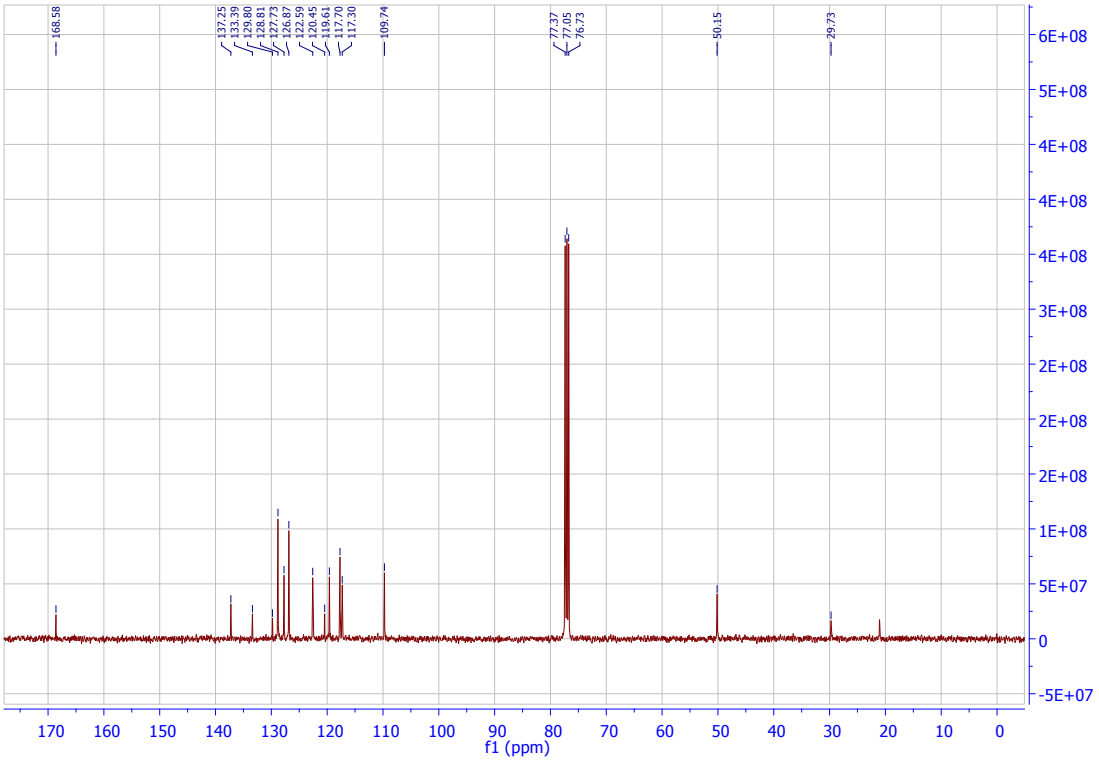
^{1}H NMR and ^{13}C NMR Spectra of Compound 4j



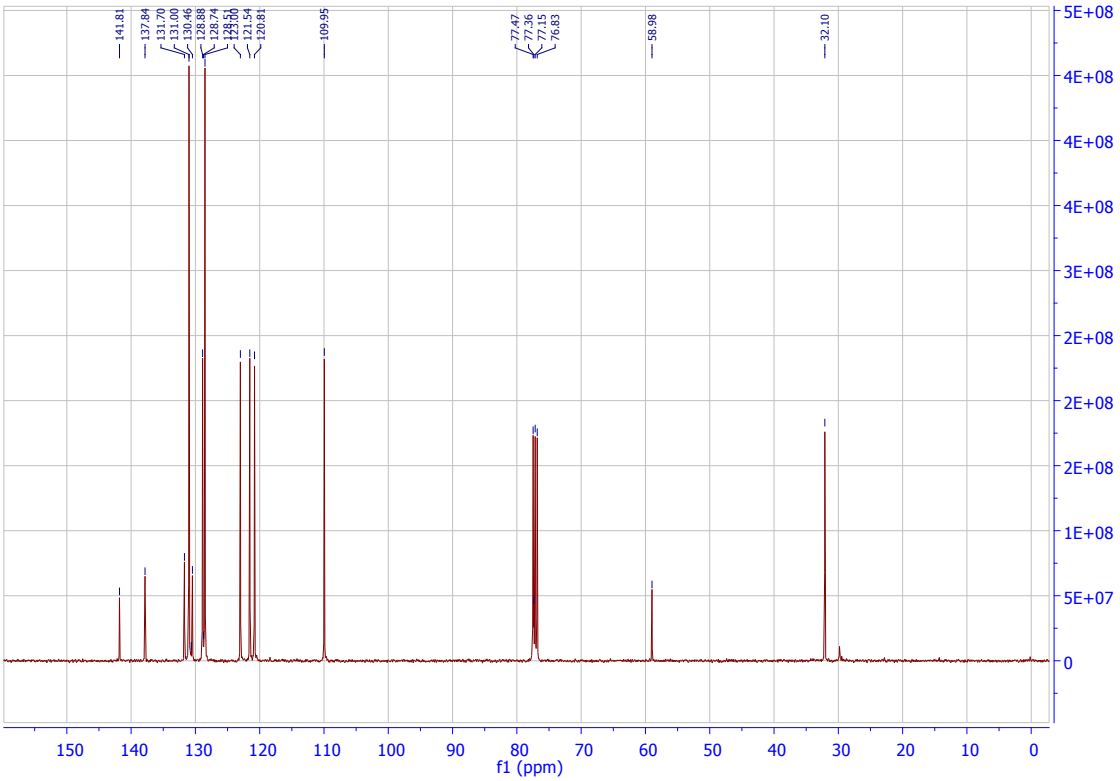


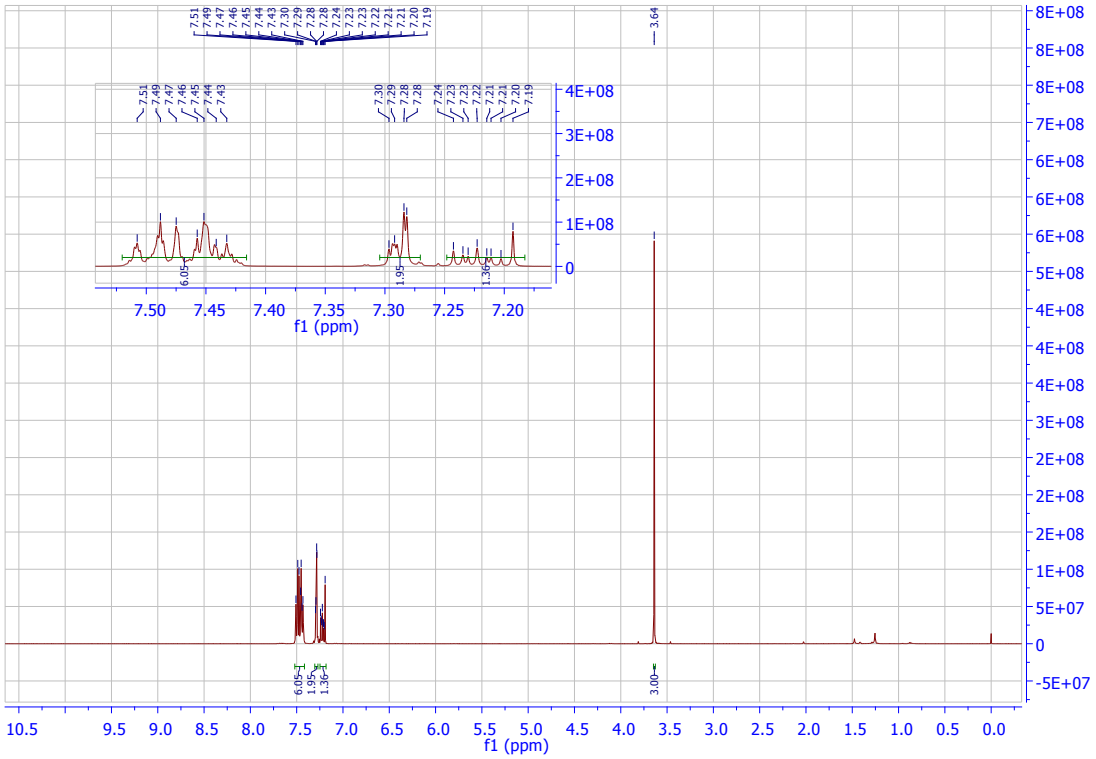
^{1}H NMR and ^{13}C NMR Spectra of Compound 4k



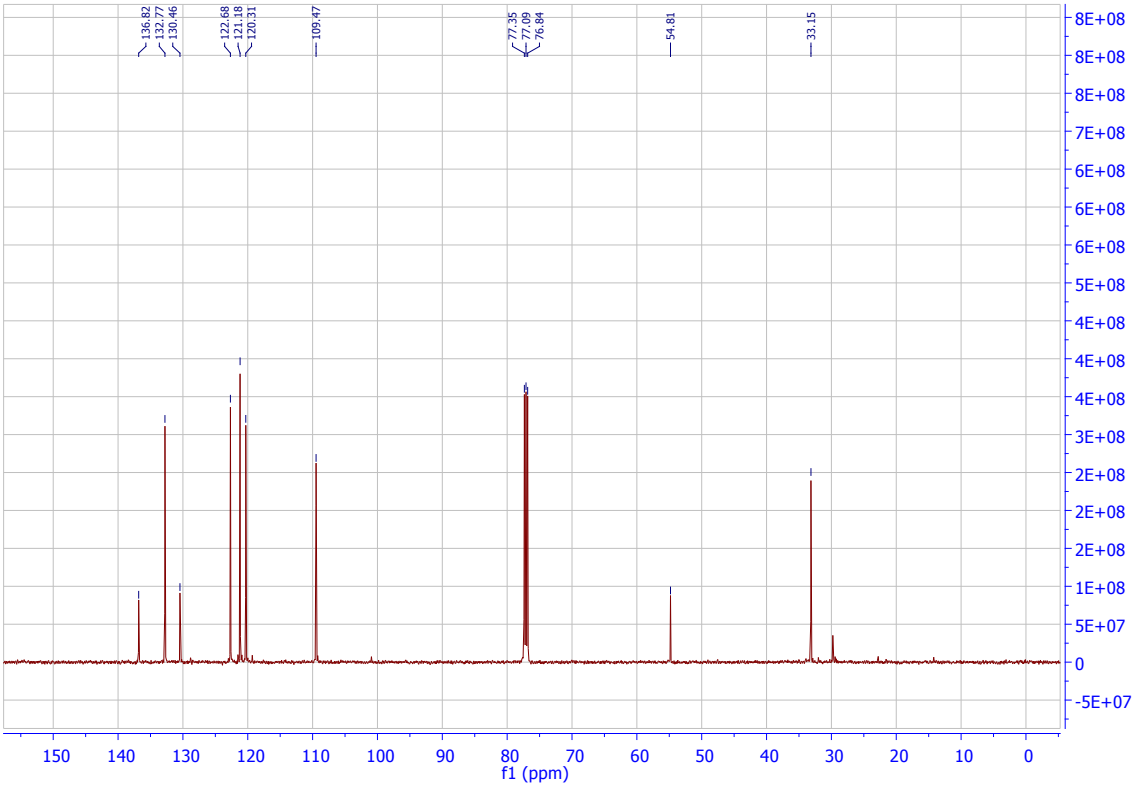


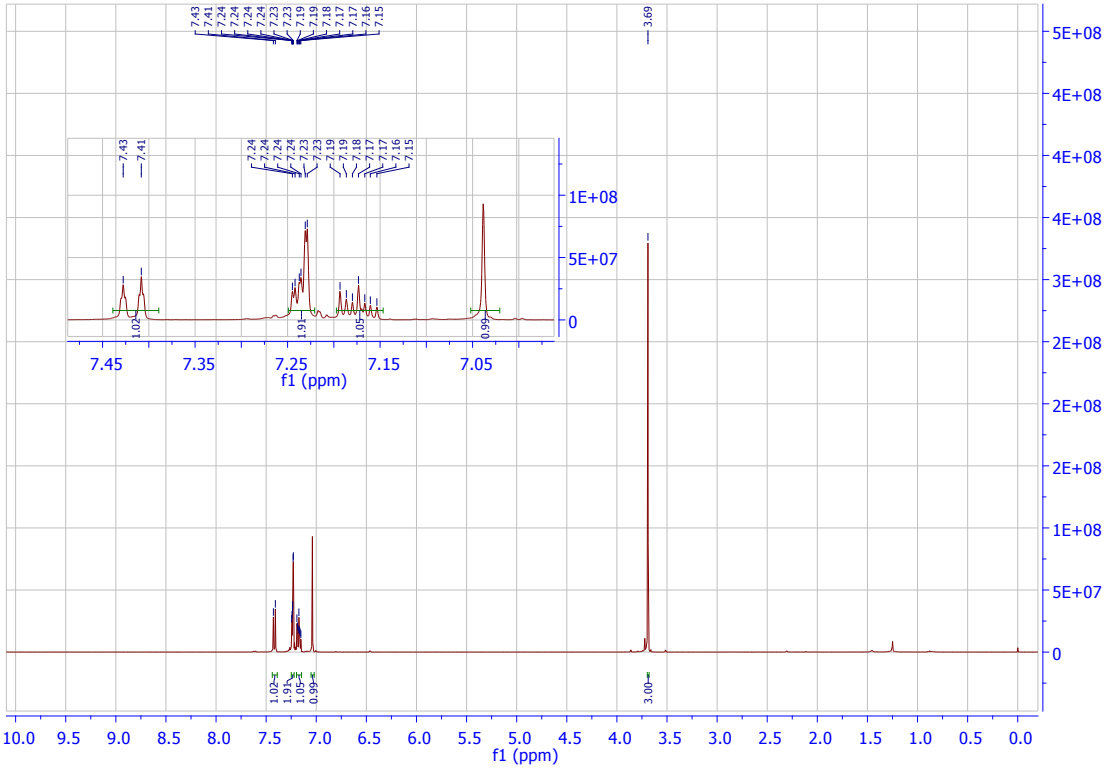
