Supporting Information

Visible-Light-Induced C-S Bond Formation in the Synthesis of 2,4 Disubstituted Thiazoles through Cascade Difunctionalization of Acetophenone: A Greener Approach

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1. General Information

All chemicals and solvents were purchased from Sigma Aldrich and used without purification. Melting points were measured on the Stewart melting point apparatus in one side open capillary and are uncorrected. The progress of the reaction was monitored by thin-layer chromatography on a glass plate coated with silica gel G-234 and fluorescent silica gel. UV lamp and iodine chamber was used for the visualization of the reaction spot. High-Resolution Mass Spectrometry (HRMS) was performed using a SCIEX X500R QTOF (TOF-MS) system. ^{1}H and ^{13}C NMR spectra were recorded on Bruker Avance 500 MHz spectrometer in DMSO d_6 using TMS as internal standard 500 MHz (^{1}H) and 126 MHz (^{13}C). All chemical shifts were reported in ppm with reference to the DMSO peak (2.50 for ^{1}H and 39.50 for ^{13}C NMR). All coupling constants are reported in hertz (Hz). Abbreviations are, s: singlet, d: doublet, t: triplet, q: quartet, bs: broad singlet, dd: double doublet. All products synthesized were confirmed by using melting point, ^{1}H and ^{13}C NMR and comparison with the literature reports.

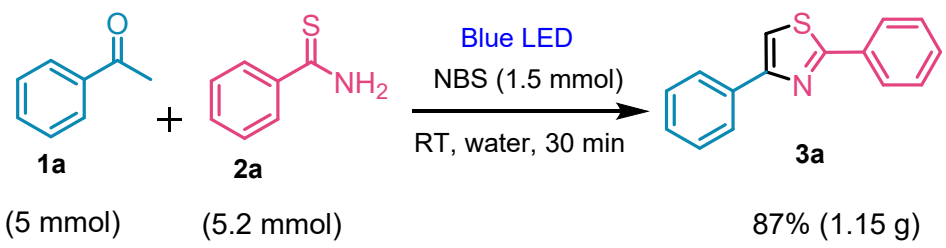
2. Experimental Procedures

2.1 General procedure for the synthesis of compound 3a-3q/4a-4l

A 25 mL RB flask equipped with a magnetic stirring bar was charged with methyl aryl ketone **1** (1.0 mmol), NBS (1.5 mmol), thioamide/thiourea **2** (1.2 mmol), and solvent (3 ml). The mixture was stirred at room temperature and irradiated with blue LEDs light strips for 30 min under the open air. The progress of the reaction was monitored via TLC. The precipitate obtained was filtered and washed with ethanol after the completion of the reaction. The desired product was obtained in good yields after recrystallization using ethanol.

2.2 Gram-scale synthesis protocol for 2,4-disubstitued thiazole (3a)

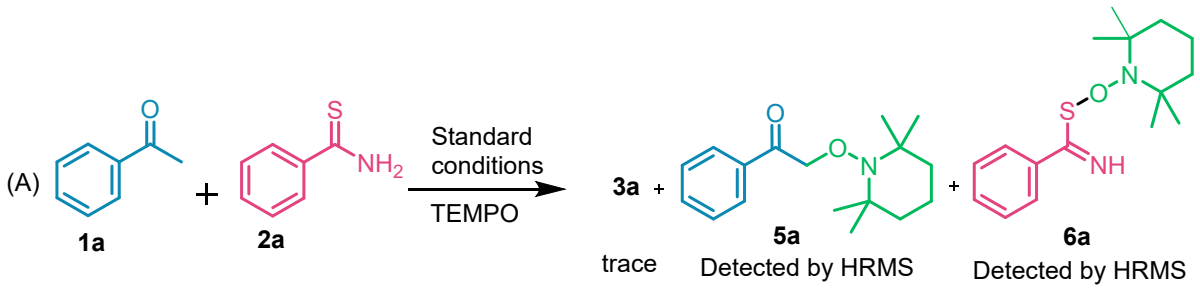
To assess the feasibility of this synthetic application of a well-established approach for 2,4-disubstituted thiazole **3a** that is aided by visible light, the experiment was conducted on gram scale using methyl aryl ketone **1a** (5.0 mmol, 1.0 equiv.), NBS (5.0 mmol, 1.5 equiv.), thioamide **2a** (5.2 mmol, 1.0 equiv.) standard conditions (Scheme 2). The experiment was carried out at room temperature, with water as a green solvent for 30 min, and the progress was monitored with TLC. The precipitate obtained was filtered and washed with ethanol after the completion of the reaction. The desired product was obtained in good yields after recrystallization using ethanol **3a** 87%. The experimental work showed a robust and acceptable gram-scale method for the synthesis of 2,4-substituted thiazole. The results showed that visible light could be used as an efficient and renewable light source in this strategy.



3. Mechanistic Studies

3.1 Radical trapping experiments by TEMPO/ HRMS data

Several mechanistic investigations were performed to investigate the mechanism of the visible light photoredox. At first, 2,2,6,6-tetramethylpiperidinooxy (TEMPO) (radical scavengers) (2 mol %) was added to the reaction system, and the trace amount of the **3a** was formed, and TEMPO adducts **5a** and **6a** were detected in HRMS data from the crude reaction mixture (Figure S1 and S2). These results suggested that the reaction passes through the radical pathway.



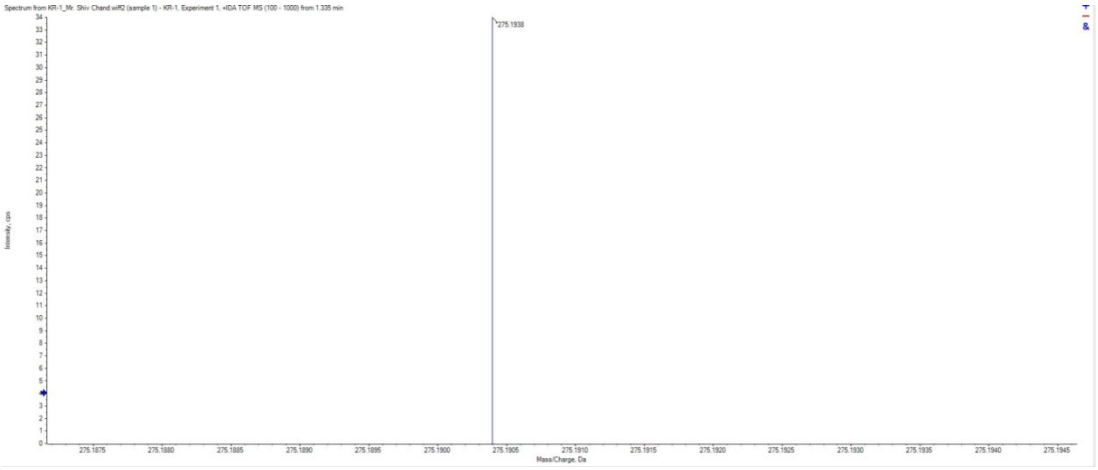


Figure S1 HRMS of adduct 5a

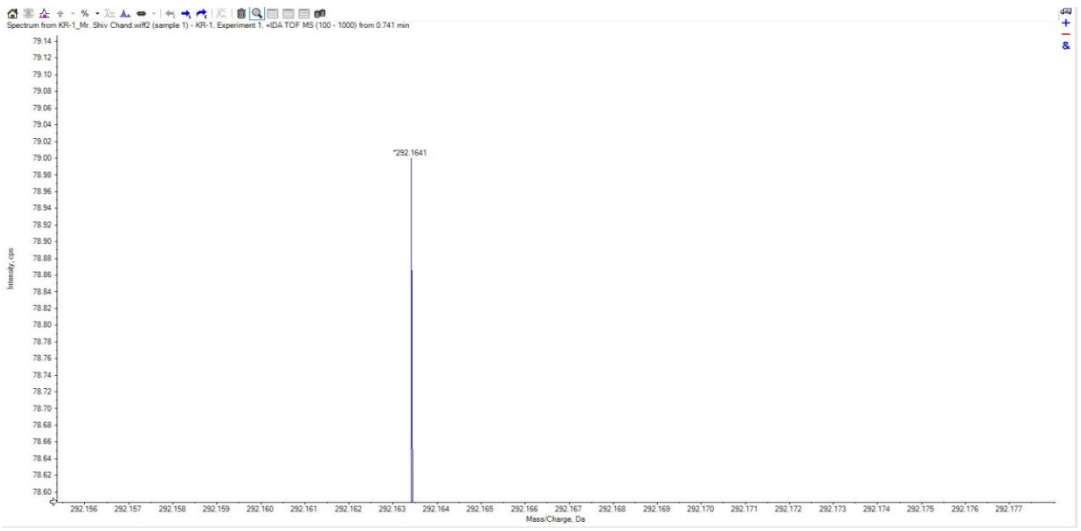


Figure S2 HRMS of adduct 6a

3.2 UV/Vis absorption spectrometry

SHIMADZU UV-800 UV-visible spectrophotometer was used to record UV- visible spectroscopy of reactants and reaction mixture. The sample was prepared by mixing of **1a**, **2a**, and NBS mixture (1a+2a+NBS) (Figure S3) and **1a** (**1a+2a**+NBS) in methanol solvent [Conc. Reaction mixture = 1.25×10-4mol/L] in a light path quartaz UV cuvette.

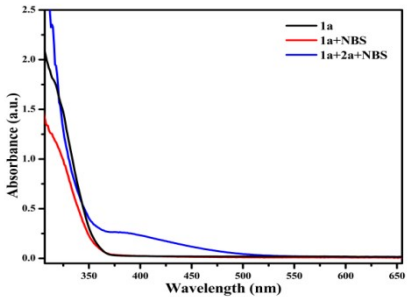


Figure S3. UV-vis absorption spectra of (1a+2a+NBS)

3.3 Stern-Volmer Fluorescence Plots and quenching experiments

In a Fluorescence experiment, the solution of intermediate-C in methanol was added to the appropriate amount of **2a**. The addition of **2a** was repeated 5 consecutive times. We recorded the emission spectra after each addition. All the solutions were excited at 320 nm, and the emission was acquired from 0 nm to 500 nm. The result shown in (Figure S4) indicates that **2a** quenches the excited state of inter-C and its emission.

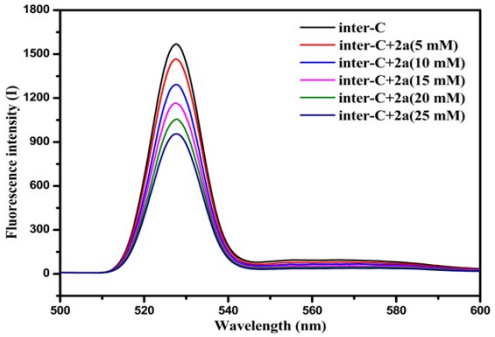


Figure S4. The fluorescence emission spectra of intermediate C with different concentrations of quencher 2a.

3.4 Light on/off experiment

The reaction between **1b** and **2a** was conducted under the standard conditions on a 1.0 mmol scale. The reaction mixture was subjected to sequential periods of stirring under visible light irradiation

(blue LED) followed by stirring in the absence of light. At each time point, one reaction system was suspended, which was then purified with column chromatography to give the corresponding products **3a**. The yield of **3a** was measured by weight of the product (Figure S5)

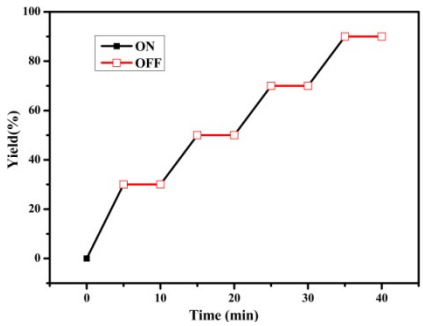
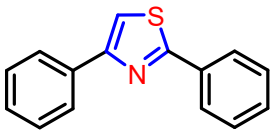


Figure S5. Light-Dark cycle experiment

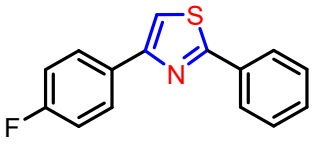
4. Characterization Data of the Products

[4.1.1] 2,4-diphenyl thiazole (3a)



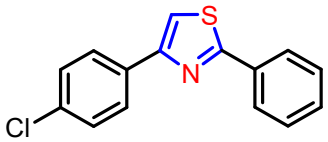
Yield 90%; white solid; m.p. 90 ^{O}C;**^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.09 (m, 2H), 8.04 (m, 2H), 7.50-7.48 (m, 6H), 7.47-7.39 (m, 1H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); 167.9, 156.3, 134.5, 133.8, 130.1, 128.9, 128.8, 128.2, 126.6, 126.5, 112.6 ppm. HRMS ESI $[M+H]^+$ calculated for $C_{15}H_{11}NS$ 238.0612, found 239.0616.

[4.1.2] 4-(4-fluorophenyl)-2-phenylthiazole (3b)



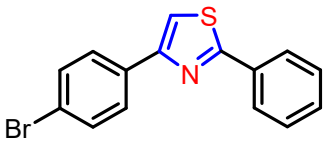
Yield 85%; white solid; m.p. 103-104 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.07 (m, 2H), 8.06-8.00 (m, 2H), 7.49-7.46 (m, 3H), 7.40-7.37 (m, 1H), 7.20-7.16 (m, 2H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 168.0, 161.8 (d, J = 248.7 Hz), 155.3, 133.5, 130.8, 130.1 (d, J = 3.7 Hz), 128.9, 128.2 (d, J = 7.6 Hz), 126.6, 115.7 (d, J = 21.4 Hz), 112.2 ppm. HRMS ESI $[M+H]^+$ calculated for $C_{15}H_{10}FNS$ 256.0517, found 257.0520.**^{19}F NMR** 108.9

[4.1.3] 4-(4-chlorophenyl)-2-phenylthiazole (3c)



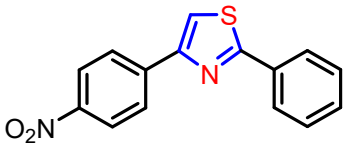
Yield 85%; white solid; m.p. 131 ^{O}C;**^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.09-8.08 (m, 2H), 8.04-8.03 (m, 2H), 7.50-7.37 (m, 6H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 168.3, 156.0, 134.6, 133.8, 130.0, 128.9, 128.8, 128.2, 126.6, 126.5, 112.6 ppm. HRMS ESI $[M+H]^+$ calculated for $C_{15}H_{10}ClNS$ 272.0222, found 273.0220.

[4.1.4] 4-(4-bromophenyl)-2-phenylthiazole (3d)



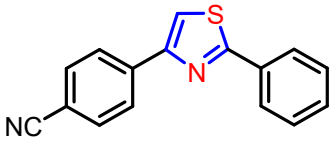
Yield 85%; white solid; m.p. 134-135 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.07-8.05 (m, 2H), 7.91-7.89 (m, 2H), 7.60-7.59 (m, 1H), 7.51-7.47 (m, 5H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 168.2, 155.1, 133.6, 133.4, 131.9, 130.2, 128.9, 128.0, 126.6, 122.2, 113.0 ppm. HRMS ESI $[M+H]^+$ calculated for $C_{15}H_{10}BrNS$ 315.9717, found 316.9721.

[4.1.7] 4-(4-nitrophenyl)-2-phenylthiazole (3e)



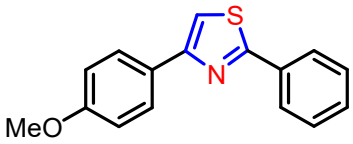
Yield 83%; yellow solid; m.p. 135-136 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.32-8.30 (d, J = 8.9 Hz, 2H), 8.18-8.16 (d, *J* = 8.8 Hz, 2H), 8.07-8.05 (d, *J* = 8.8 Hz, 2H), 7.69 (s, 1H), 7.51-7.50 (m, 3H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 168.8, 153.8, 147.3, 140.3, 133.2, 130.6, 129.0, 126.9, 126.7, 124.2, 116.0. HRMS $[M+H]^+$ calculated for $C_{15}H_{10}N_2O_2S$ 283.0463, found 284.0467.

[4.1.8] 4-(4-cyanophenyl)-2-phenylthiazole (3f)



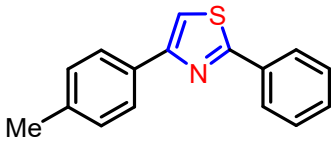
Yield 83%; yellow solid m.p. 135-137 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.14-8.12 (d, J = 8.4 Hz, 2H), 8.07-8.05 (m, 2H), 7.76-7.75 (d, *J* = 8.4 Hz, 2H), 7.65 (s, 1H), 7.50-7.49 (m, 3H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 168.7, 154.2, 138.5, 133.3, 132.6, 130.5, 129.0, 126.9, 126.7, 119.0, 115.3, 111.4 ppm. HRMS $[M+H]^+$ calculated for $C_{16}H_{10}N_2S$ 263.0564, found 264.0560.

[4.1.5] 4-(4-methoxyphenyl)-2-phenylthiazole (3g)



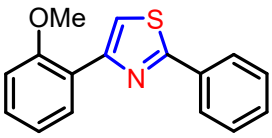
Yield 88%; pale yellow solid; m.p. 115-116 ^{O}C;**^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.07-8.05 (d, 2H), 7.97-7.95 (d, 2H), 7.50-7.45 (m, 3H), 7.37 (s, 1H), 7.01-7.00 (d, 2H), 3.89(s, 3H, OCH_3) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 167.7, 159.7, 156.1, 133.9, 130, 129, 129.9, 128.7, 127.8, 126.6, 114.1, 110.9, 55.4 ppm. HRMS $[M+H]^+$ calculated for $C_{16}H_{13}NOS$ 268.0717, found 269.0713.

[4.1.6] 2-phenyl-4-p-tolylthiazole (3h)



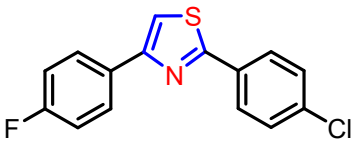
Yield 89%; white solid; m.p. 116 ^{O}C;**^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.08-8.06 (d, 2H), 7.93-7.91 (d, 2H), 7.50-7.45 (m, 4H), 7.29-7.26 (m, 2H), 2.43 (s, 3H, CH_3) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 167.7, 156.4, 138.0, 133.9, 131.9, 130.0, 129.4, 128.9, 126.6, 126.4, 111.9, 21.3 ppm. HRMS $[M+H]^+$ calculated for $C_{16}H_{13}NS$ 252.0768, found 253.0764.

[4.1.9] 4-(2-methoxyphenyl)-2-phenylthiazole (3i)



Yield 88%; white solid; m.p. 83 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.48-8.46 (d, J = 8.4 Hz, 1H), 8.10-8.08 (d, 2H), 7.99 (s, 1H), 7.51-7.44 (m, 3H), 7.37-7.34 (m, 1H), 7.15-7.12 (m, 1H), 7.06-7.04 (m, 1H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 165.7, 157.0, 152.0, 134.0, 130.3, 129.8, 128.9, 128.9, 126.7, 123.3, 121.0, 117.1, 111.1, 55.5 ppm. HRMS $[M+H]^+$ calculated for $C_{16}H_{13}NOS$ 268.0717, found 269.0713.

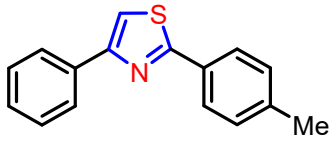
[4.1.10] 2-(4-chlorophenyl)-4-(4-fluorophenyl)-thiazole (3j)



Yield 85%; white solid m.p. 125-127 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.00-7.97 (m 4H), 7.47-7.44 (m 4H), 7.18-7.14 (m, 1H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 166.7, 163.8, 161.9,

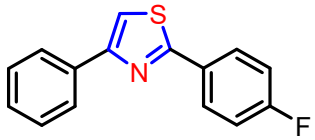
155.5, 136.0, 132.1, 130.6, 129.1, 128.2, 127.9, 115.8, 112.4 ppm. HRMS $[M+H]^+$ calculated for $C_{15}H_9ClFNS$ 290.0128, found 291.0132.

[4.1.11] 4-phenyl-2-(4-methylphenyl) (3k)



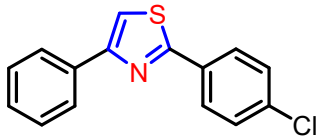
Yield 88%; white solid m.p. 124-125 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.03 (d, J = 7.4 Hz, 2H), 7.97-7.96 (d, J = 8.1 Hz, 2H), 7.49-7.46 (m, 3H), 7.39-7.38 (t, J = 7.4 Hz, 1H), 7.30-7.28 (d, J = 8.0 Hz, 2H), 2.44 (s, 3H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 168.1, 156.2, 140.3, 134.6, 131.2, 129.6, 128.7, 128.1, 126.5, 126.4, 112.2, 21.5 ppm. HRMS $[M+H]^+$ calculated for $C_{16}H_{13}NS$ 252.0768, found 253.0764.

[4.1.12] 4-phenyl-2-(4-flurophenyl) (3l)



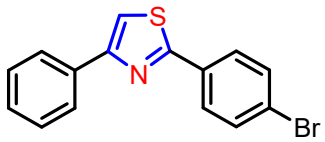
Yield 85%; white solid mp 117-118 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.08-8.00 (m, 4H), 7.49-7.46 (m, 3H), 7.40-7.37 (m, 1H), 7.20-7.16 (m, 2H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$, ppm); δ 166.7, 164.9 (d, J = 250.7 Hz), 156.4, 134.4, 130.1 (d, J = 3.7 Hz), 128.8, 128.6 (d, J = 8.8 Hz), 128.3, 126.4, 116.1, 115.9 (d, J = 22.7 Hz); HRMS $[M+H]^+$ calculated for $C_{15}H_{10}FNS$ 256.0517, found 257.0513

[4.1.13] 4-phenyl-2-(4-chlorophenyl) (3m)



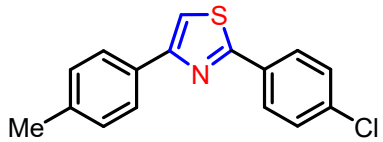
Yield 85%; white solid m.p. 110 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.02-8.00 (m, 4H), 7.50-7.40 (m, 5H), 7.40-7.38 (m, 1H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 166.5, 156.5, 136.0, 134.3, 132.3, 129.2, 128.8, 128.3, 127.8, 126.5, 112.8 ppm. HRMS $[M+H]^+$ calculated for $C_{15}H_{10}ClFNS$ 272.0222, found 273.0225.

[4.1.14] 4-phenyl-2-(4-bromophenyl) (3n)



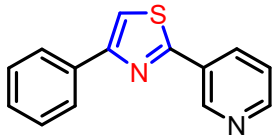
Yield 85%; white solid m.p. 103-104 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.07-8.05 (m, 2H), 7.91-7.89 (m, 2H), 7.60-7.59 (m, 2H), 7.51-7.50 (m, 3H), 7.48-7.47 (m, 1H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 168.2, 155.2, 133.6, 133.4, 131.9, 130.2, 128.9, 128.0, 126.6, 122.2, 113.0 ppm. HRMS $[M+H]^+$ calculated for $C_{15}H_{10}ClFNS$ 315.9717, found 315.9714.

[4.1.15] 2-(4-chlorophenyl)-4-(p-tolyl)-thiazole (3o)



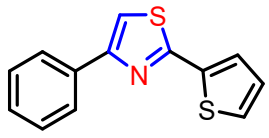
Yield 85%; white solid, m.p. 164-165 ^{O}C, **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.01-7.99 (m, 2H), 7.91-7.89 (d, J = 1.8 Hz, 2H), 7.46-7.45 (m, 3H), 7.29-7.27 (m, 2H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 166.4, 156.6, 138.2, 135.9, 132.3, 131.6, 129.5, 129.1, 127.8, 126.4, 112.1, 21.3 ppm. HRMS $[M+H]^+$ calculated for $C_{16}H_{12}ClNS$ 286.0378, found 287.0381.

[4.1.16] 4-phenyl-2-(pyridin-3-yl)-thiazole (3p)



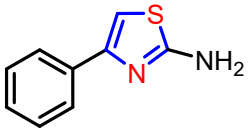
Yield: 75%; Pale Yellow solid, m.p. 268-269 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.90-8.88 (d, J = 1.5 Hz, 1H), 8.75 (dd, J = 5.0 Hz, 1H), 7.95-7.91 (dd, J = 8.0 Hz, 5H), 7.52-7.49 (dd, J = 8.5 Hz, 1H), 7.19-7.18 (m, 2H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 164.3, 156.9, 150.6, 147.6, 134.1, 133.8, 129.9, 128.8, 128.5, 126.5, 123.8, 113.3 ppm. HRMS $[M+H]^+$ calculated for $C_{14}H_{10}N_2S$ 239.0564, found 240.0560.

[4.1.17] 4-phenyl-2-(thiophen-2-yl)-thiazole (3q)



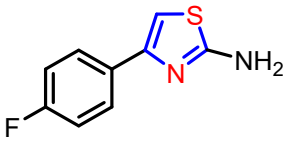
Yield 75%; colourless oil, **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.43-8.41 (m, 2H), 8.09-8.07 (m, 2H), 7.91-7.89 (m, 1H), 7.56-7.55 (m, 3H), 7.52-7.43 (m, 1H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 161.2, 156.5, 137.2, 134.3, 129.2, 128.8, 128.3, 127.8, 126.5, 112.9 ppm. HRMS $[M+H]^+$ calculated for $C_{13}H_9NS_2$ 244.0176, found 245.0172.

[4.1.18] 4-phenylthiazol-2-amine (4a)



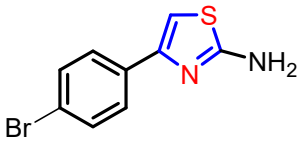
Yield 85%; pale yellow solid; m.p. 150-151 ^{O}C;**^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.81 (m, 2H), 7.42-7.39 (m, 2H), 7.33-7.31 (m, 1H), 6.75 (s, 1H), 4.12-4.11 (s, 2H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 167.2, 151.4, 134.7, 128.6, 127.7, 126.0, 102.9, ppm. HRMS $[M+H]^+$ calculated for $C_9H_8NS_2$ 177.0408, found 178.0404.

[4.1.19] 4-(4-flurophenyl)-thiazol-2-amine (4b)



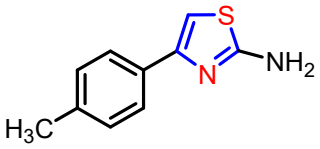
Yield 80%; White Solid; m.p. 102-103 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.76-7.72 (m, 2H), 6.95-6.92 (m, 2H), 6.61 (s, 1H), 4.98 (s, 2H) ppm. **^{13}C NMR** (126 MHz $CDCl_3$); δ 167.3, 163.5, 161.5, 150.2, 130.8, 127.7, 127.7, 115.6, 115.4, 102.4 ppm. HRMS $[M+H]^+$ calculated for $C_9H_7FN_2S$ 195.0313, found 196.0320.

[4.1.20] 4-(4-bromophenyl)-thiazol-2-amine (4c)



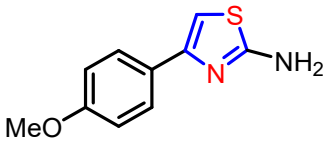
Yield 80%; white solid; m.p. 182-183 ^{O}C; **^{1}HNMR** (500 MHz, $CDCl_3$); δ 7.67-7.66 (m, 2H), 7.52-7.51 (m, 2H), 6.74 (s, 1H), 5.11 (brs, 2H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 167.3, 150.2, 133.6, 131.7, 127.6, 121.6, 103.4 ppm. HRMS $[M+H]^+$ calculated for $C_9H_7BrN_2S$ 254.9513, found 255.9516.

[4.1.21] 4-(4-methylphenyl)-thiazol-2-amine (4d)



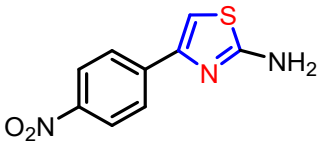
Yield 80%; white solid, m.p. 150-151 ^{O}C; **^{1}H NMR** (500 MHz,$CDCl_3$); δ 7.69-7.68 (d, *J* = 8.0 Hz, 2H), 7.21-7.20 (d, *J* = 8.5 Hz, 2H), 6.69 (s, 1H), 5.11 (brs, 2H), 2.38 (s, 3H) ppm.**^{13}C NMR** (126 MHz, $CDCl_3$); δ 167.2, 151.4, 137.5, 131.9, 129.3, 125.9, 102.1, 21.2 ppm. HRMS $[M+H]^+$ calculated for $C_{10}H_{10}N_2S$ 191.0565, found 192.0569.

[4.1.22] 4-(4-methoxyphenyl)-thiazol-2-amine (4e)



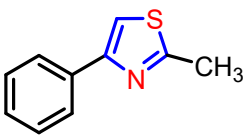
Yield 85%; brown solid, m.p: 199-200 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.91-7.89 (d, *J* = 8.7 Hz, 1H), 7.77-7.76 (d, *J* = 6.0 Hz, 1H), 7.69-7.67 (m, 1H), 7.58-7.56(m, 1H), 6.91 (m, 1H), 5.03 (brs, 2H) 4.12 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$); δ 165.8, 159.6, 155.0, 127.8, 127.7, 114.3, 98.1, 55.4 ppm. HRMS $[M+H]^+$ calculated for $C_{10}H_{10}N_2OS$ 207.0513, found 208.0517.

[4.1.23] 4-(4-nitroyphenyl)-thiazol-2-amine (4f)



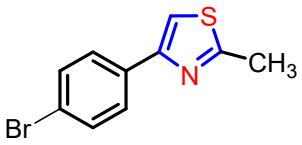
Yield 80%; brown solid, m.p: 199-200 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.03-8.02 (d, *J* = 8.7 Hz, 2H), 7.68-7.67 (d, *J* = 6.0 Hz, 2H), 6.67 (s, 1H), 4.98 (brs, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$); δ 167.2, 148.1, 143.8, 138.8, 127.3, 127.2, 126.1, 126.0, 107.5 ppm. HRMS $[M+H]^+$ calculated for $C_{10}H_{10}N_2OS$ 222.0259, found 222.0554.

[4.1.24] 4-phenyl-2-methyl-thiazole (4g)



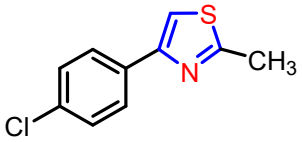
Yield 85%; white solid; m.p. 65-66 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.91-7.90 (m, 2H), 7.45-7.42 (m, 2H), 7.36 (m, 1H), 7.33 (m, 1H), 2.80 (s, 3H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 165.9, 155.2, 134.5, 128.8, 128.7, 128.5, 127.9, 126.3, 112.3, 19.3 ppm. HRMS $[M+H]^+$ calculated for $C_{10}H_9NS$ 176.0455, found 177.0452

[4.1.25] 4-(4-bromophenyl)-2-methyl-thiazole (4h)



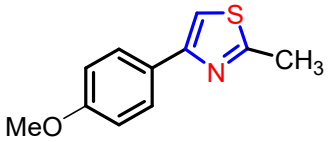
Yield 83%; white solid; m.p. 130-131 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.76-7.75 (m, 2H), 7.55-7.54 (m, 2H), 7.33-7.28 (m, 1H), 2.78-2.77 (s, 3H) ppm; **^{13}C NMR** (126 MHz, $CDCl_3$); δ 165.2, 154.0, 133.5, 131.8, 127.9, 121.9, 112.7, 19.3 ppm. HRMS $[M+H]^+$ calculated for $C_{10}H_8BrNS$ 253.9560, found 254.9564.

[4.1.26] 4-(4-chlorophenyl)-2-methyl-thiazole (4i)



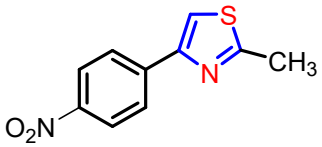
Yield 83%; white solid; m.p. 113 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.76-7.75 (m, 2H), 7.55 (s, 2H), 7.33-7.30 (m, 1H) ppm; **^{13}C NMR** (126 MHz, $CDCl_3$); δ 166.2, 154.0, 134.1, 133.5, 128.9, 127.9, 112.7, 19.3 ppm. HRMS $[M+H]^+$ calculated for $C_{10}H_8ClNS$ 210.0065, found 211.0062.

[4.1.27] 4-(4-methoxyphenyl)-2-methyl-thiazole (4j)



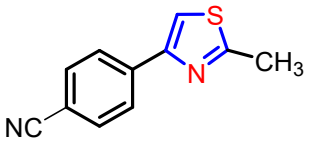
Yield 88%; white solid; m.p. 66-68 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.83-7.81 (m, 2H), 7.18 (s, 1H), 6.97-6.95 (m, 2H), 3.86 (s, 3H), 2.78 (s, 3H) ppm; **^{13}C NMR** (126 MHz, $CDCl_3$); δ 165.7, 159.5, 154.9, 127.6, 127.5, 114.1, 110.5, 55.3, 19.3 ppm. HRMS $[M+H]^+$ calculated for $C_{11}H_{11}NOS$ 206.0561, found 207.0565.

[4.1.28] 4-(4-nitrophenyl)-2-methyl-thiazole (4k)



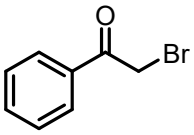
Yield 80%; white solid; m.p. 132-135^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.36-8.28 (m, 2H), 8.07-8.06 (m, 2H), 7.55 (m, 1H), 2.81 (s, 3H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 166.8, 152.7, 147.2, 140.3, 140.0, 126.8, 124.2, 124.0, 115.9, 19.3 ppm. HRMS $[M+H]^+$ calculated for $C_{10}H_8N_2O_2S$ 221.0408, found 222.0404.

[4.1.29] 4-(4-cyanophenyl)-2-methyl-thiazole (4l)



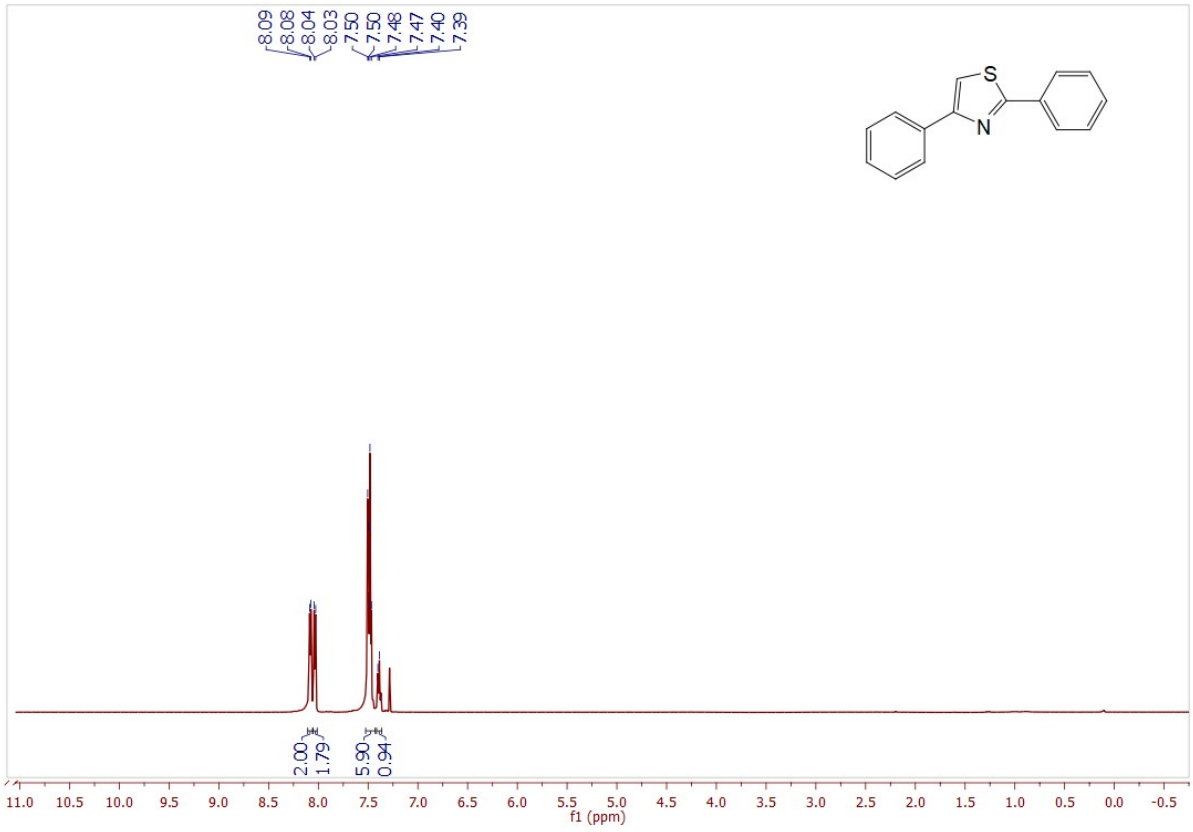
Yield 80%; white solid; m.p. 134 ^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.10-8.00 (m, 2H), 7.82-7.70 (m, 2H), 7.49 (s, 1H), 2.81 (s, 3H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 166.8, 153.0, 138.6, 132.6, 126.8, 118.9, 115.2, 111.3, 19.3 ppm. HRMS $[M+H]^+$ calculated for $C_{11}H_8N_2S$ 201.0408, found 202.0411.

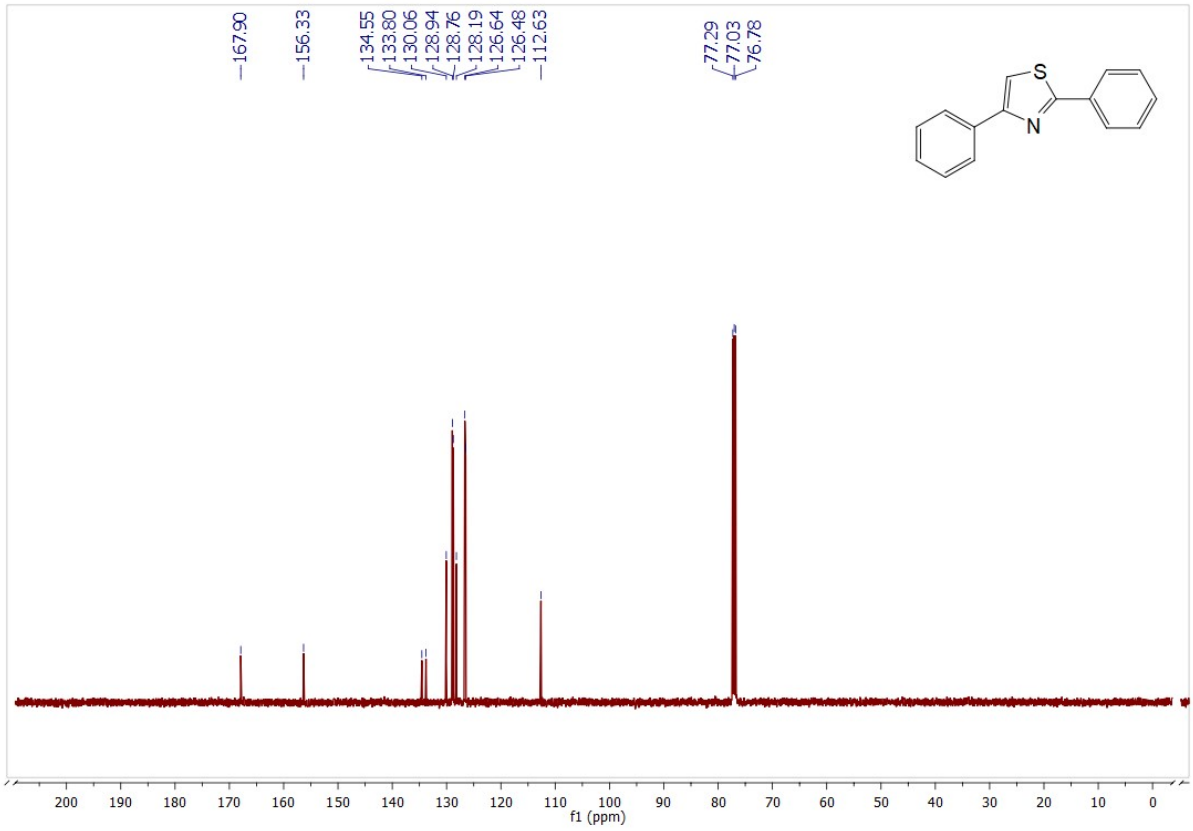
[4.1.30] 2-bromo-1-phenylethan-1-one (Figure 6, Intermediate C)



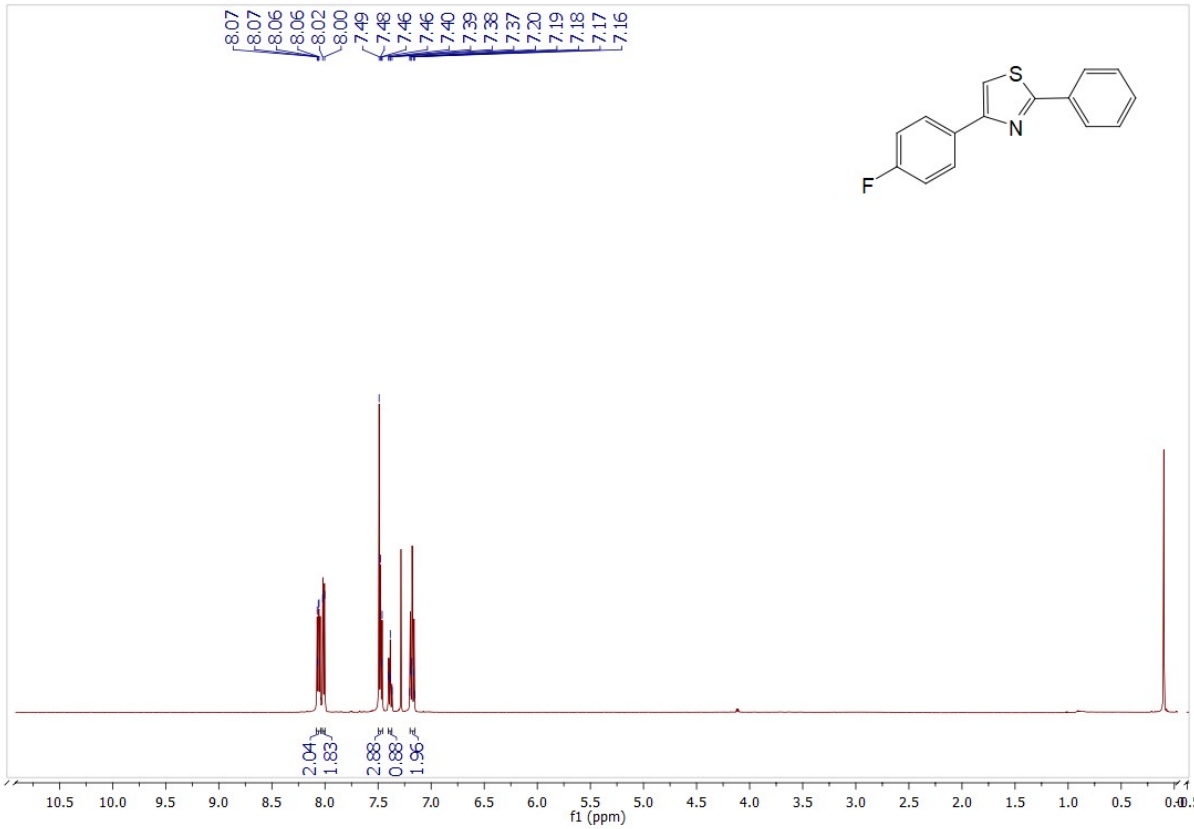
m.p. 53^{O}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.02-8.00 (m, 2H), 7.65-7.62 (m, 1H), 7.54-7.51 (m, 2H), 4.49 (s, 2H) ppm. **^{13}C NMR** (126 MHz, $CDCl_3$); δ 191.3, 134.0, 133.9, 128.9, 128.9, 30.9 ppm.

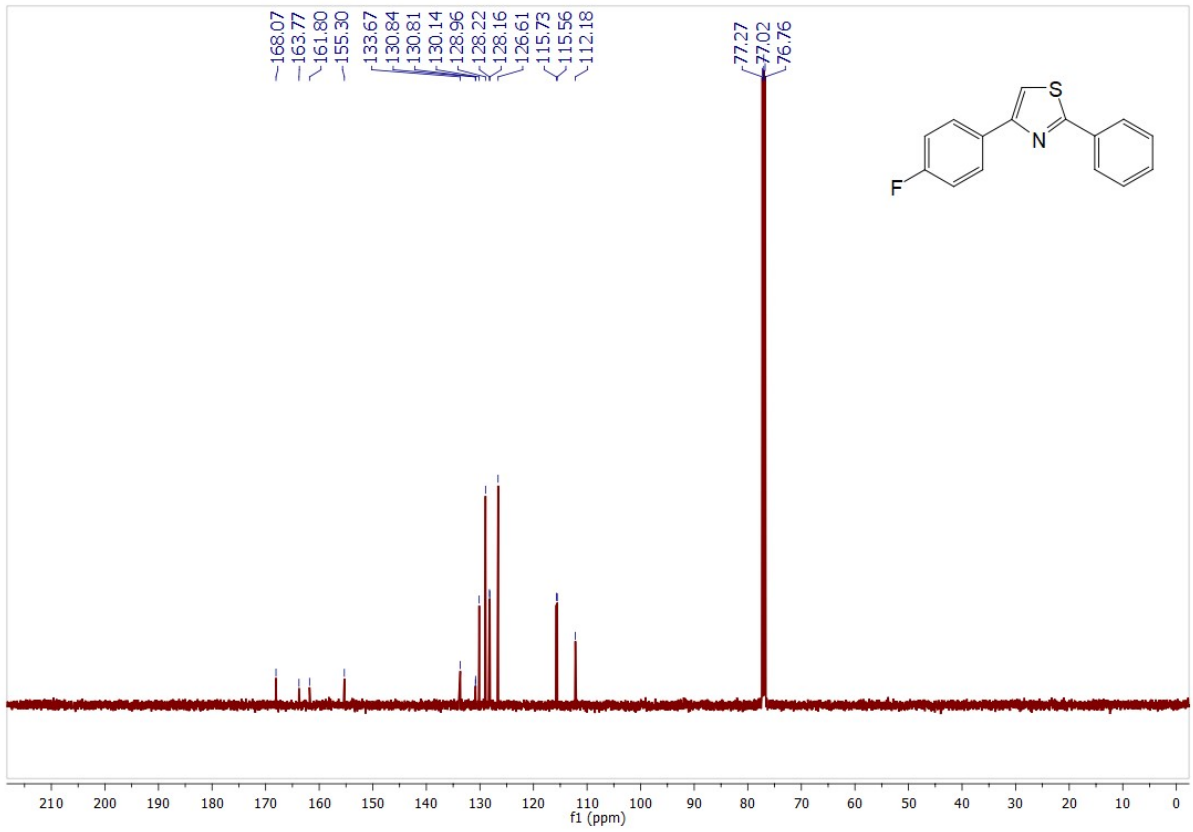
^{1}H & ^{13}C NMR Spectra of 2,4-diphenyl thiazole (3a)