^{1}H NMR and ^{13}C NMR Spectra of Compound 4l



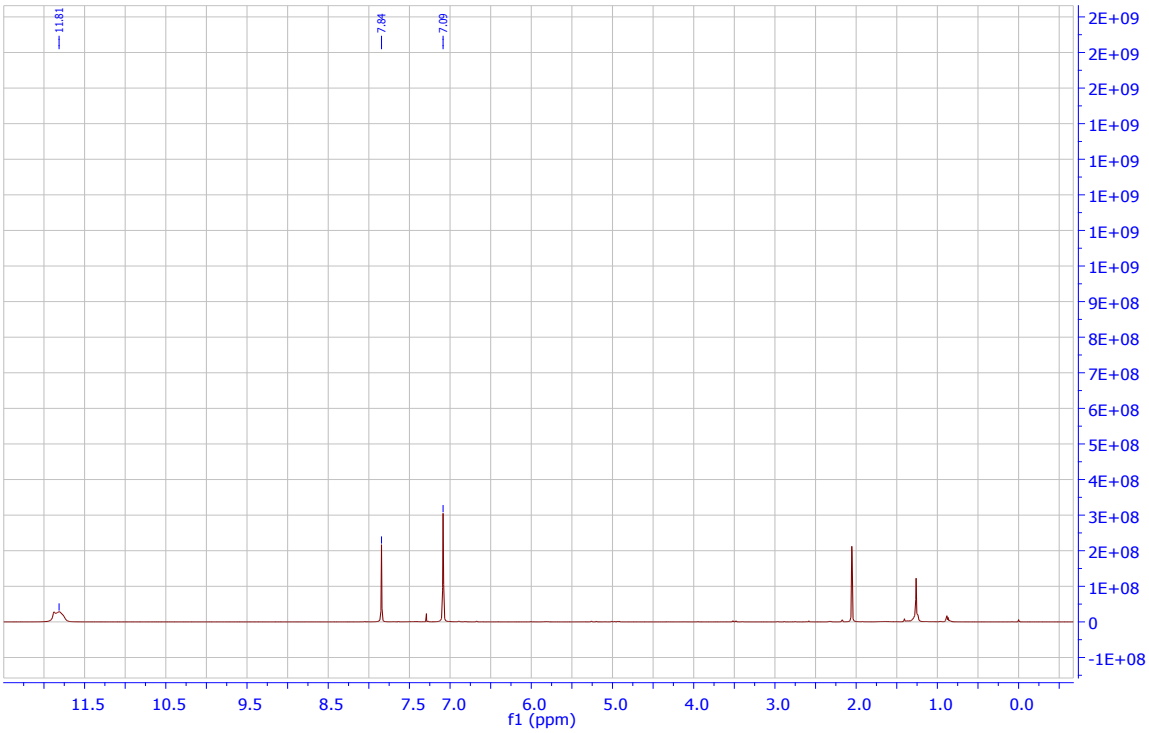


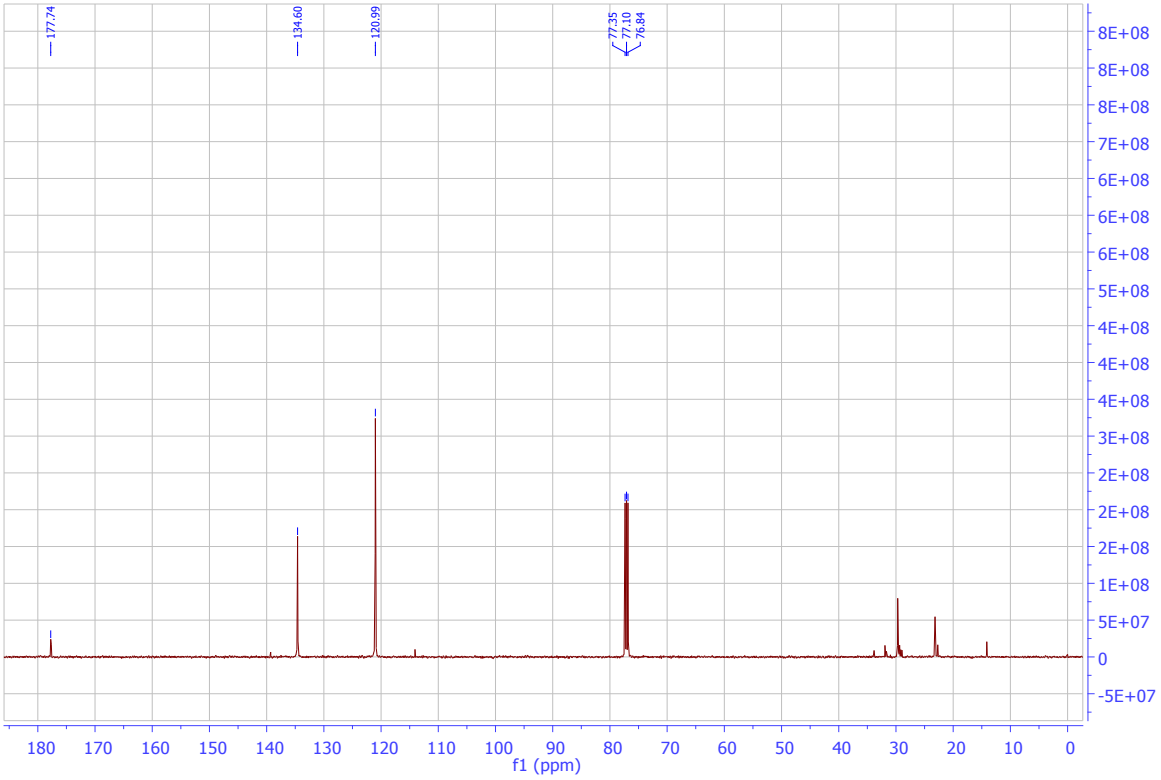
^{1}H NMR and ^{13}C NMR Spectra of Compound 4m



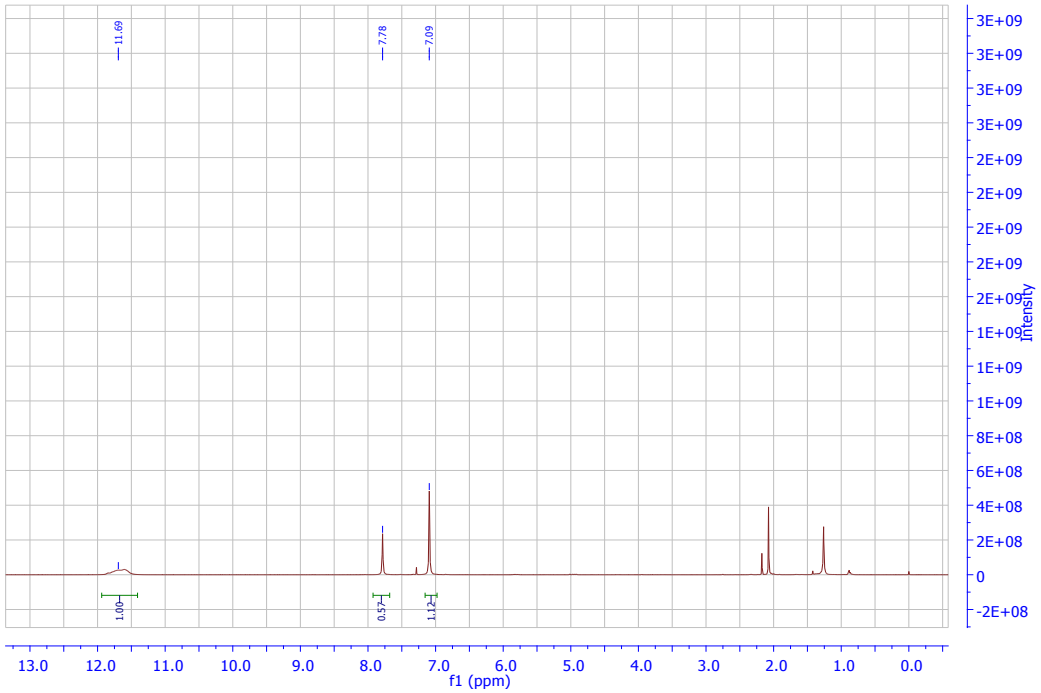


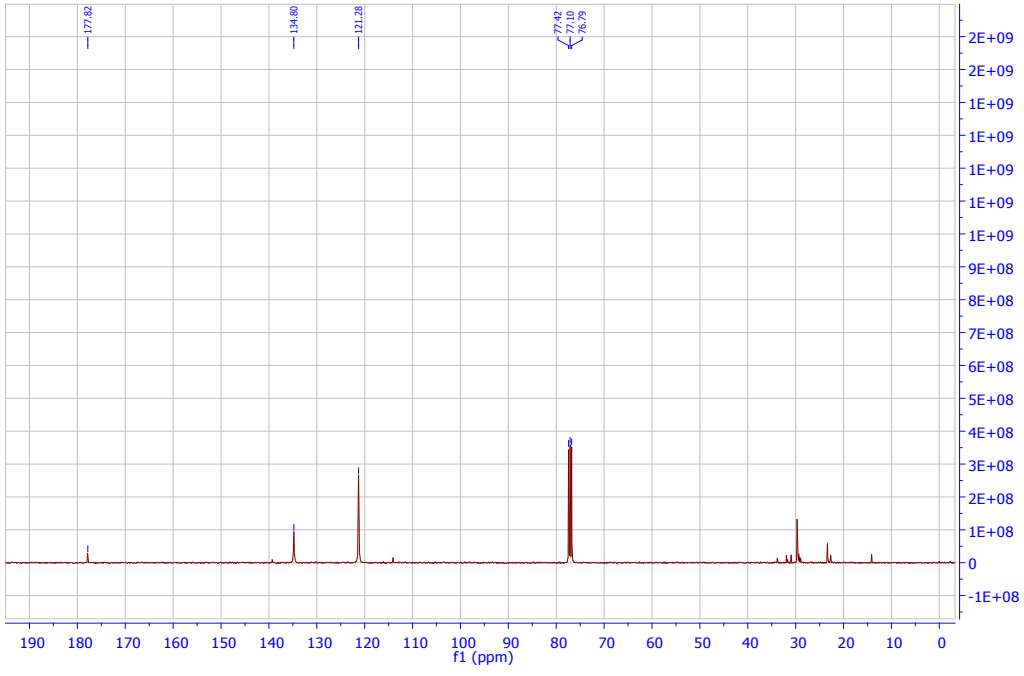
^{1}H NMR and ^{13}C NMR Spectra of Compound 5a





^{1}H NMR and ^{13}C NMR Spectra of Compound 5b