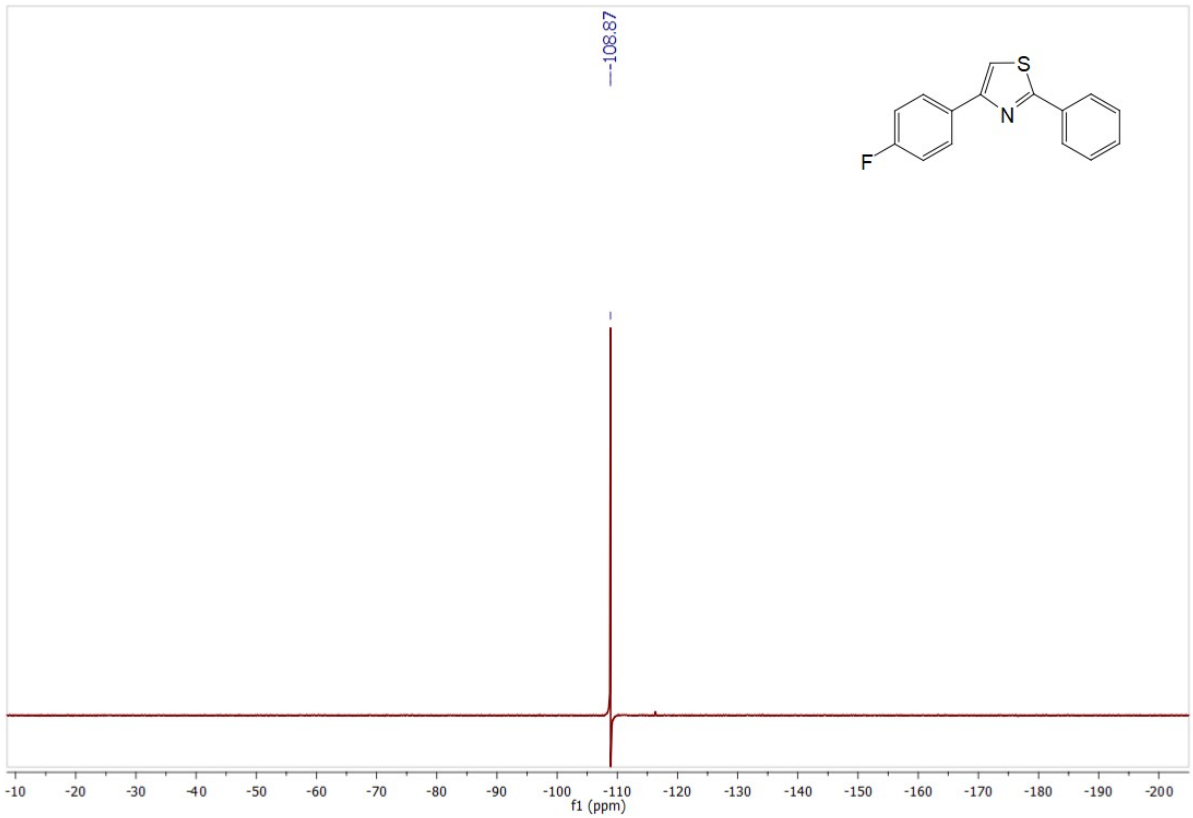


^{1}H & ^{13}C NMR Spectra 4-(4-fluorophenyl)-2-phenylthiazole (3b)

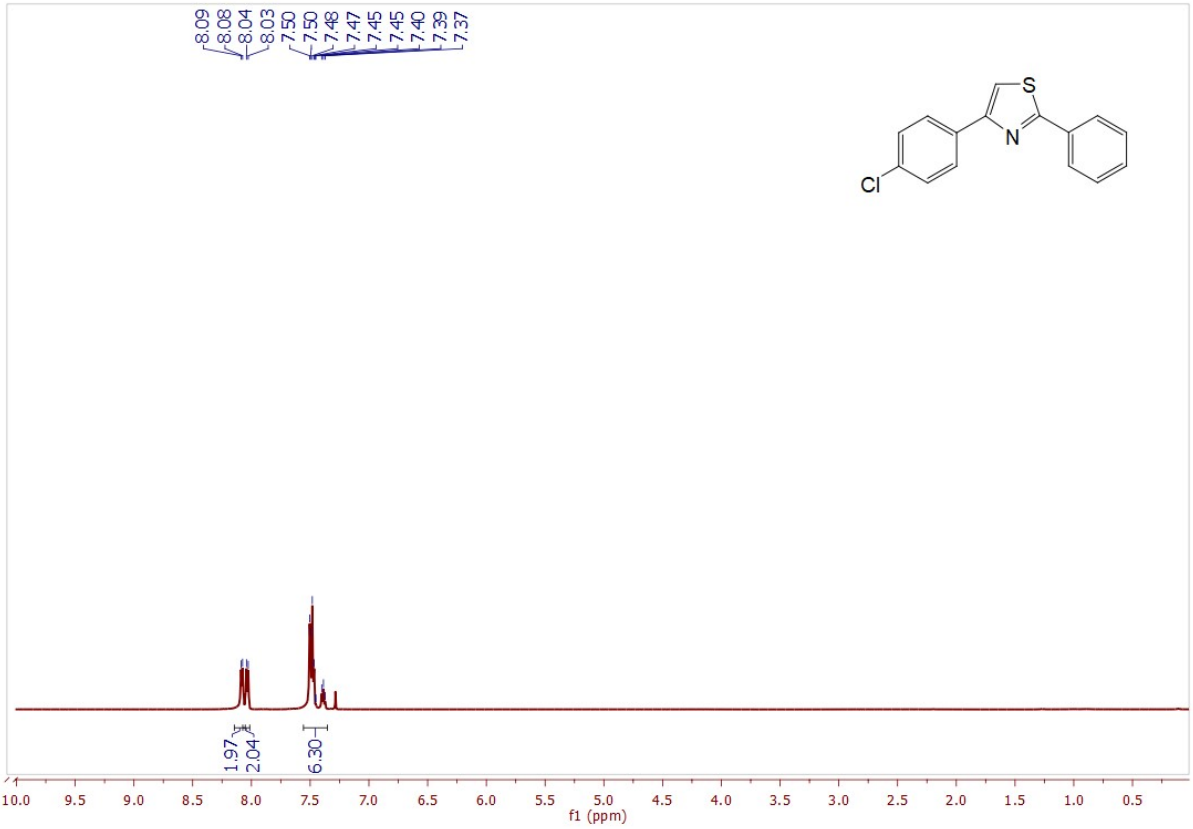


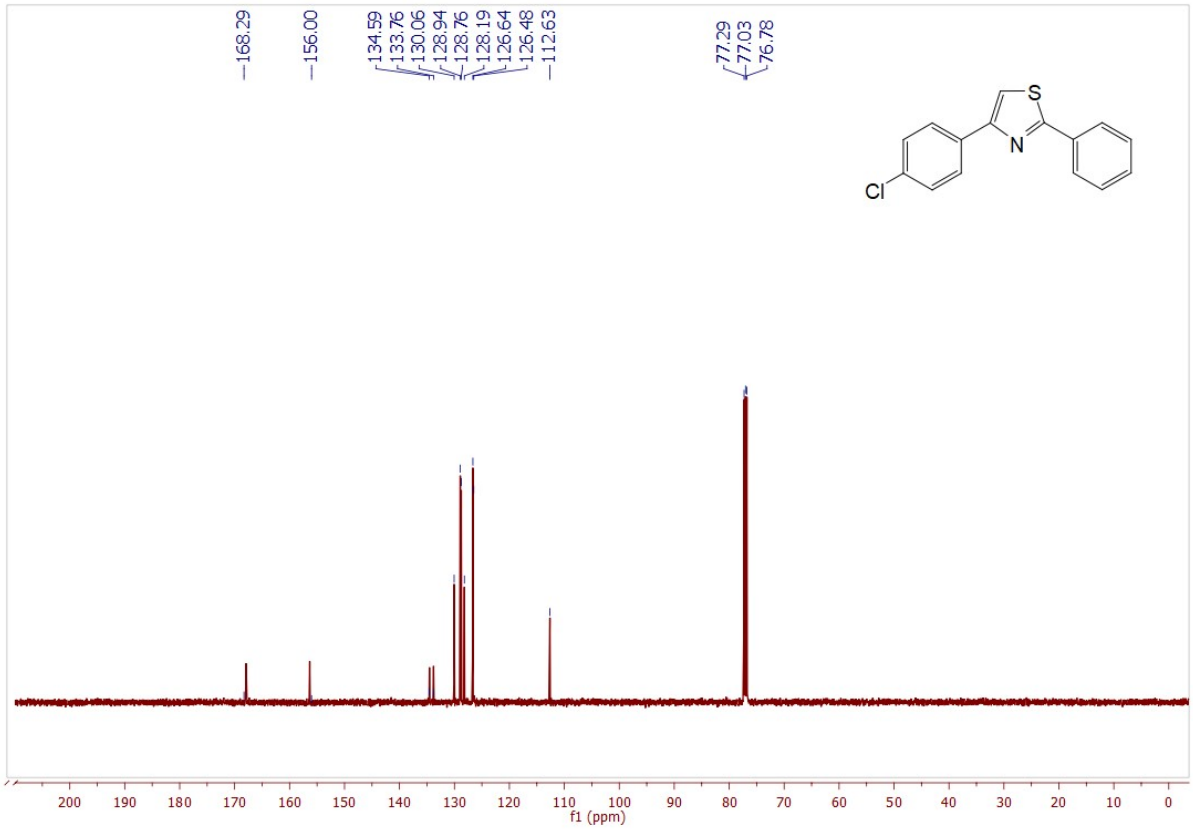


^{19}F NMR for Spectra 4-(4-fluorophenyl)-2-phenylthiazole (3b)

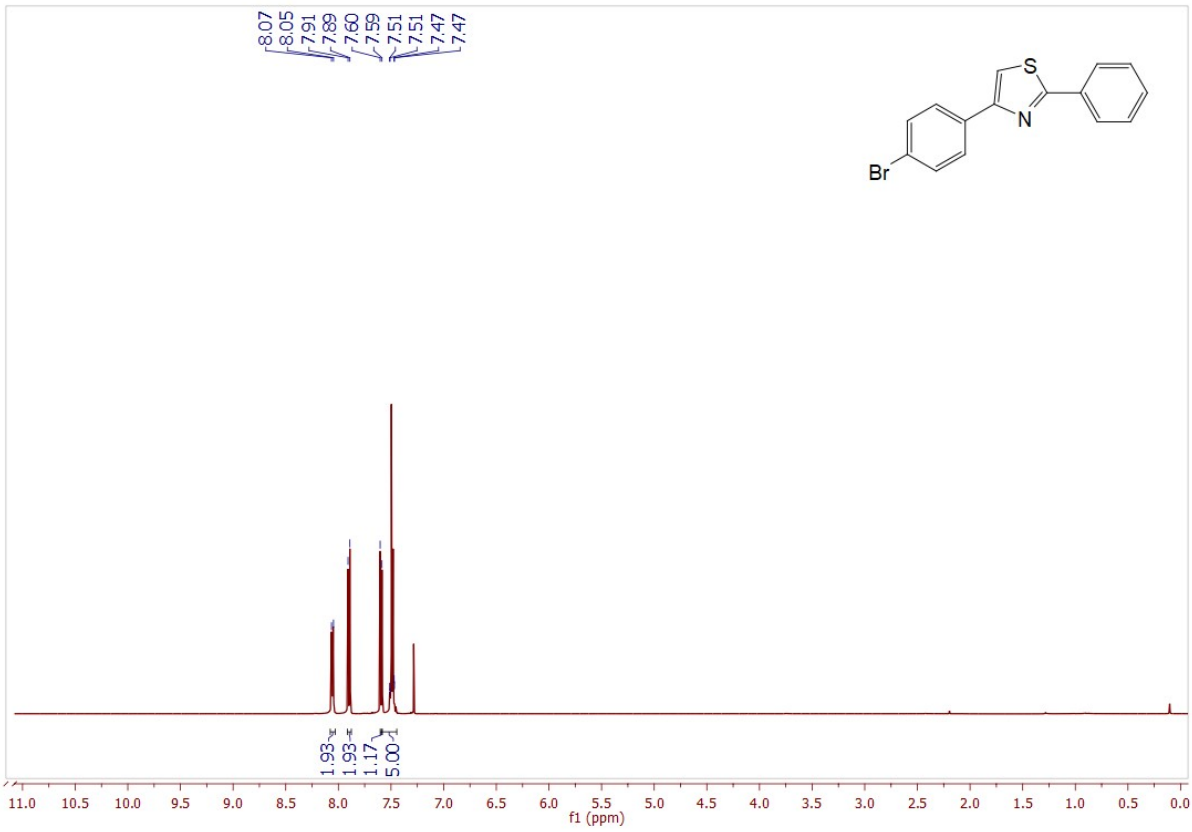


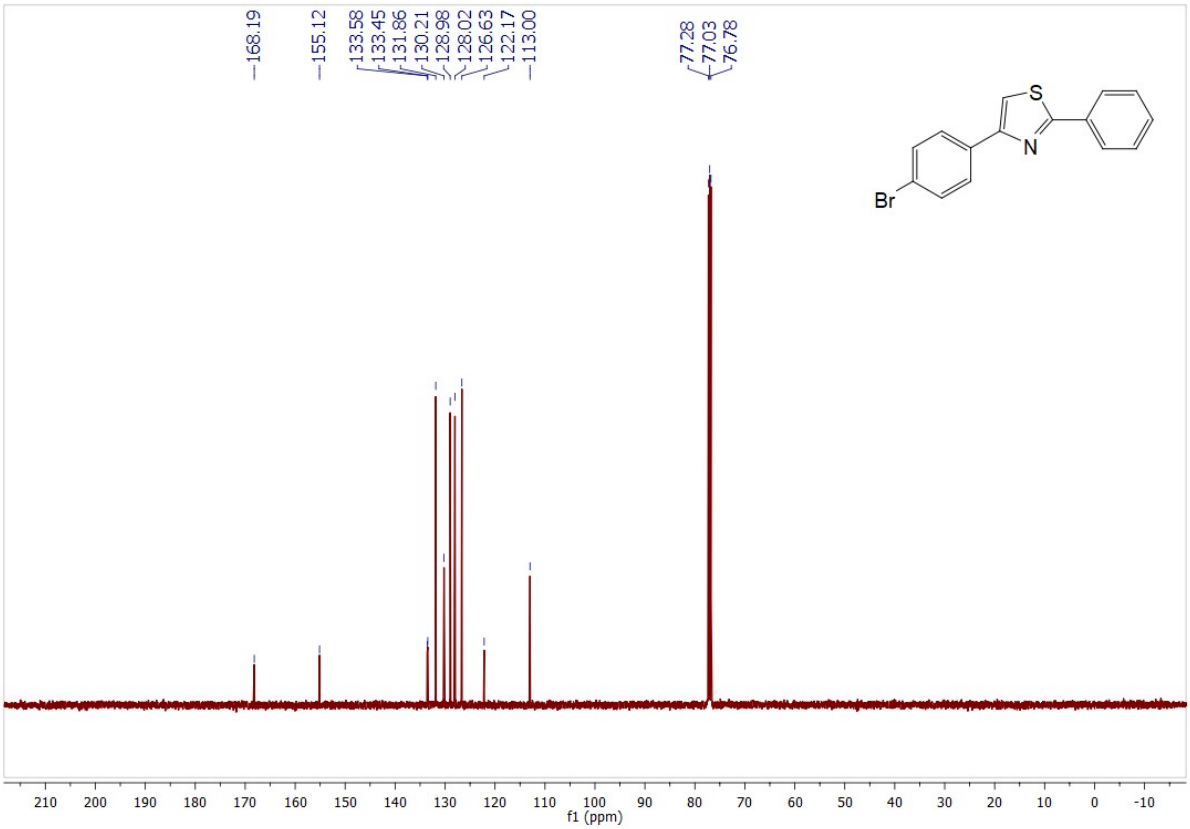
^{1}H & ^{13}C NMR Spectra 4-(4-chlorophenyl)-2-phenylthiazole (3c)



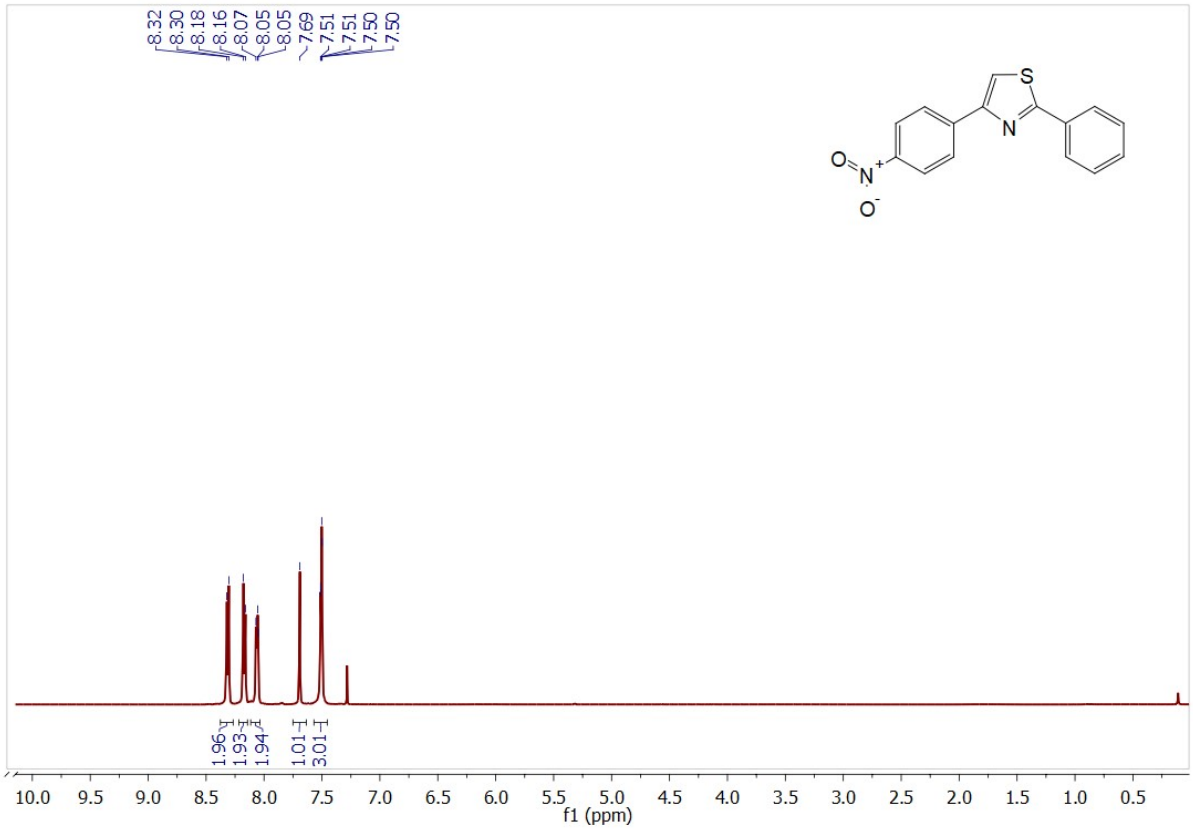


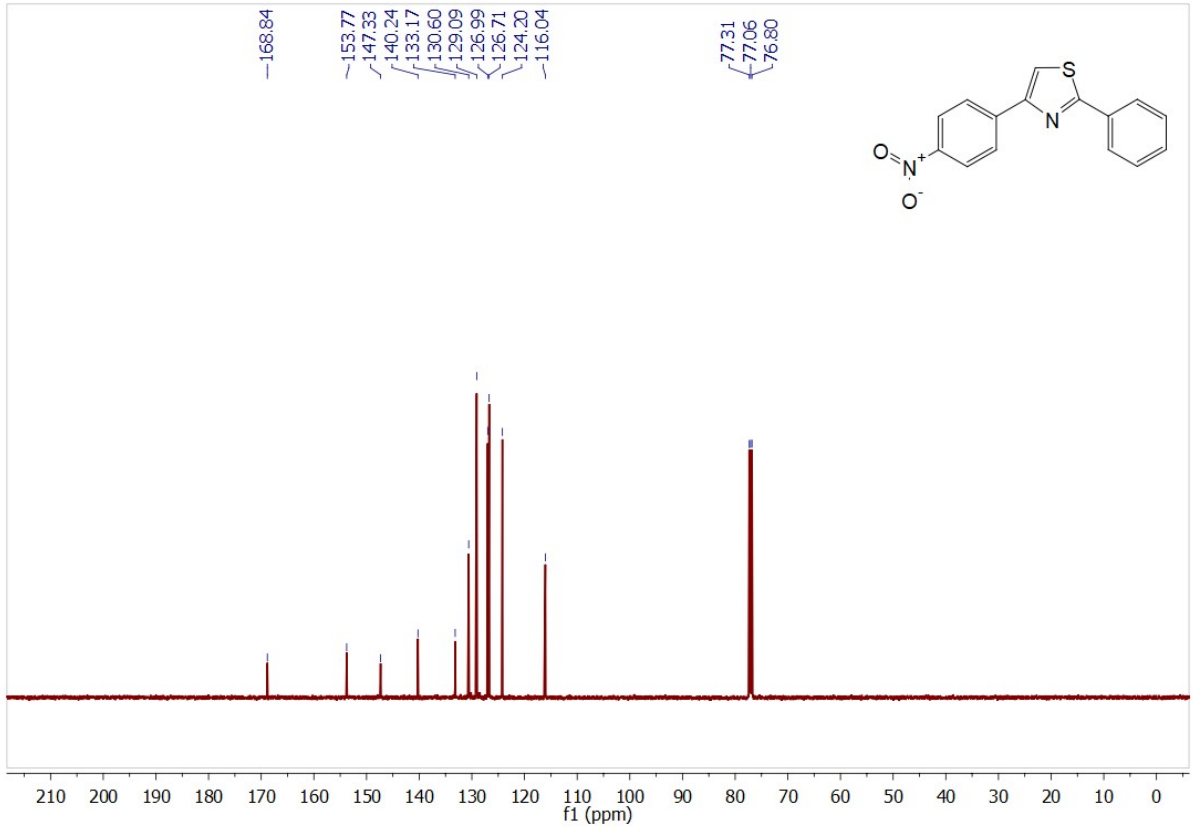
^{1}H & ^{13}C NMR Spectra 4-(4-bromophenyl)-2-phenylthiazole (3d)



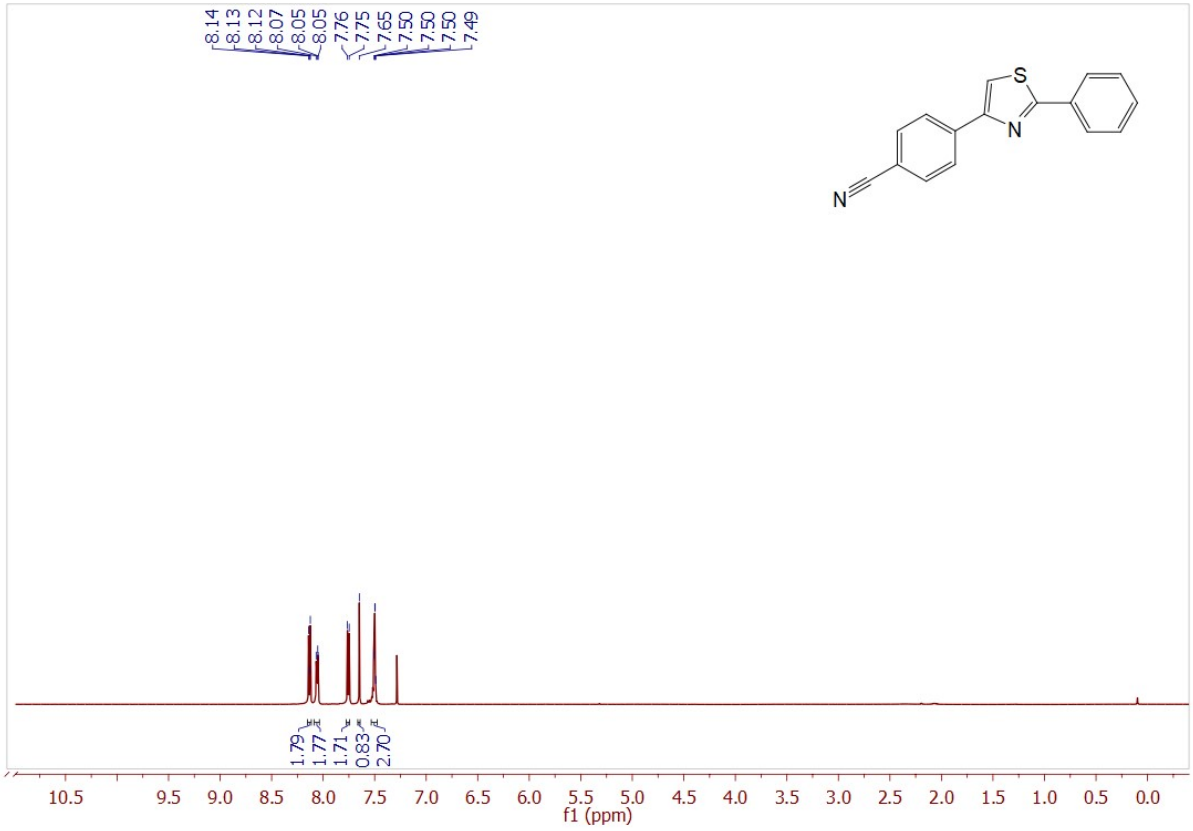


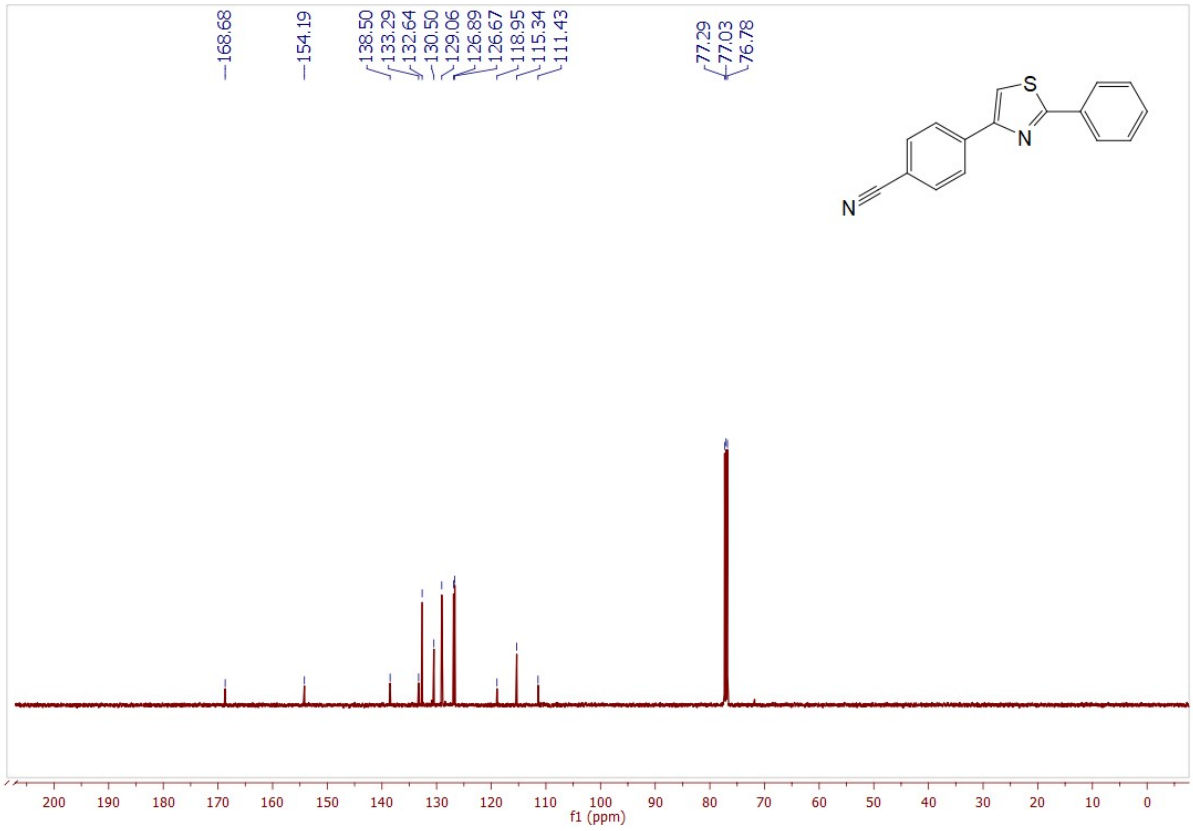
^{1}H & ^{13}C NMR Spectra 4-(4-nitrophenyl)-2-phenylthiazole (3e)



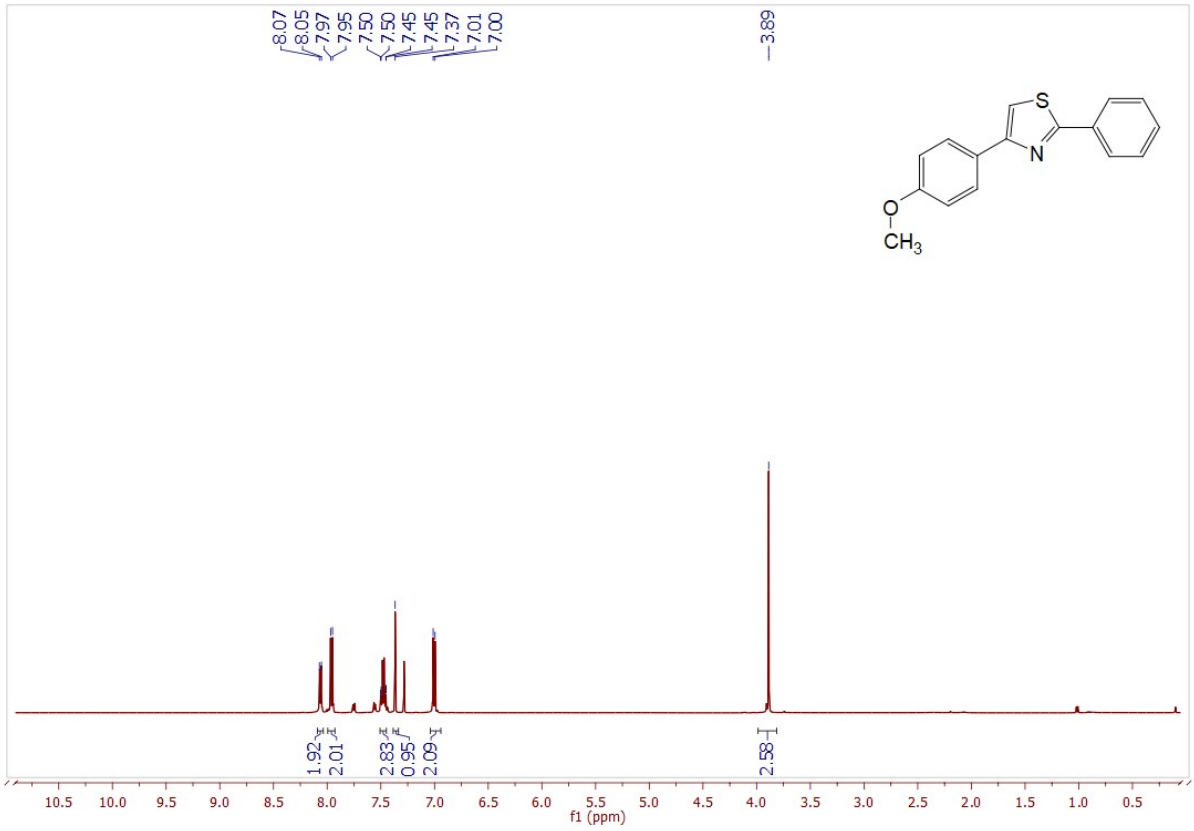


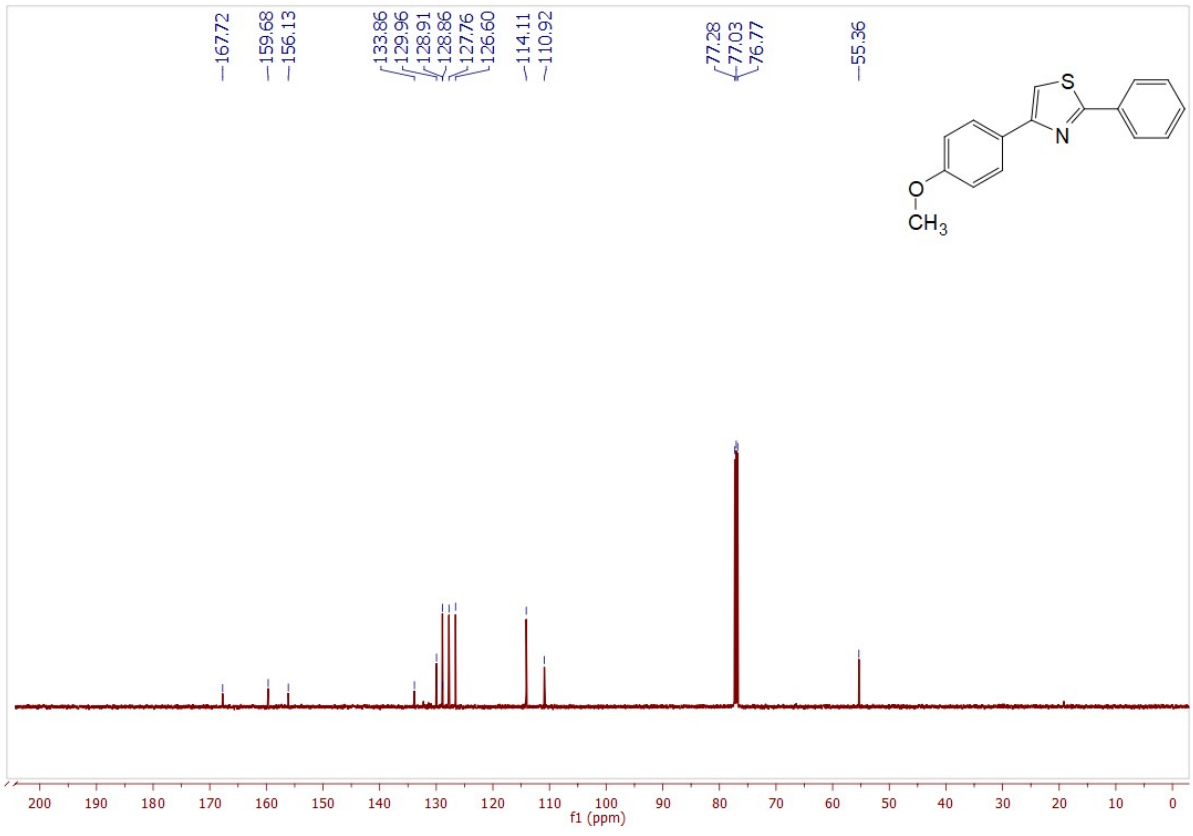
^{1}H & ^{13}C NMR Spectra 4-(4-cyanophenyl)-2-phenylthiazole (3f)



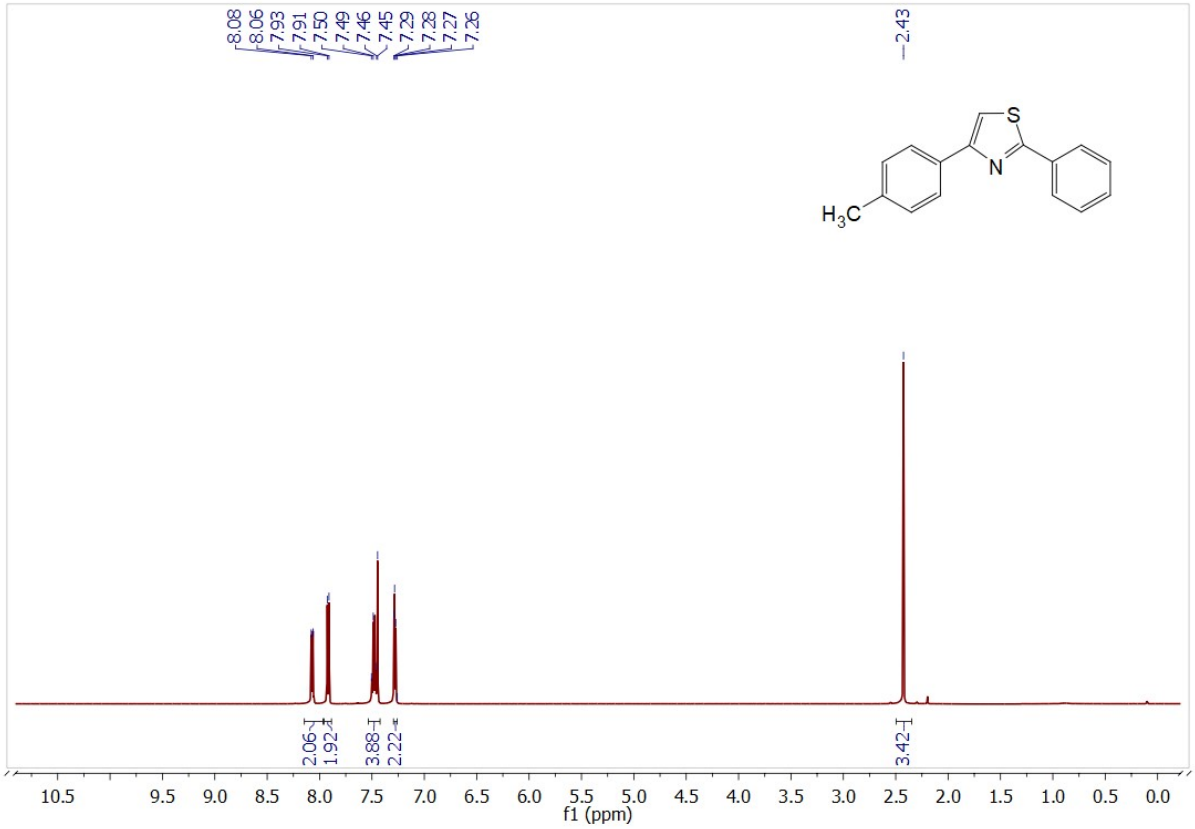


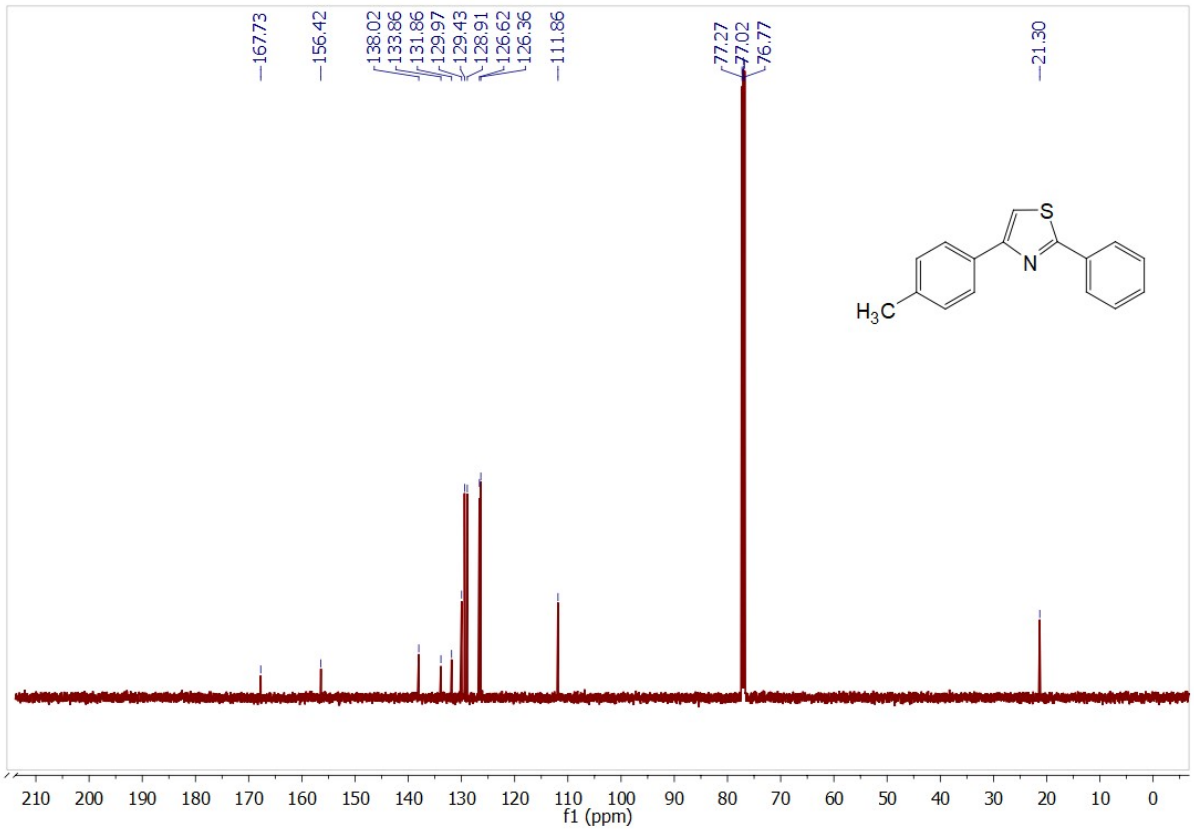
^{1}H & ^{13}C NMR Spectra 4-(4-methoxyphenyl)-2-phenylthiazole (3g)



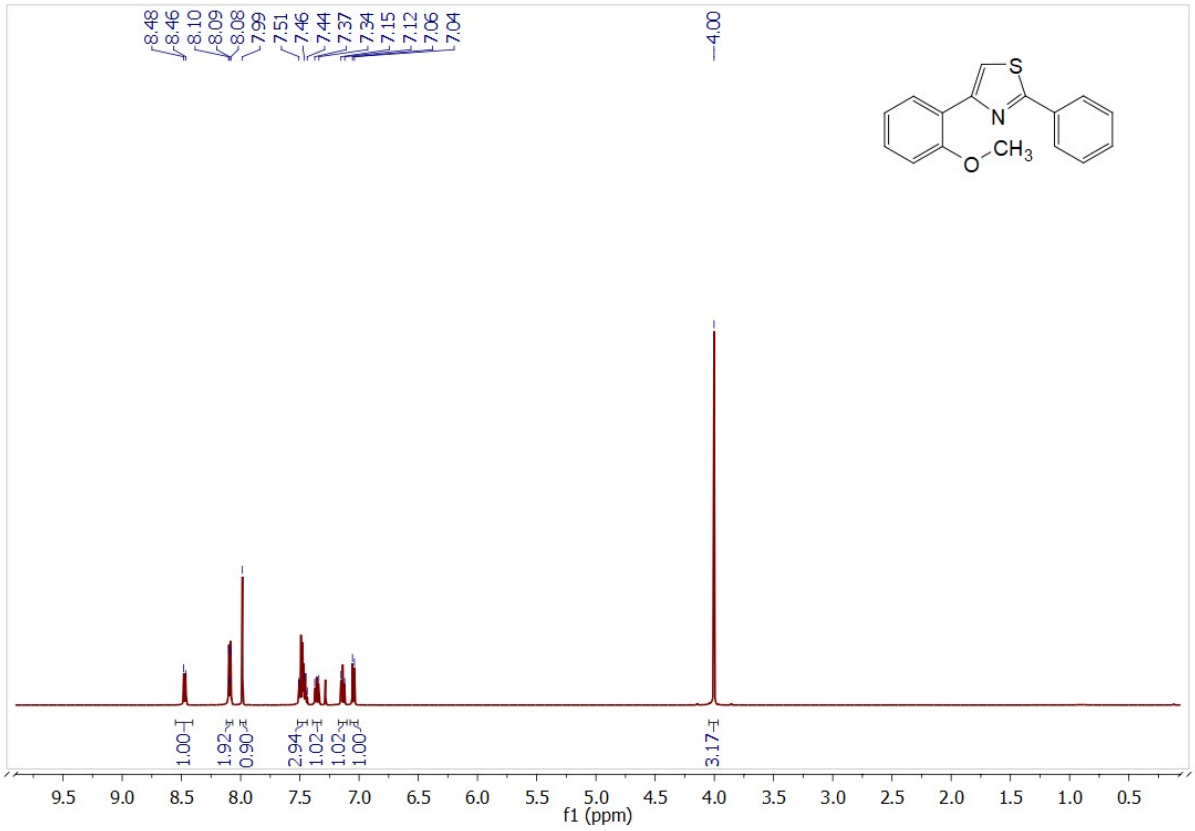


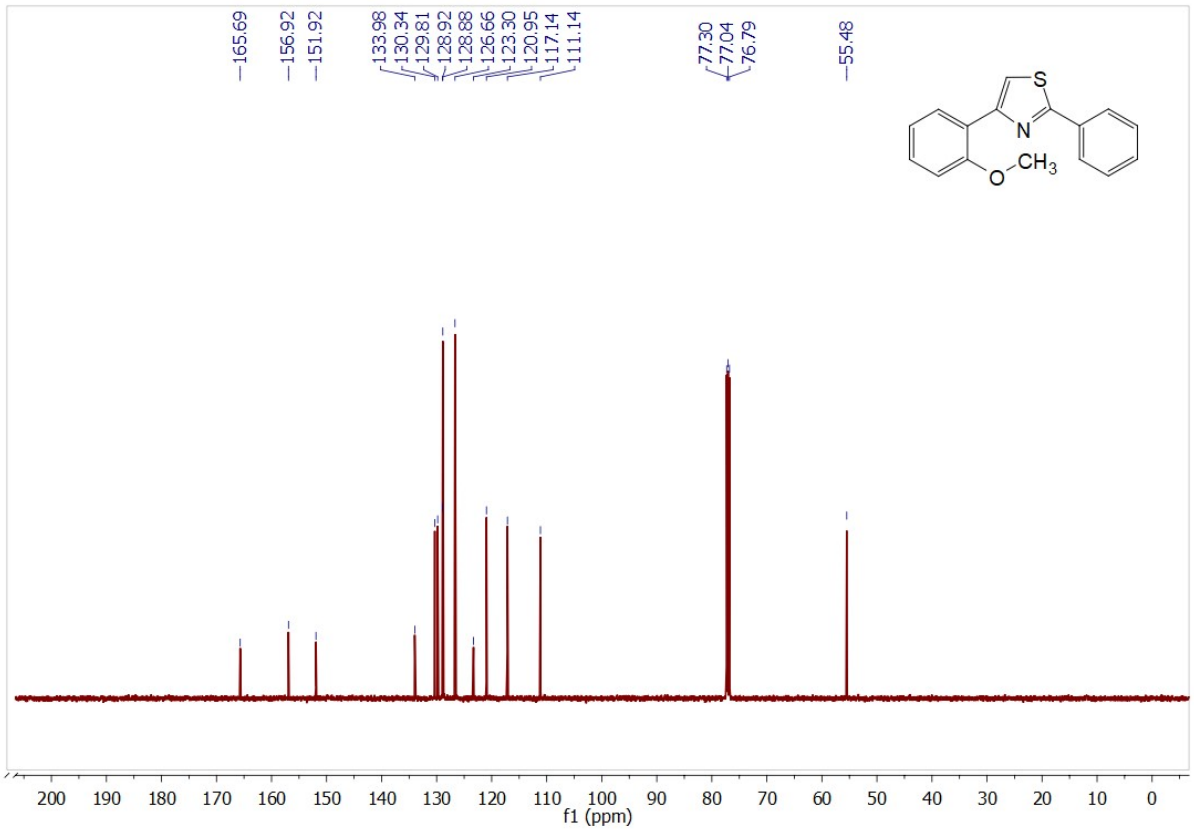
^{1}H & ^{13}C NMR Spectra 2-phenyl-4-p-tolylthiazole (3h)