5. References:

1) J. Yan, T. Ni, F. Yan, *Tetrahedron Lett.,* 2015, **56**, 1096-1098.
2) M. Largeron, B. Farrell, J. F. Rousseau, M. B. Fleury, P. Potier, R. H. Dodd, *Tetrahedron Lett.,*2000, **41**, 9403-9406.
3) T. Guney, J. J. Lee, G.A. Kraus, *Org. Lett,.* 2014, **16***,*1124-1127.
4) Jing Zhao, Xiuzhi Cheng, Jun Le, Wei Yang, FengtianXue, Xuan Zhang and Chao Jiang., *Org. Biomol. Chem.*,2015,**13**,9000-9004.
5) B. Hugon, F. Anizon, C. Bailly, R.M. Golsteyn, A. Pierre, S. Leonce, J. Hickman, B. Pfeifferc, M. Prudhomme, *Bioorg. Med. Chem. Lett.,* 2007, **15**, 5965.
6) Leilei Shi, Dongmei Zhang, Riyuan Lin, Chun Zhang, Xun Li, Ning Jiao, *Tetrahedron Lett.,*2014, **55**, 2243-2245.
7) S. Deslandes, C. Frongia, S. Chassaing, C. Bruyere, O. Lozach, L. Meijer, B. Ducommun, R. Kiss, E. Delfourne, *Eur. J. Med. Chem.*, 2012, **54**, 626-636.
8) S. Song, X. Sun, X. Li, Y. Yuan, N. Jiao, *Org. Lett.*, 2015, **17***,* 2886-2889.
9) V. Bocchi, G. Palla, *Synthesis*, 1982, **12**, 1096-1097.
10) O. Pitayatanakul, K. Iijima, M. Ashizawa, T. Kawamoto, H. Matsumoto, T. Mori, *J. Mater. Chem. C*, 2015, **3**, 8612-8617.
11) Philipp Barbie and UliKazmaier, *Org. Biomol. Chem.***,** 2015, **13**, 9267-92675.
12) S. Jeon, J. H. Lee, K. Lee, W. H. Lee, B. G. Kim, *Dyes and Pigments*, 2016, **133**, 114-117.
13) W. Gordon, Gribble, Yanbing Liu, *Organic Preparations & Procedures,* 2001, **33**, 615-619.
14) Birgitte Langer Eriksen, perveds, sanderine morel and Mikael begtrup, *J.Org.Chem.*,1998, **63**, 12-16.
15) P.Borikarsanjay, Thomas Daniel, Vincent paul, *Tetrahedron letters,* 2009, **50(9),** 1007-1009.