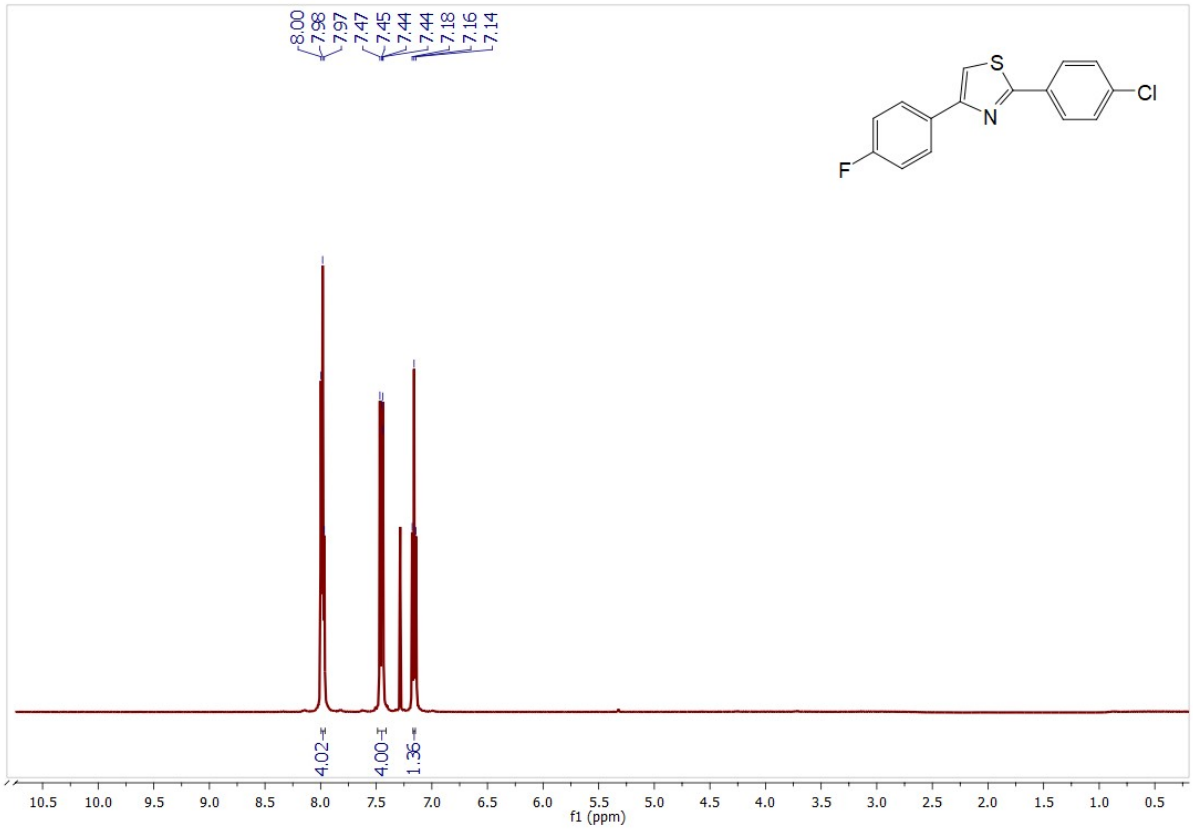


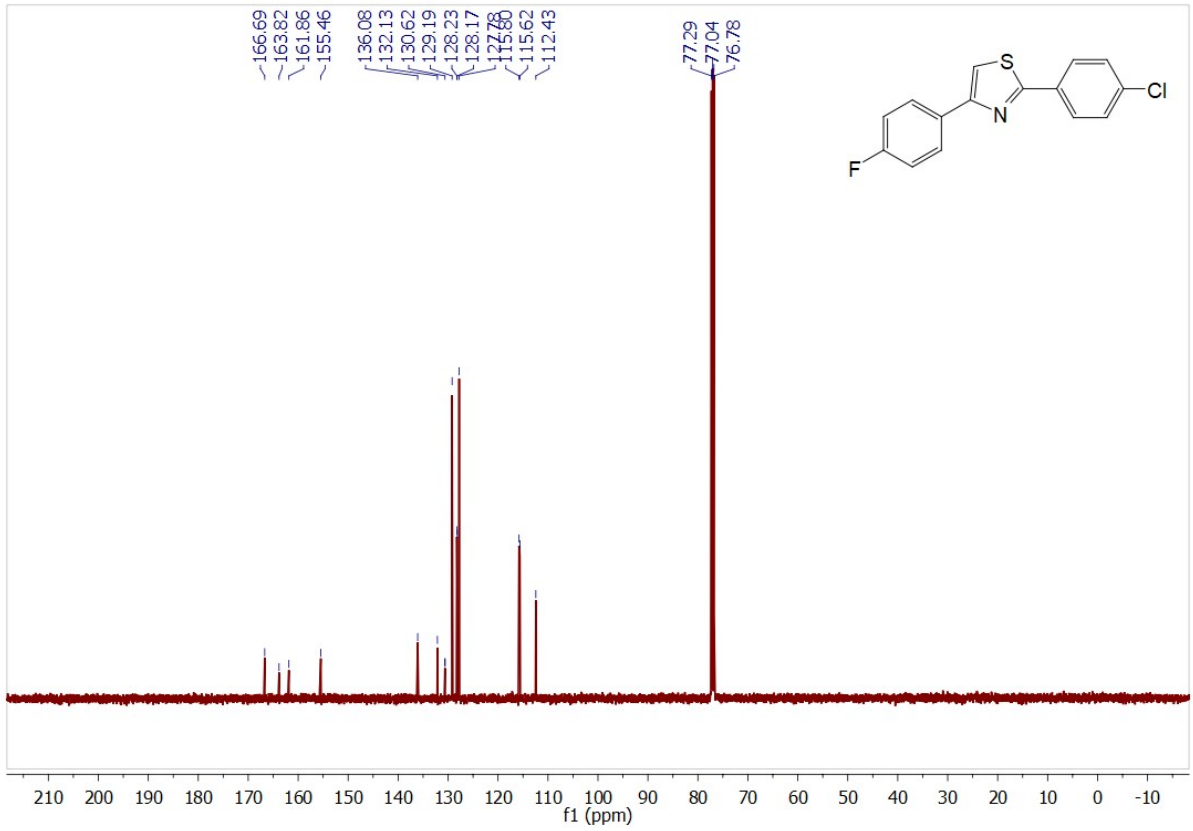
^{1}H & ^{13}C NMR Spectra 4-(2-methoxyphenyl)-2-phenylthiazole (3i)



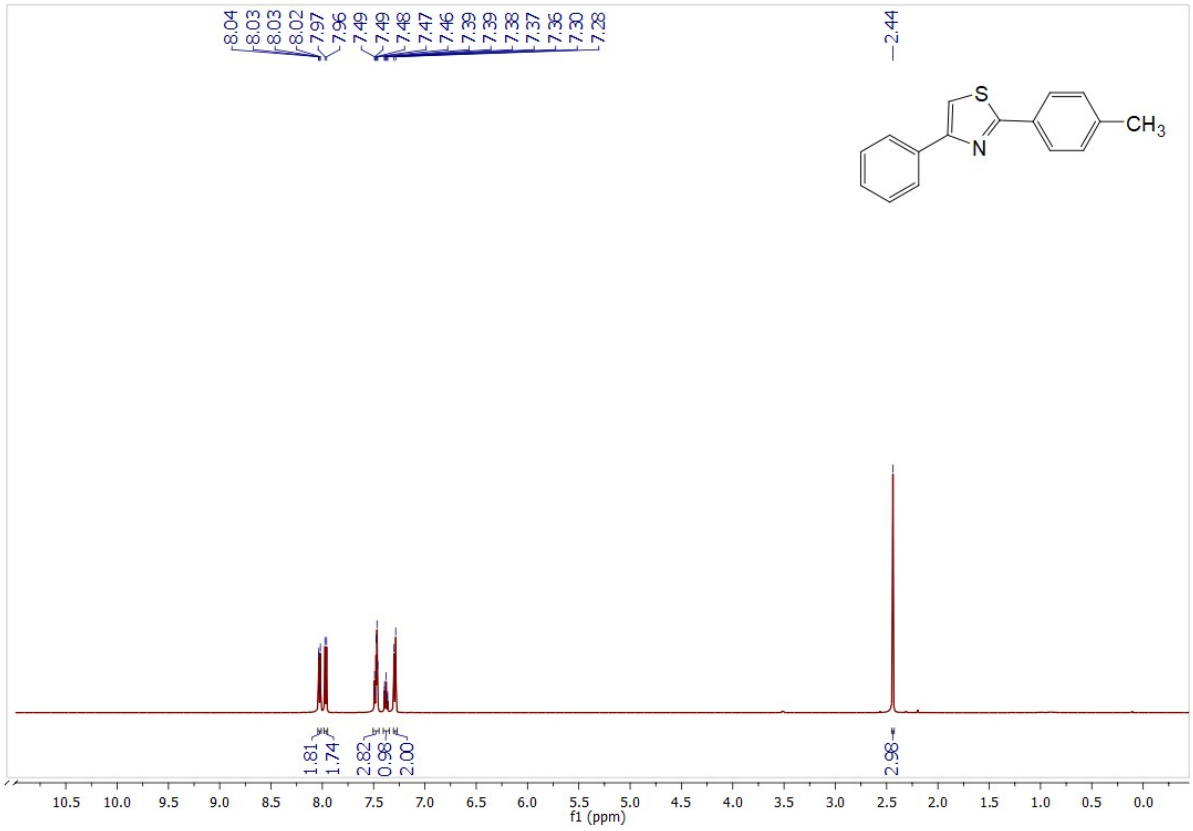


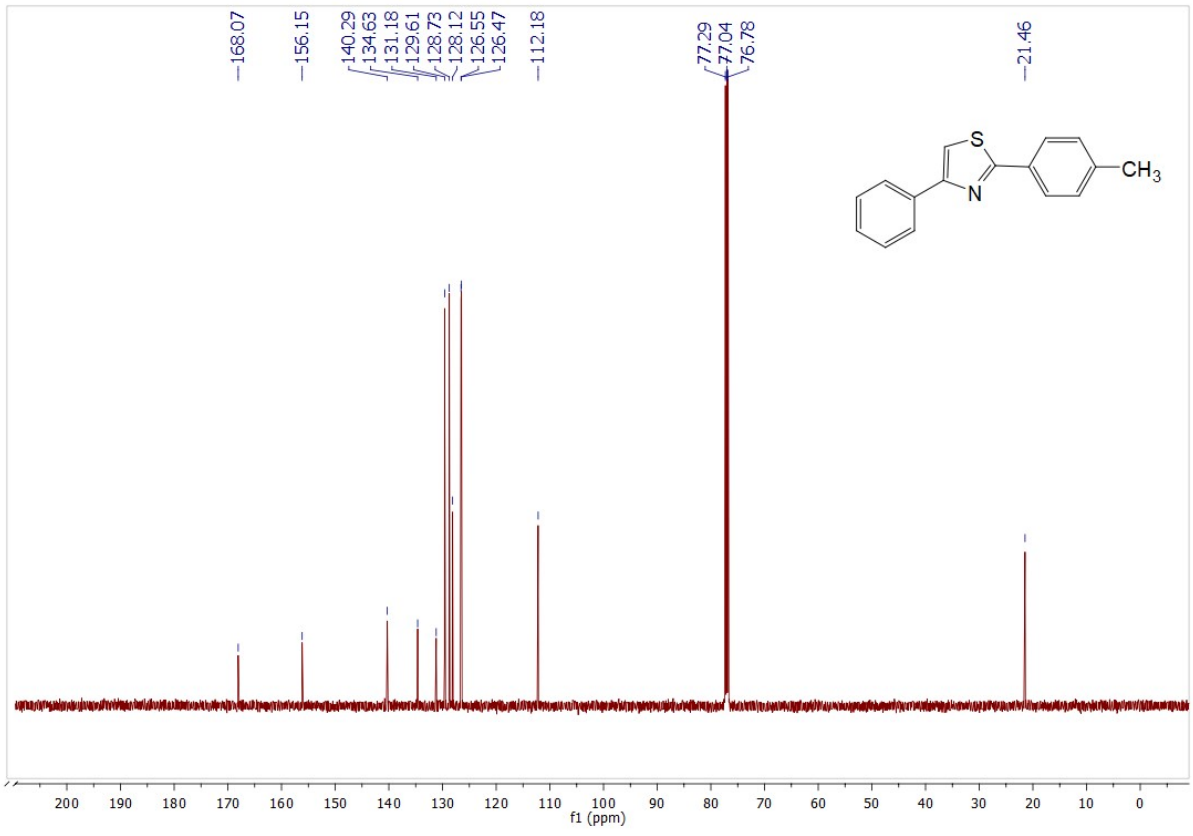
^{1}H & ^{13}C NMR Spectra 2-(4-chlorophenyl)-4-(4-fluorophenyl)-thiazole (3j)



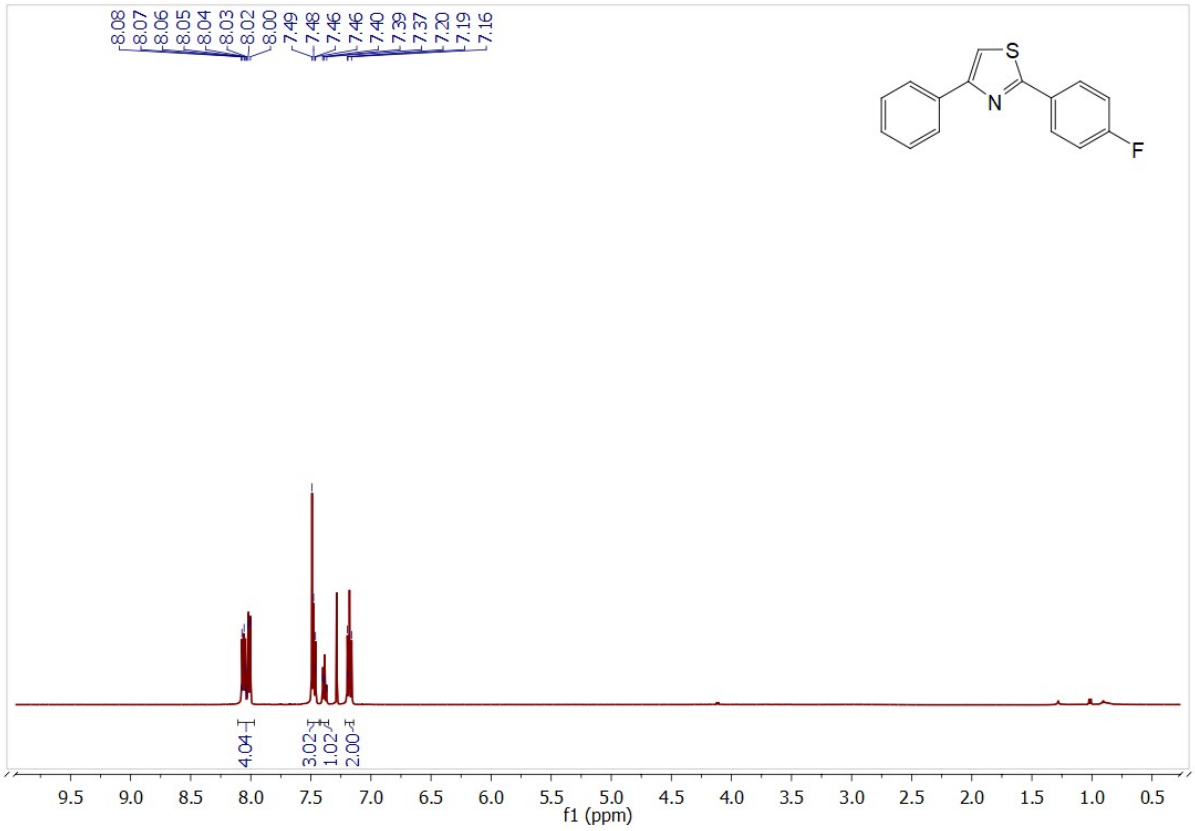


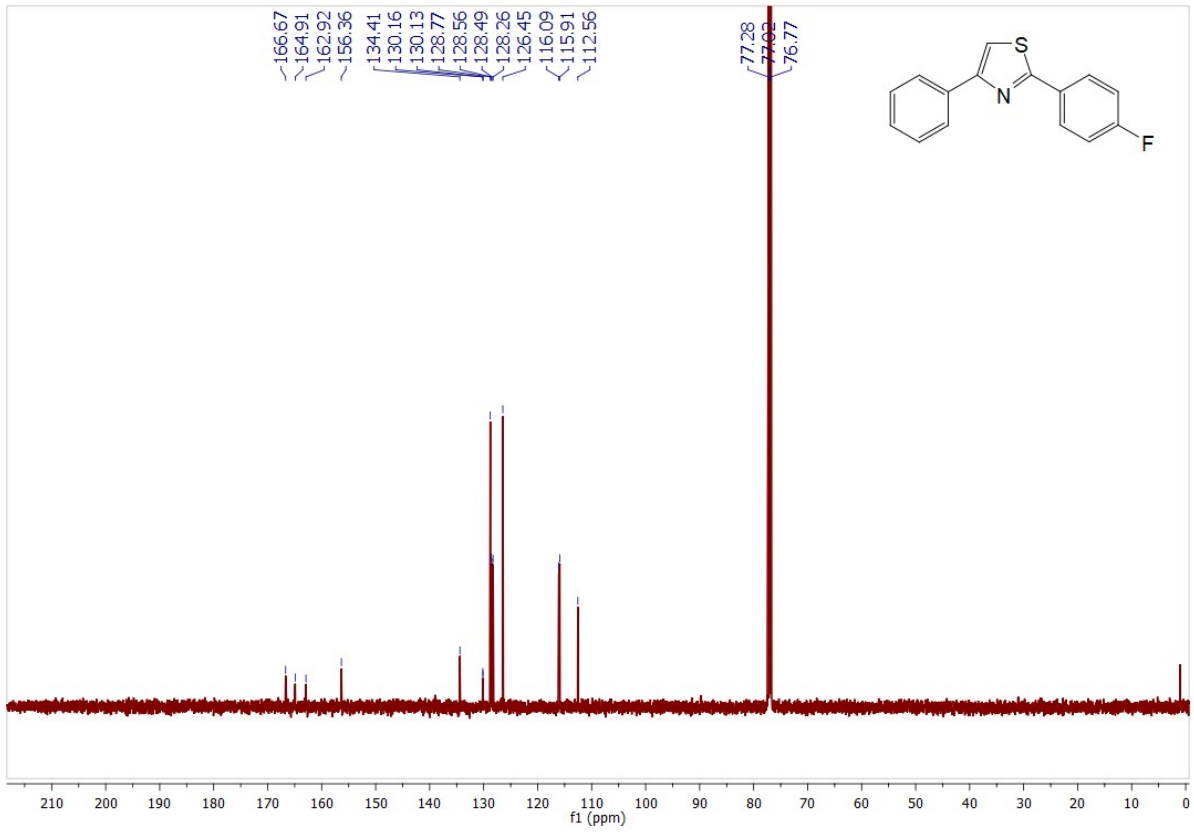
^{1}H & ^{13}C NMR Spectra 4-phenyl-2-(4-methylphenyl) (3k)



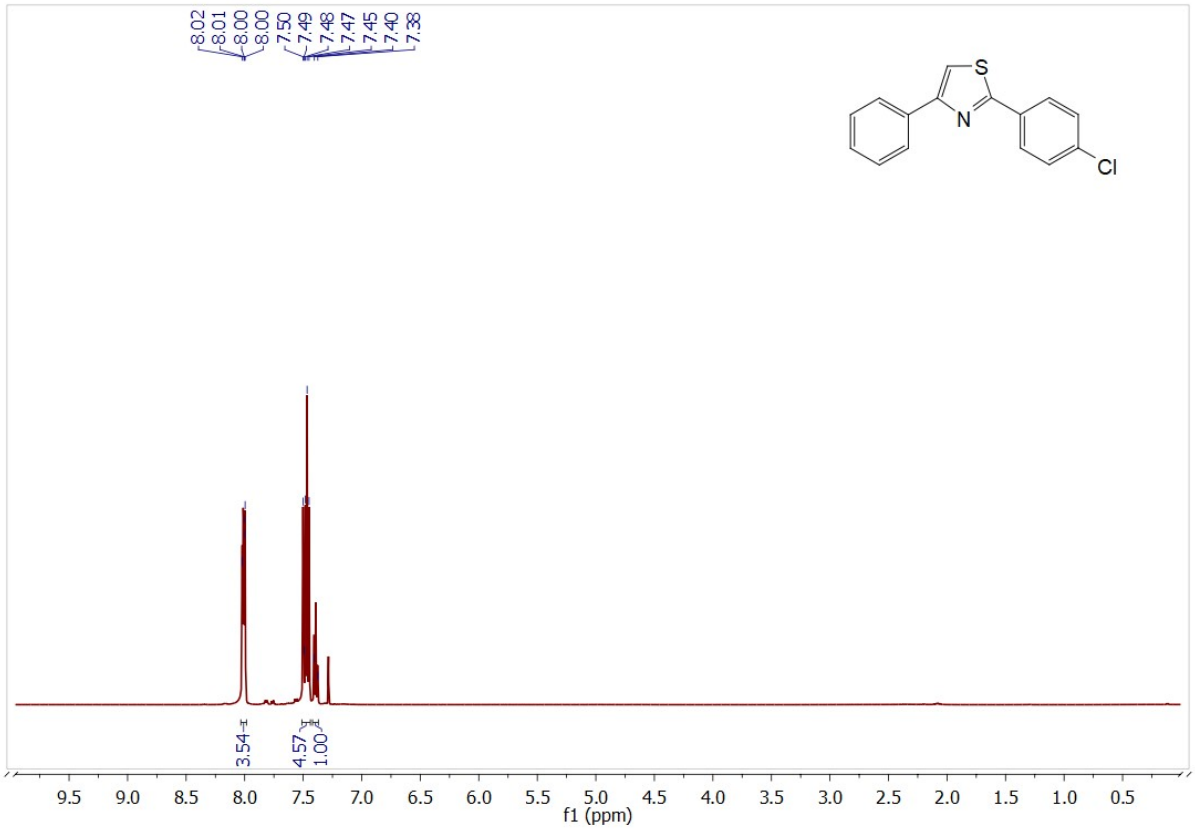


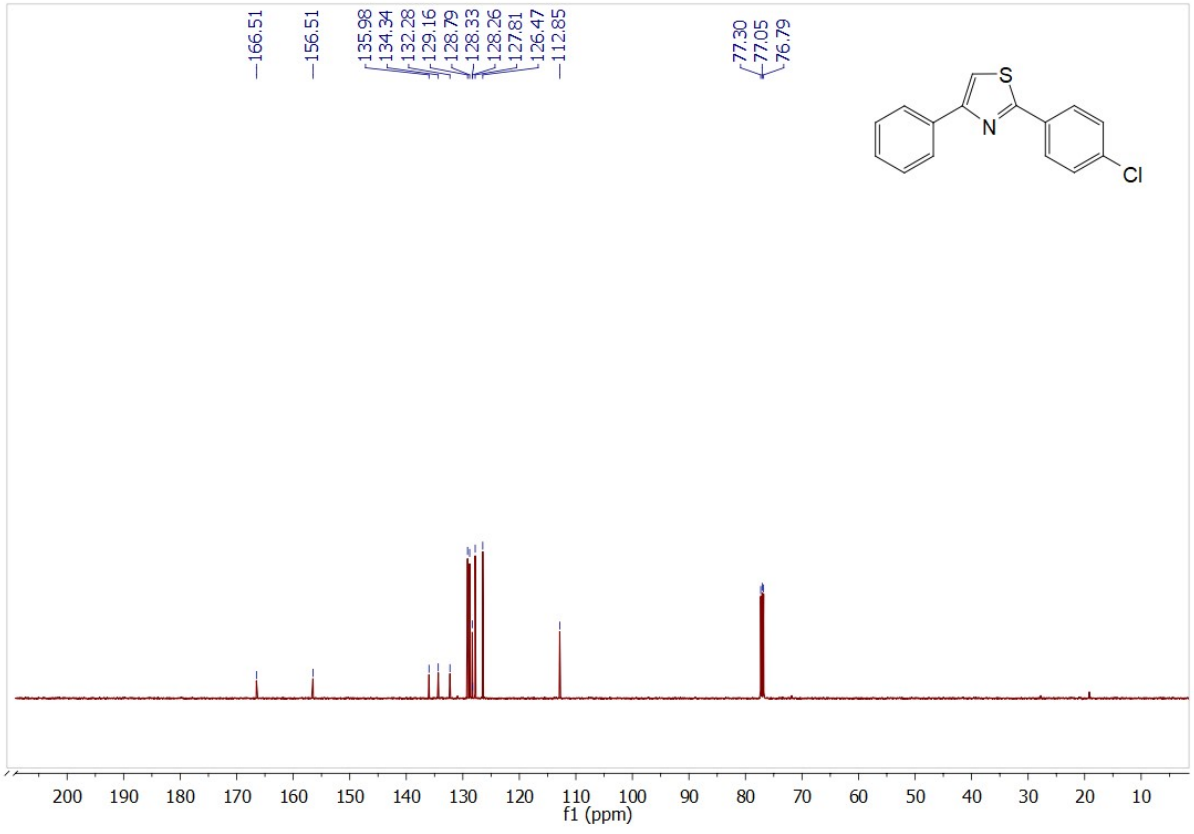
^{1}H & ^{13}C NMR Spectra 4-phenyl-2-(4-flurophenyl) (3l)



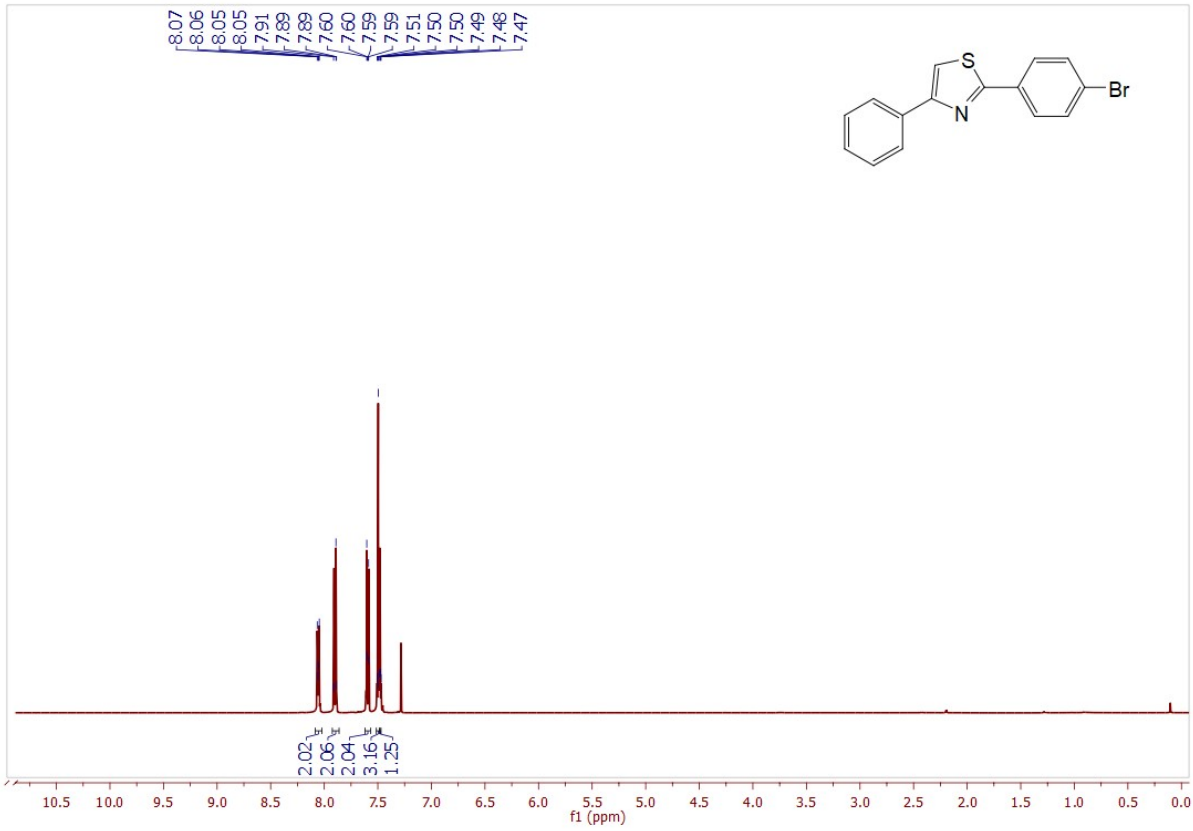


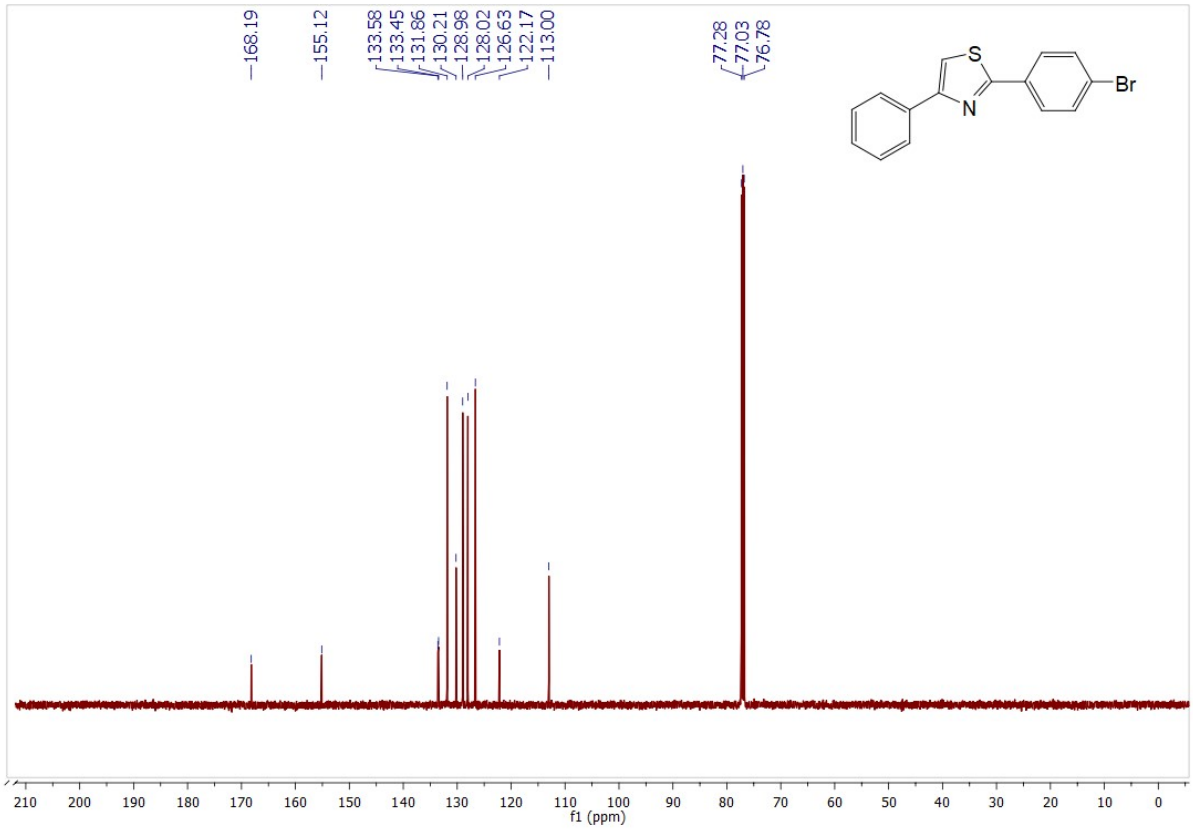
^{1}H & ^{13}C NMR Spectra 4-phenyl-2-(4-chlorophenyl) (3m)



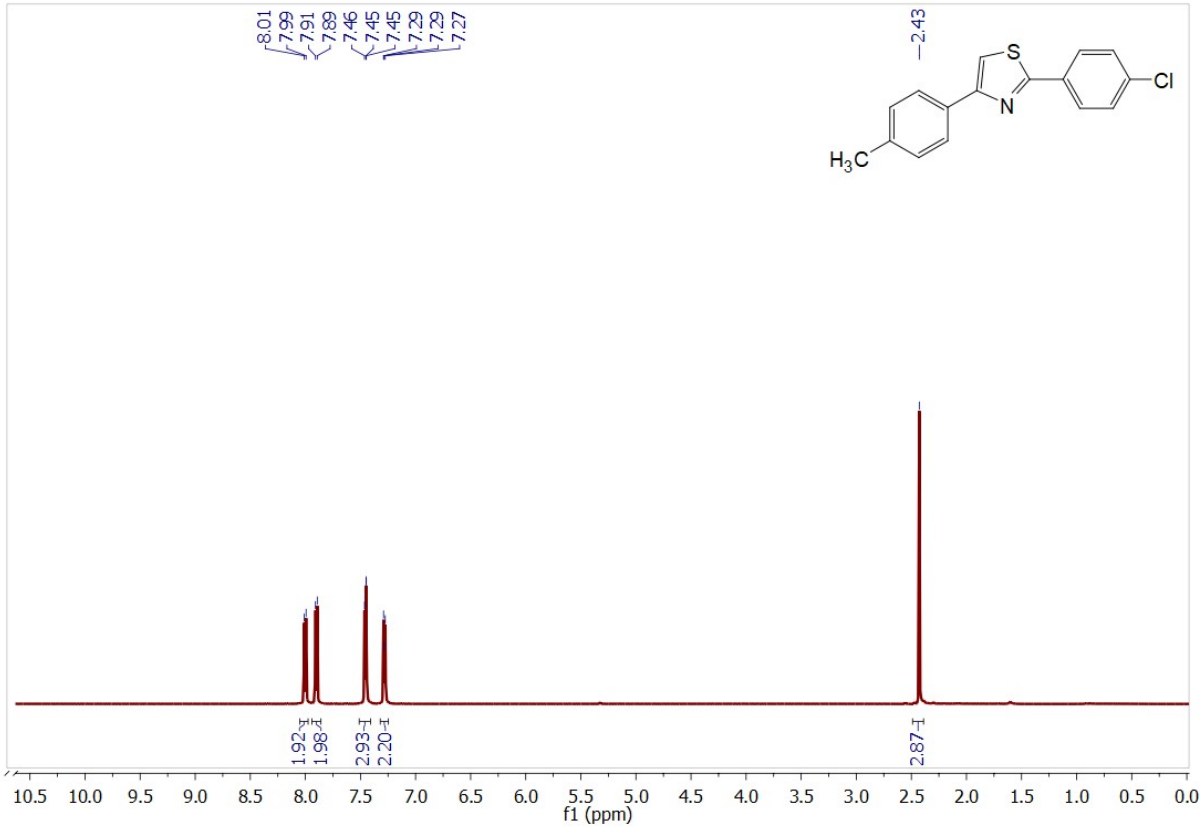


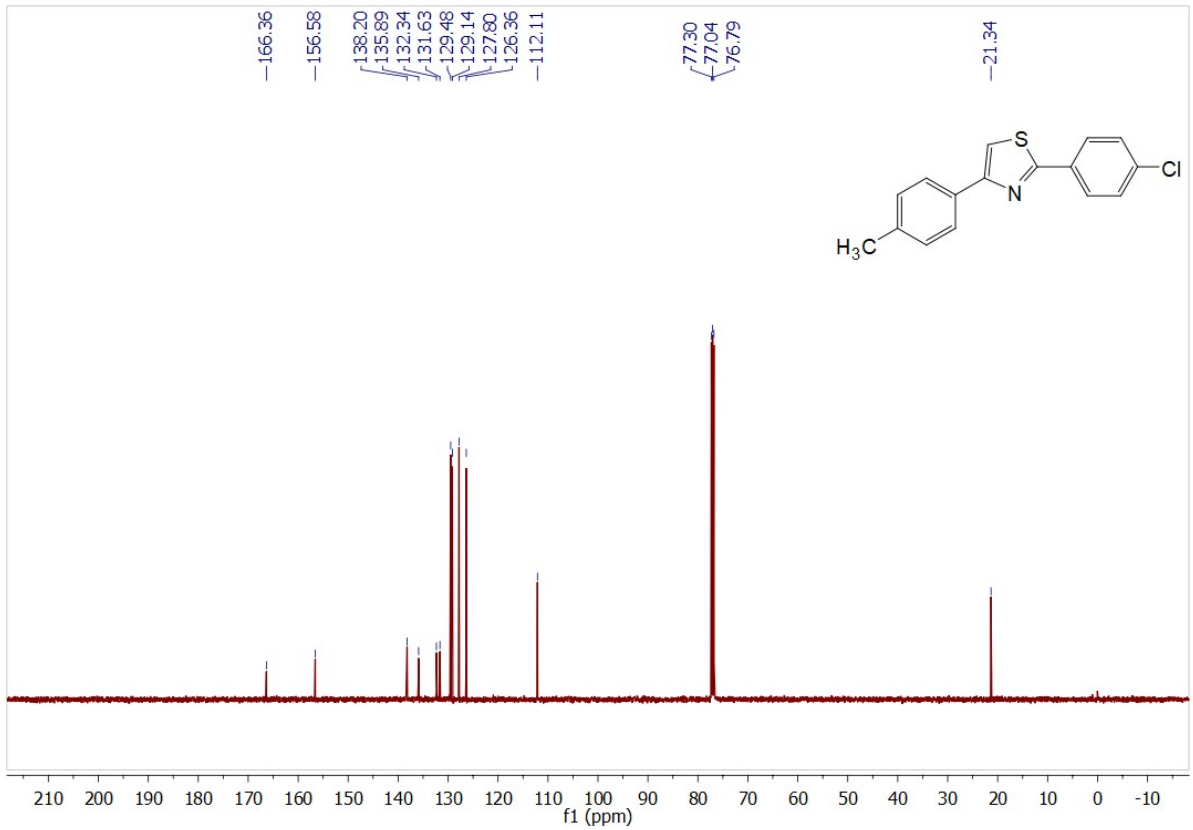
^{1}H & ^{13}C NMR Spectra 4-phenyl-2-(4-bromophenyl) (3n)



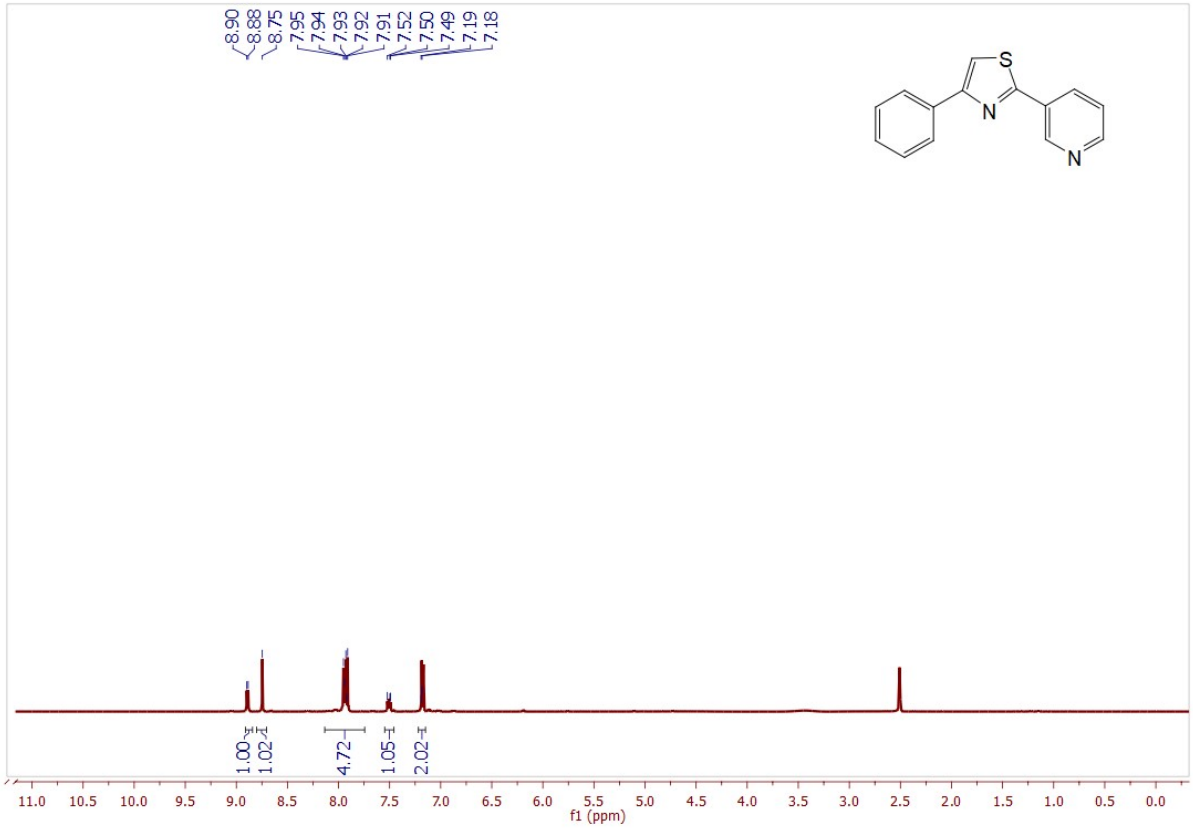


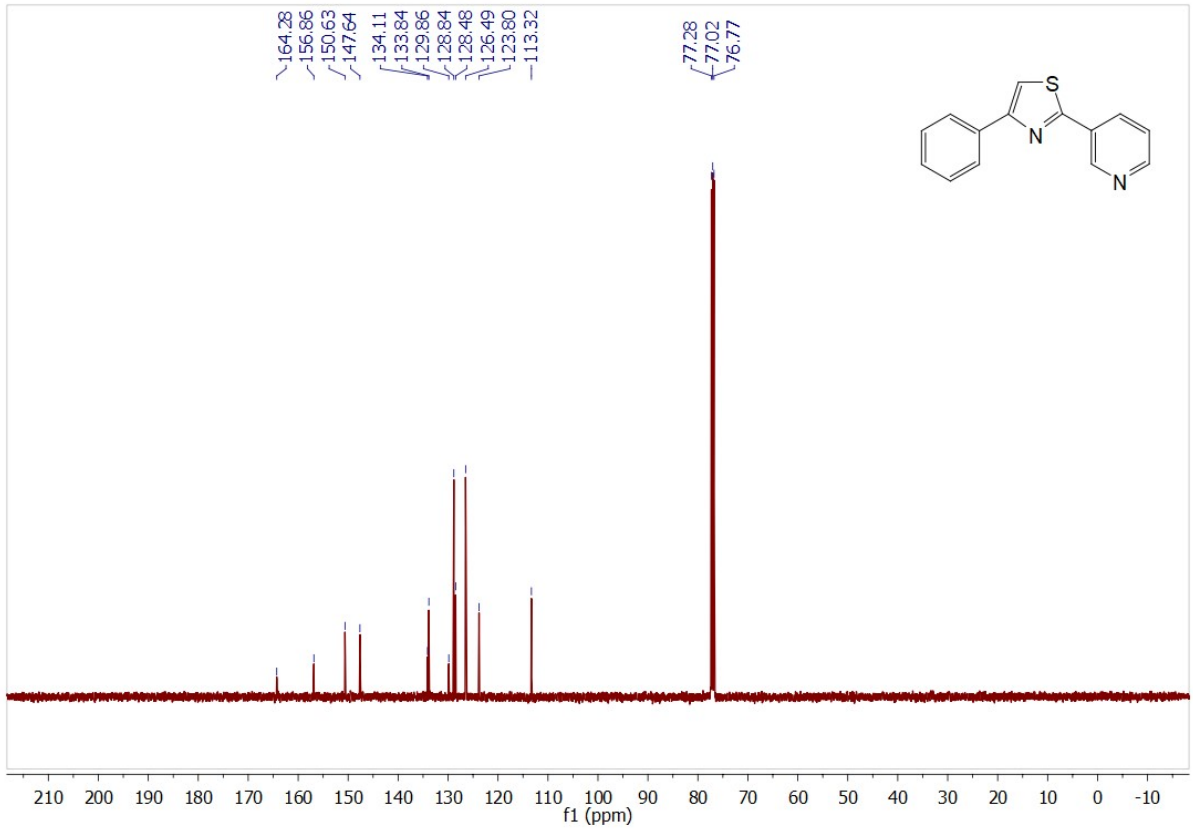
^{1}H & ^{13}C NMR Spectra 2-(4-chlorophenyl)-4-(p-tolyl)-thiazole (3o)



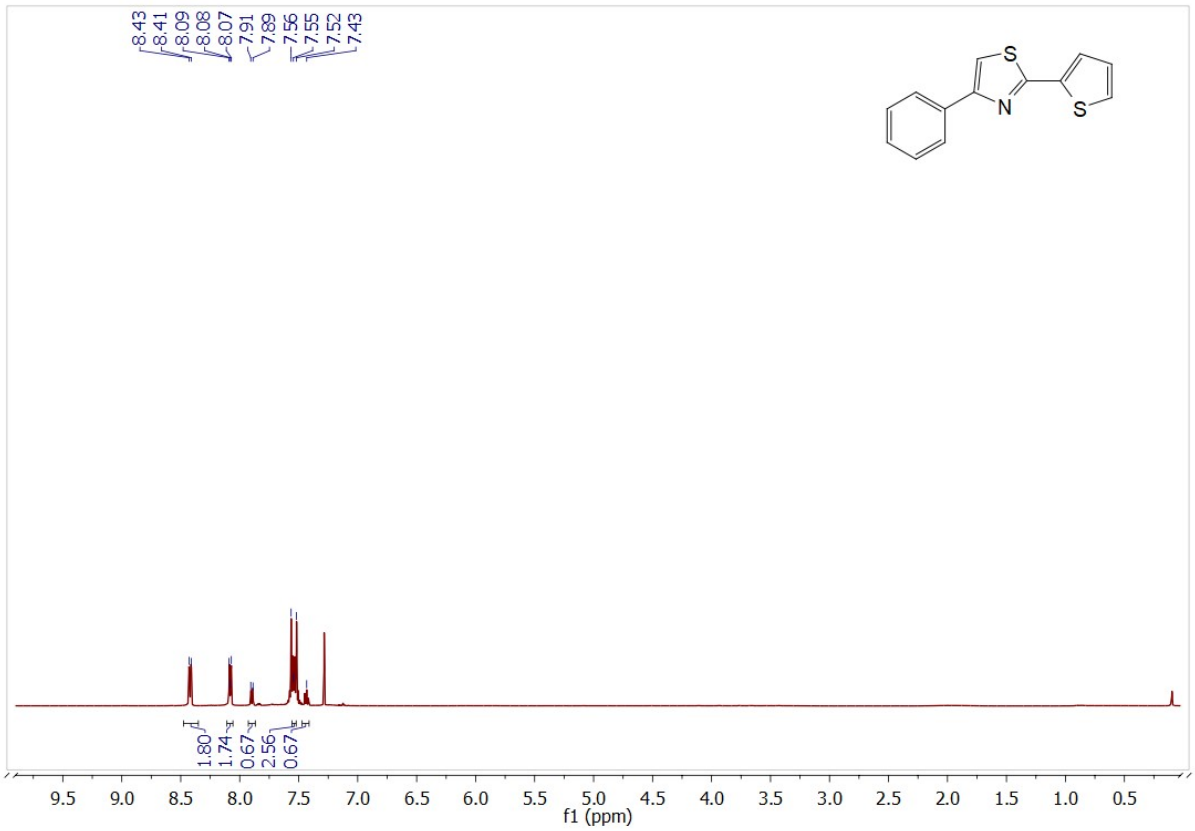


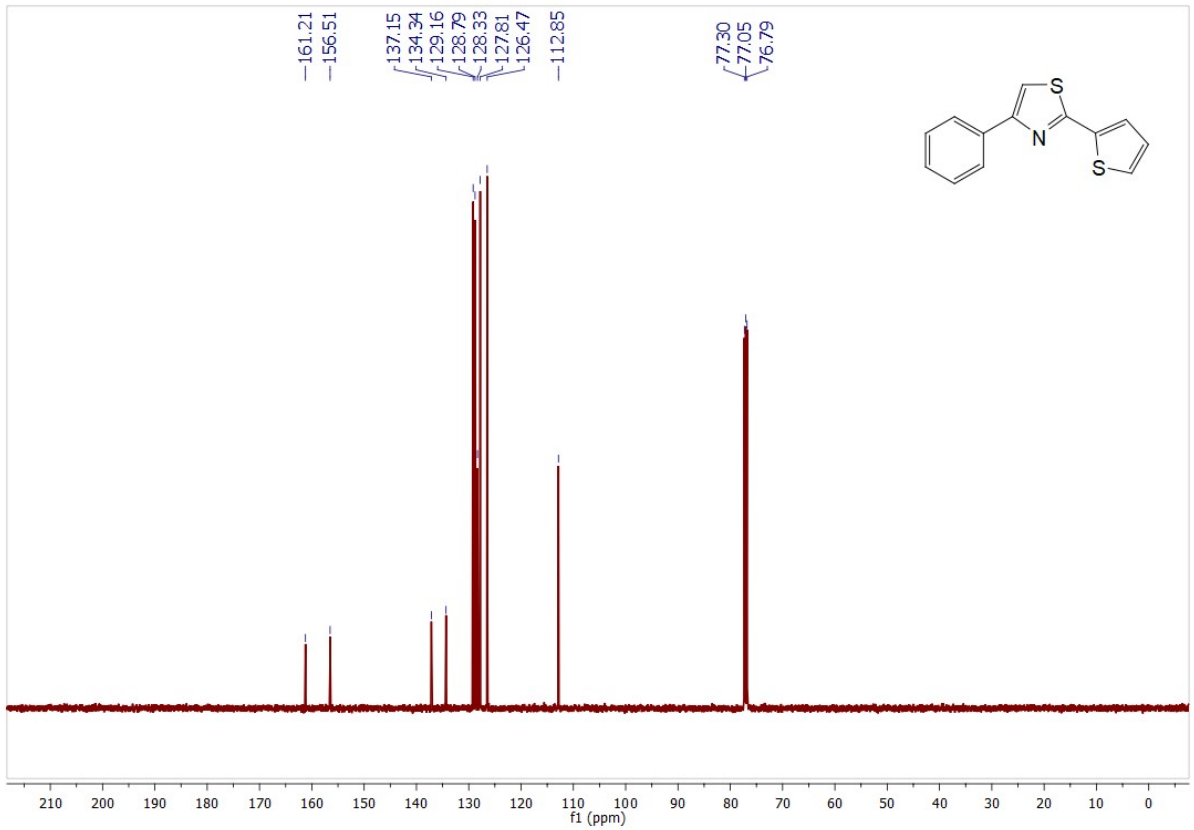
^{1}H & ^{13}C NMR Spectra 4-phenyl-2-(pyridin-3-yl)-thiazole (3p)



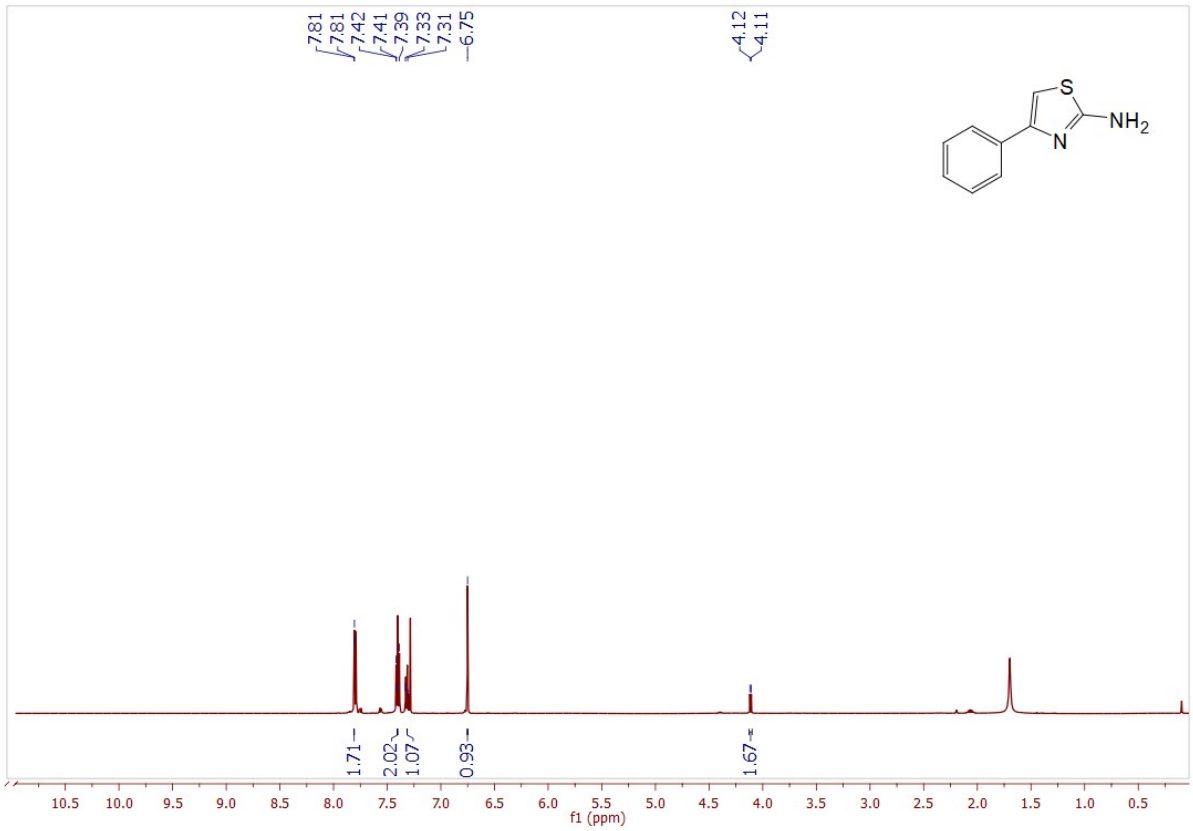


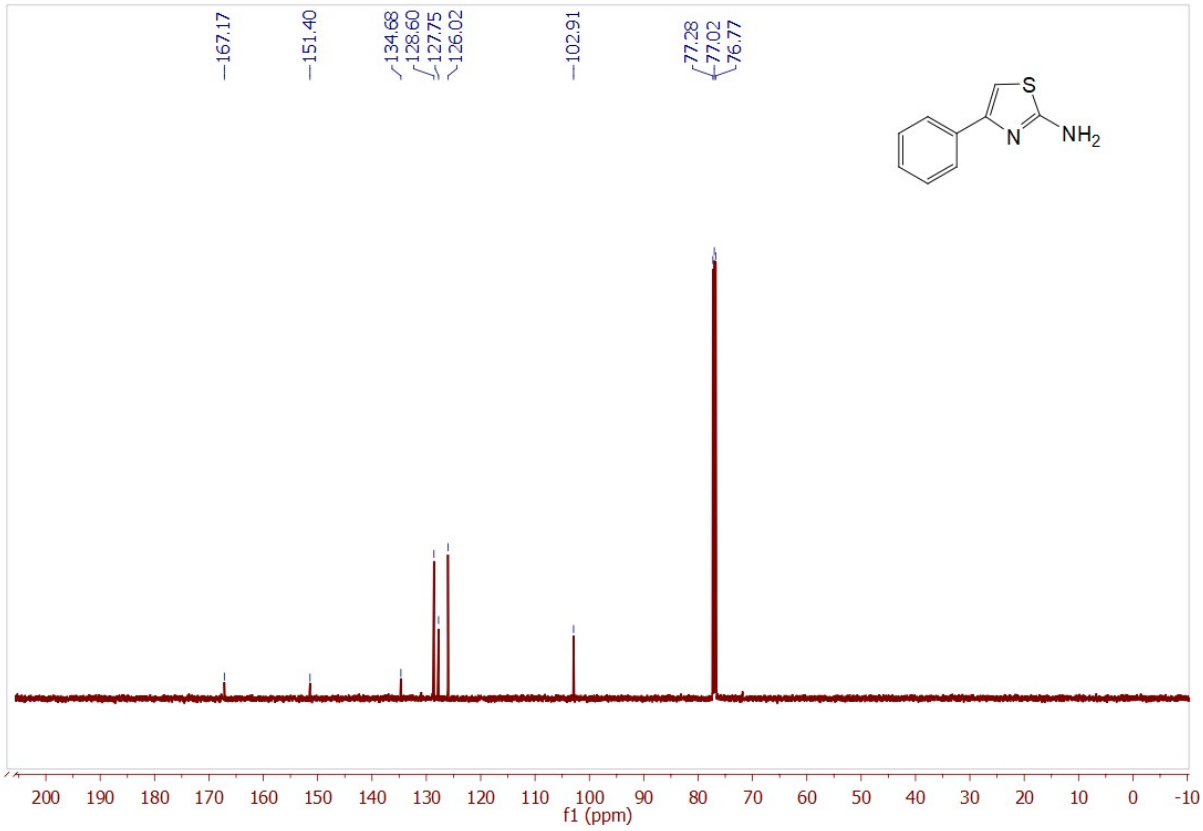
^{1}H & ^{13}C NMR Spectra 4-phenyl-2-(thiophen-2-yl)-thiazole (3q)



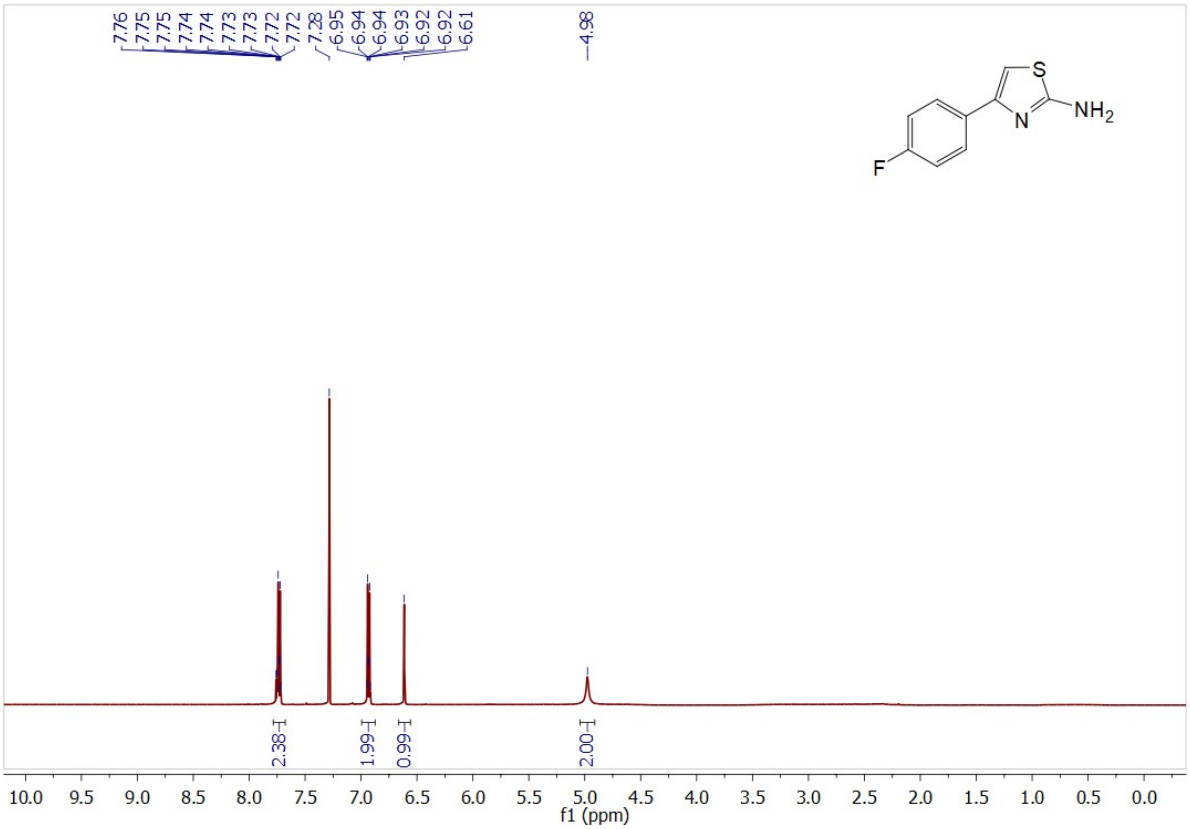


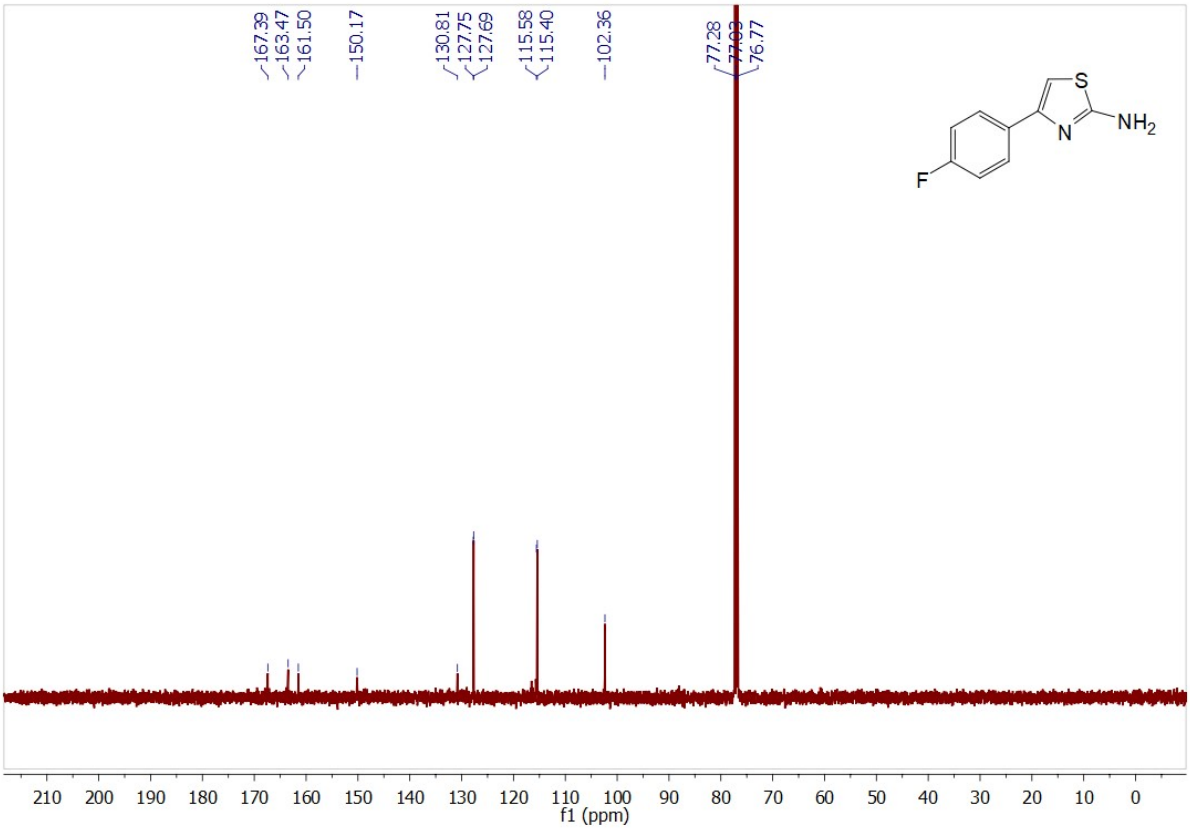
^{1}H & ^{13}C NMR Spectra 4-phenylthiazol-2-amine (4a)



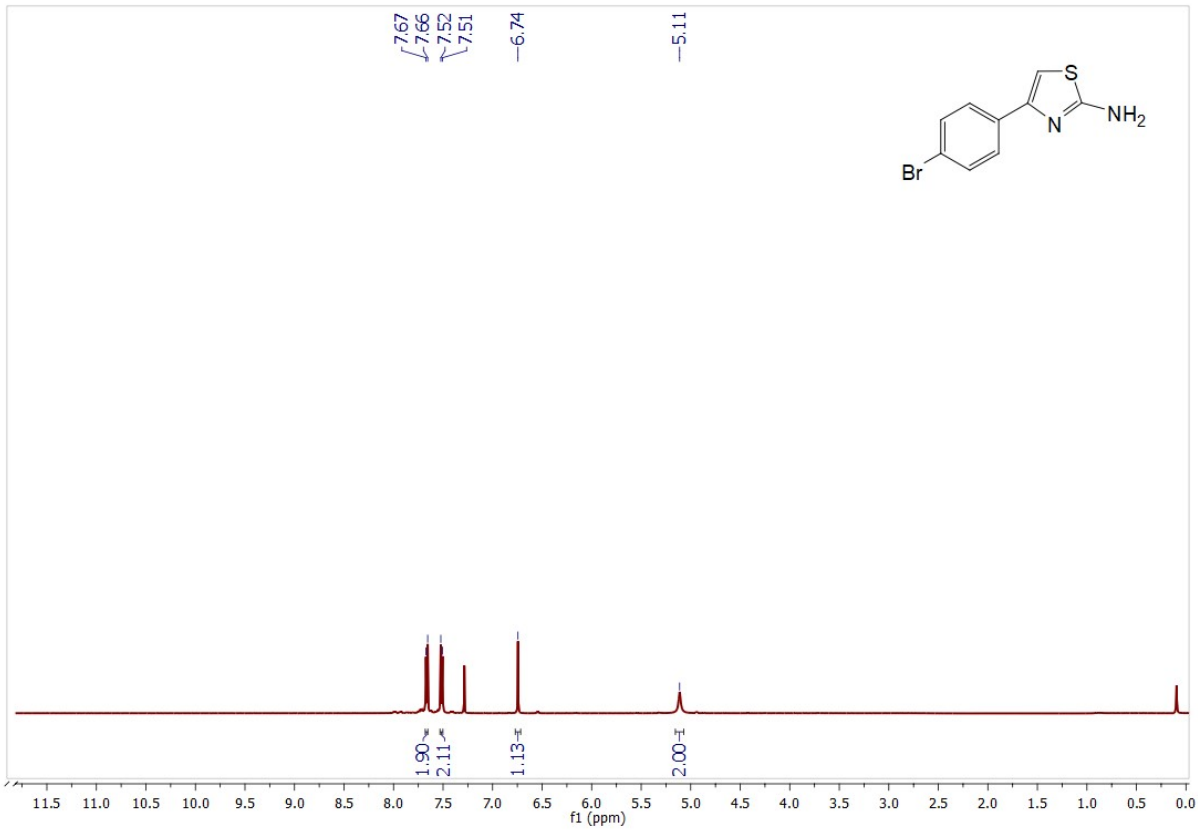


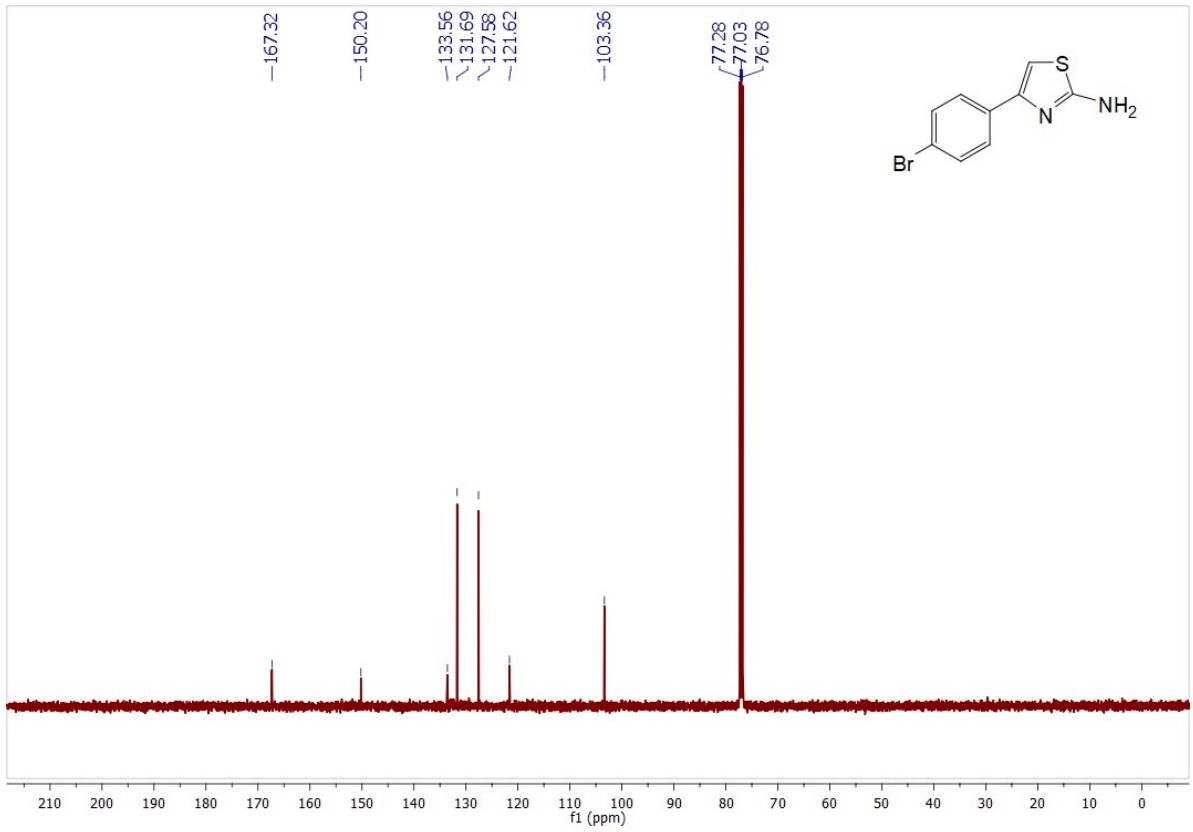
^{1}H & ^{13}C NMR Spectra 4-(4-flurophenyl)-thiazol-2-amine (4b)



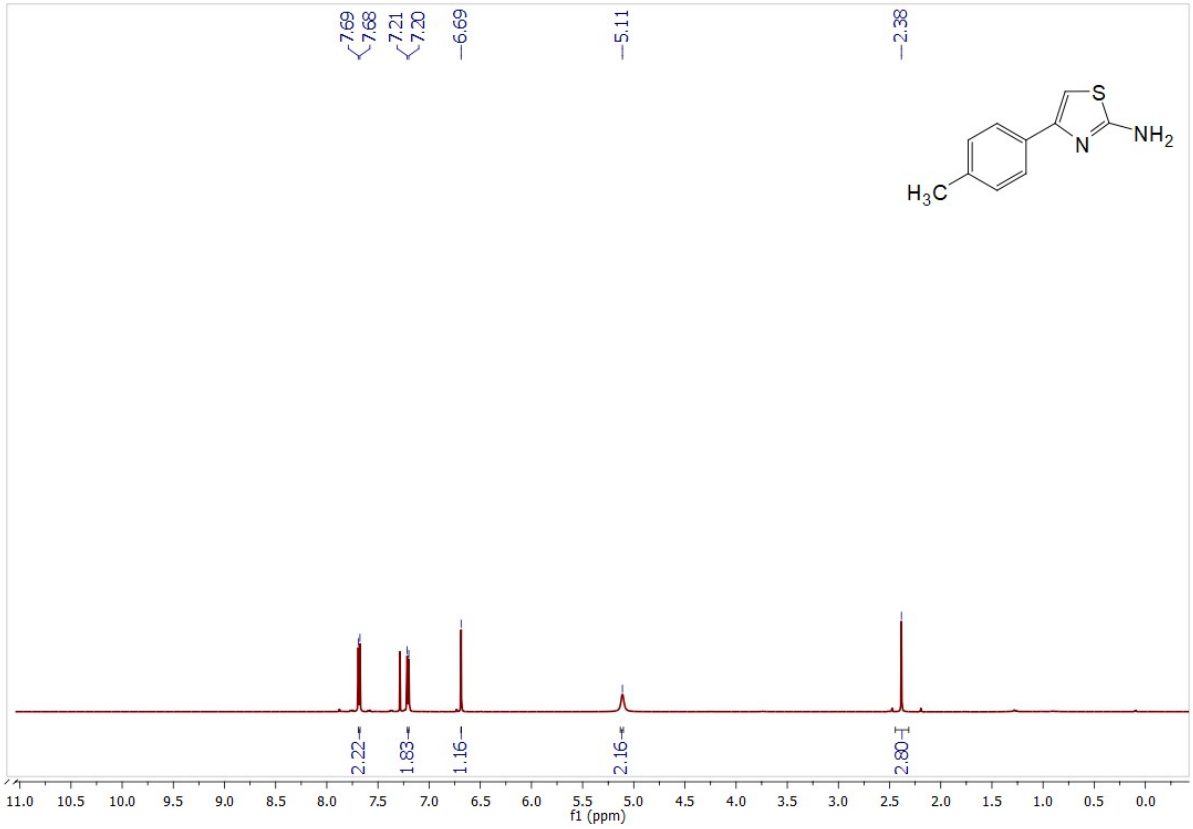


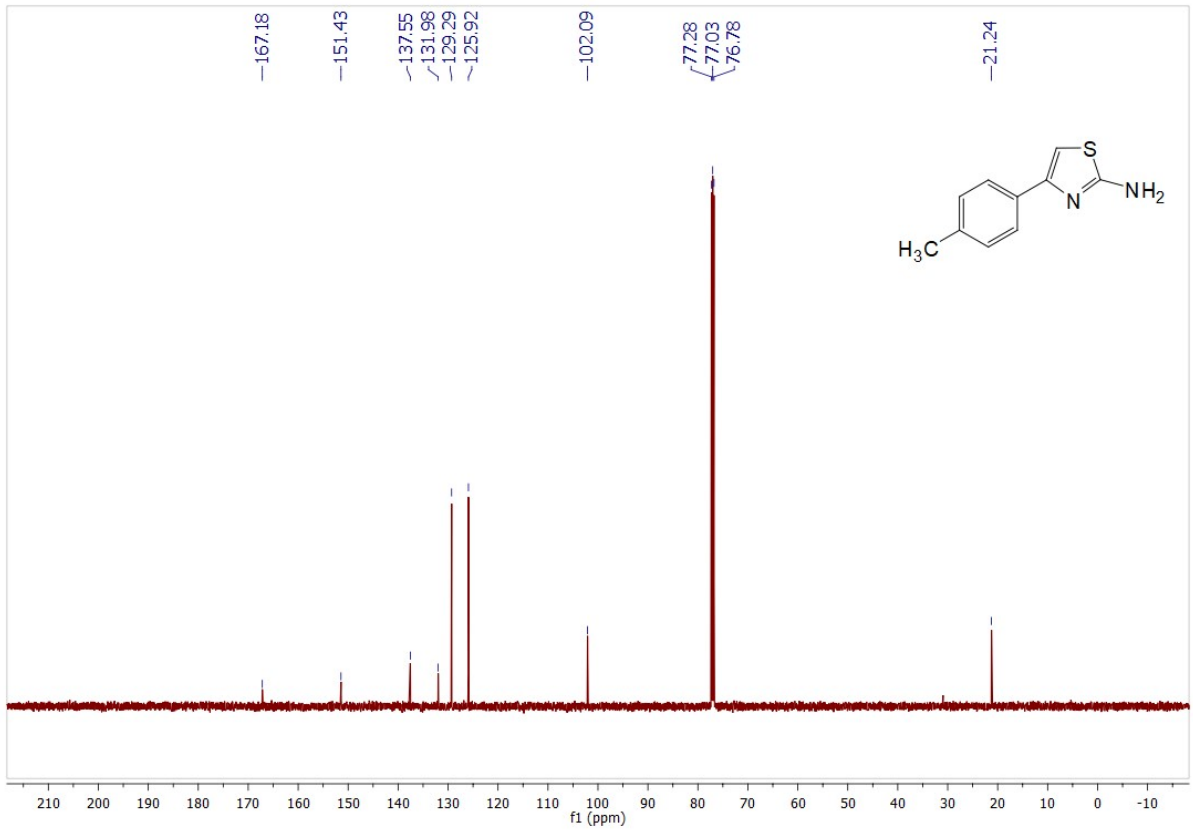
^{1}H & ^{13}C NMR Spectra 4-(4-bromophenyl)-thiazol-2-amine (4c)



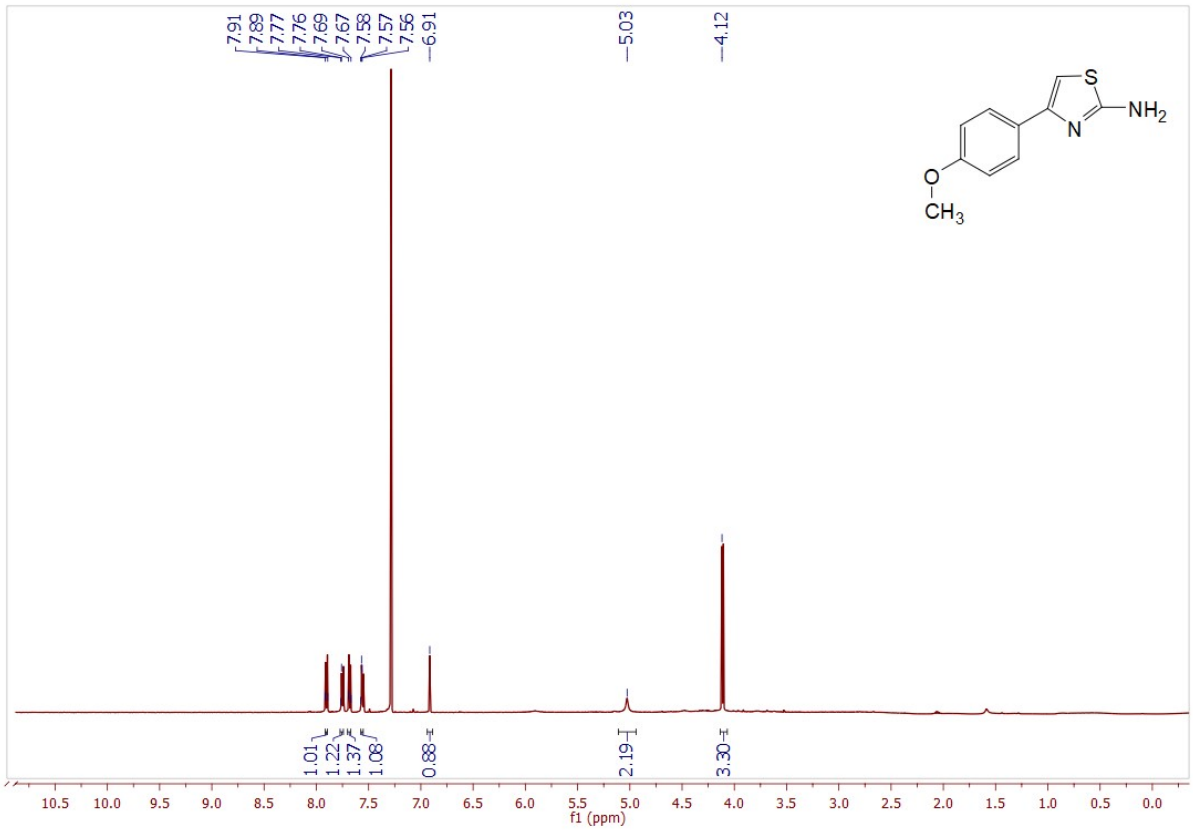


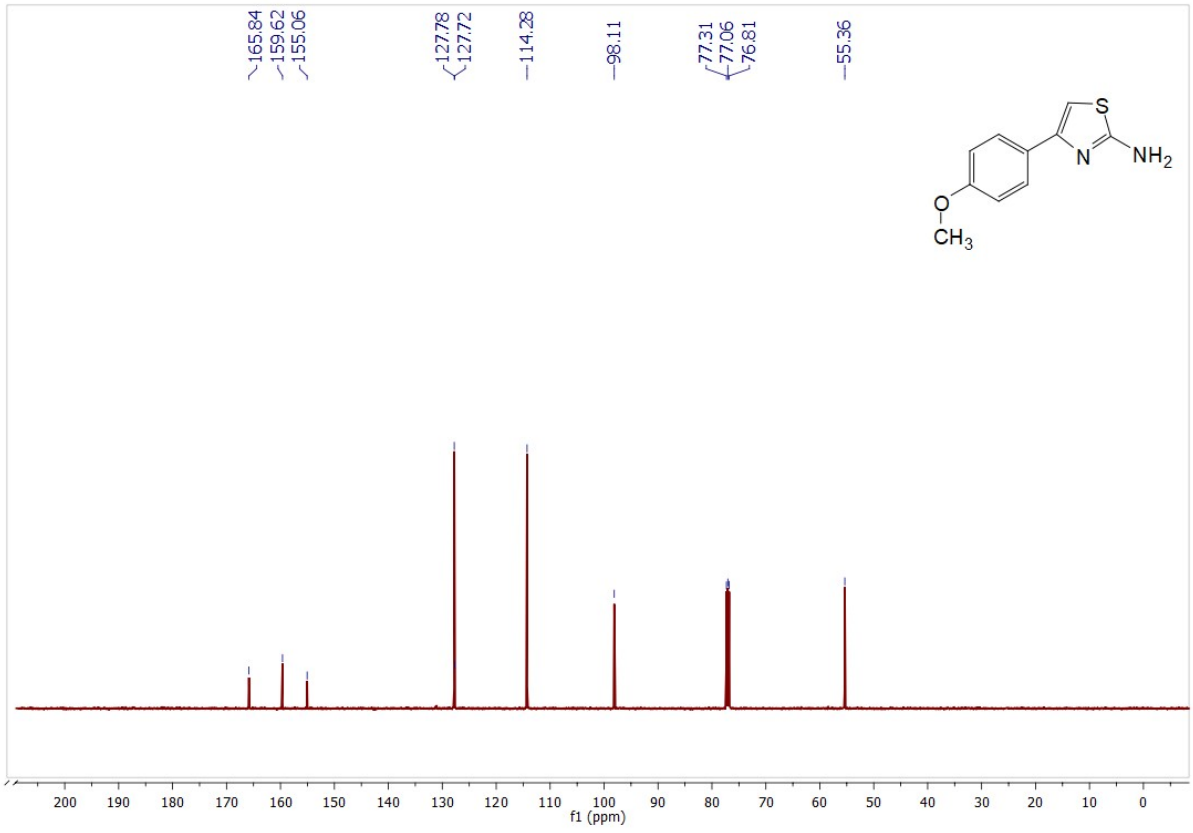
^{1}H & ^{13}C NMR Spectra 4-(4-methylphenyl)-thiazol-2-amine (4d)



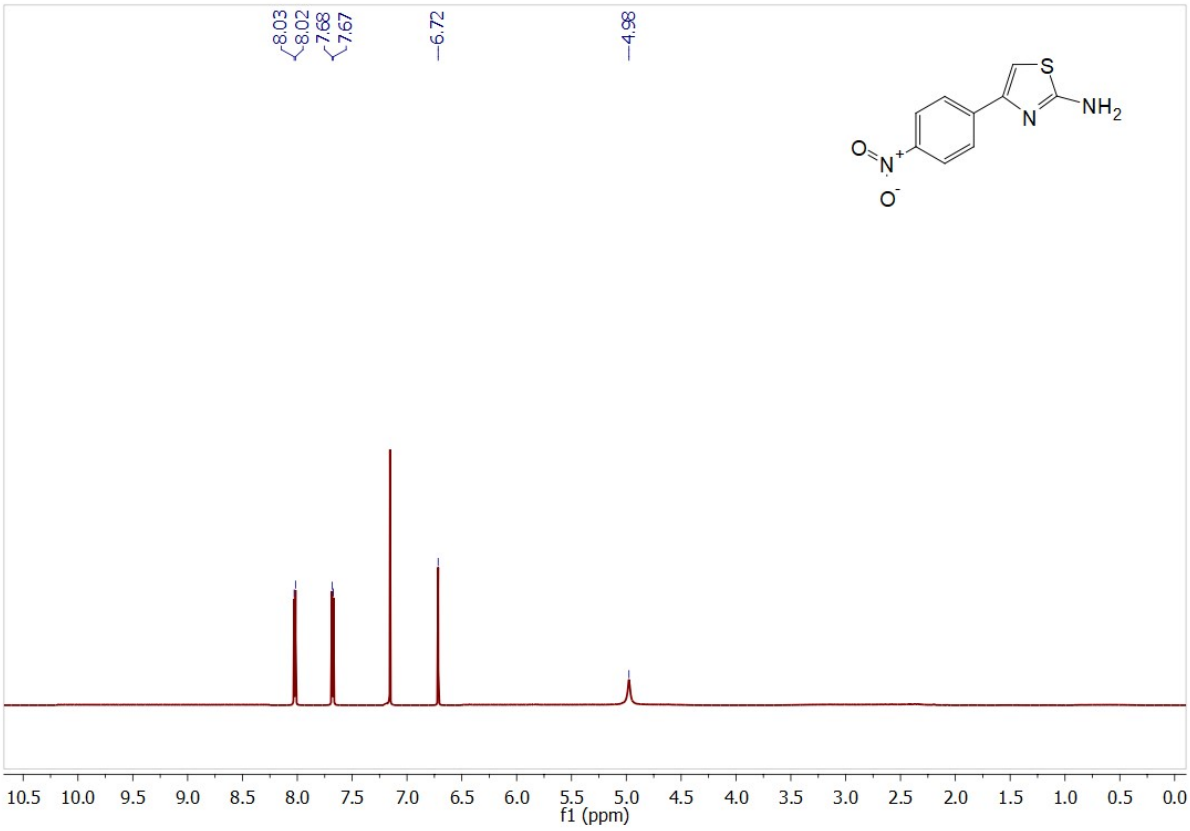


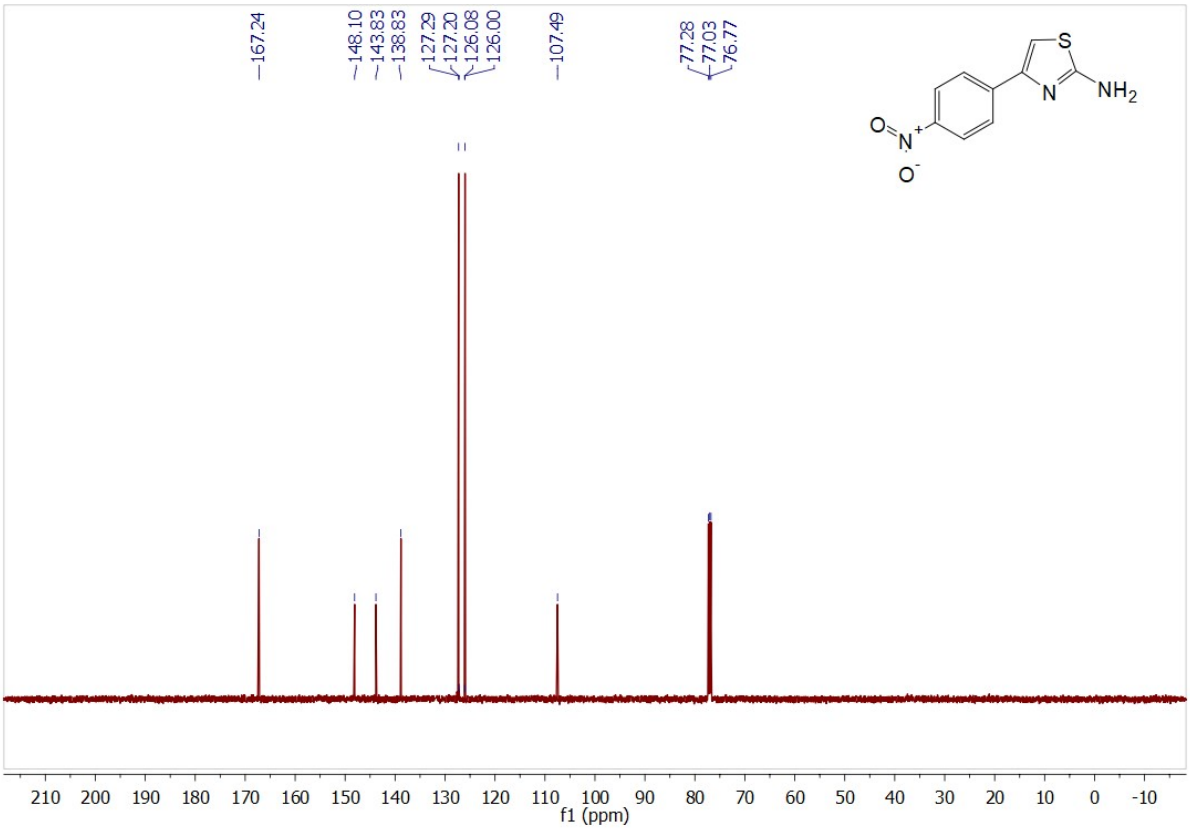
^{1}H & ^{13}C NMR Spectra 4-(4-methoxyphenyl)-thiazol-2-amine (4e)



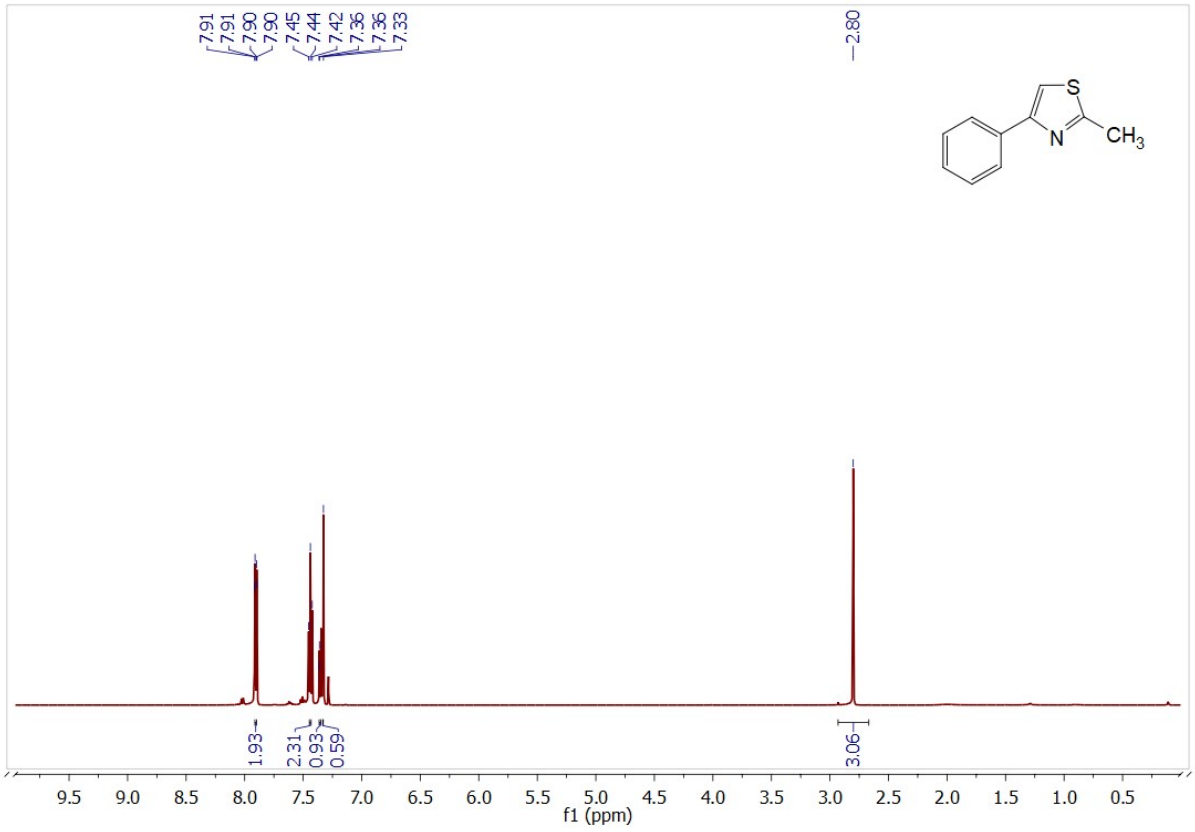


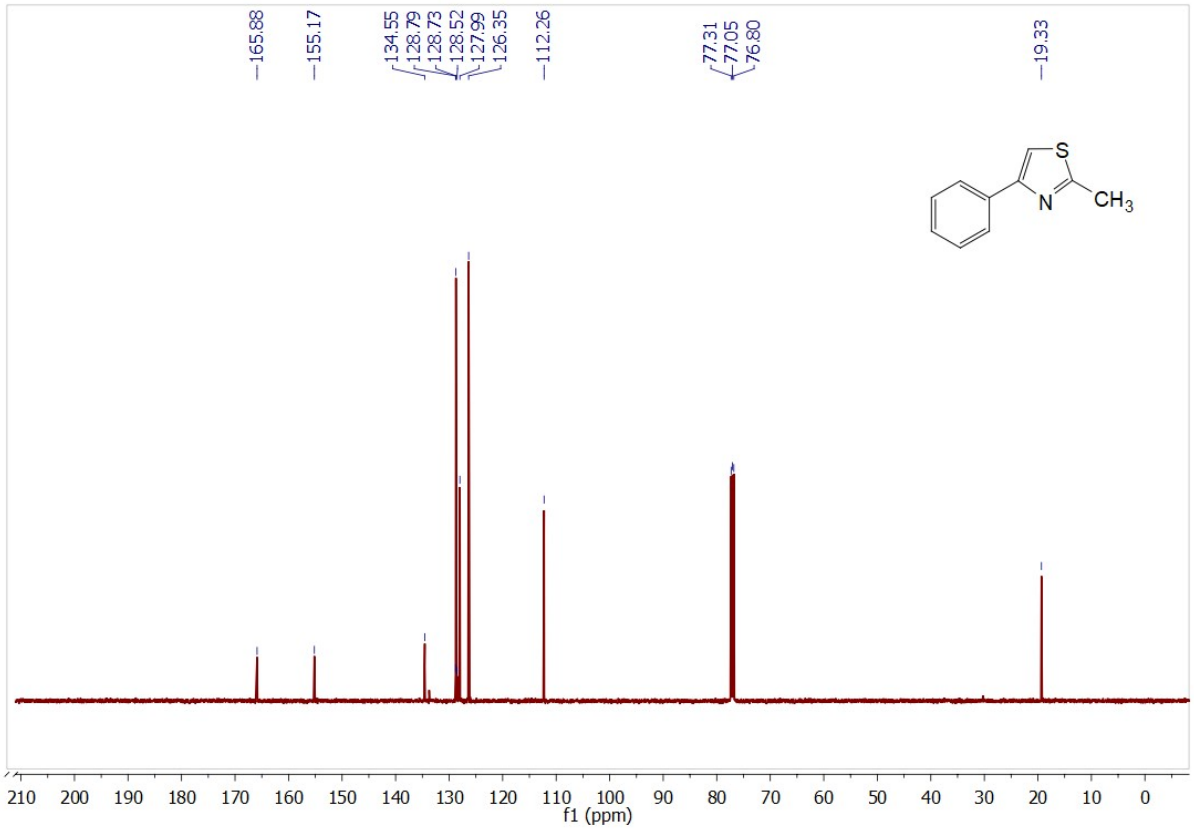
^{1}H & ^{13}C NMR Spectra 4-(4-nitroyphenyl)-thiazol-2-amine (4f)



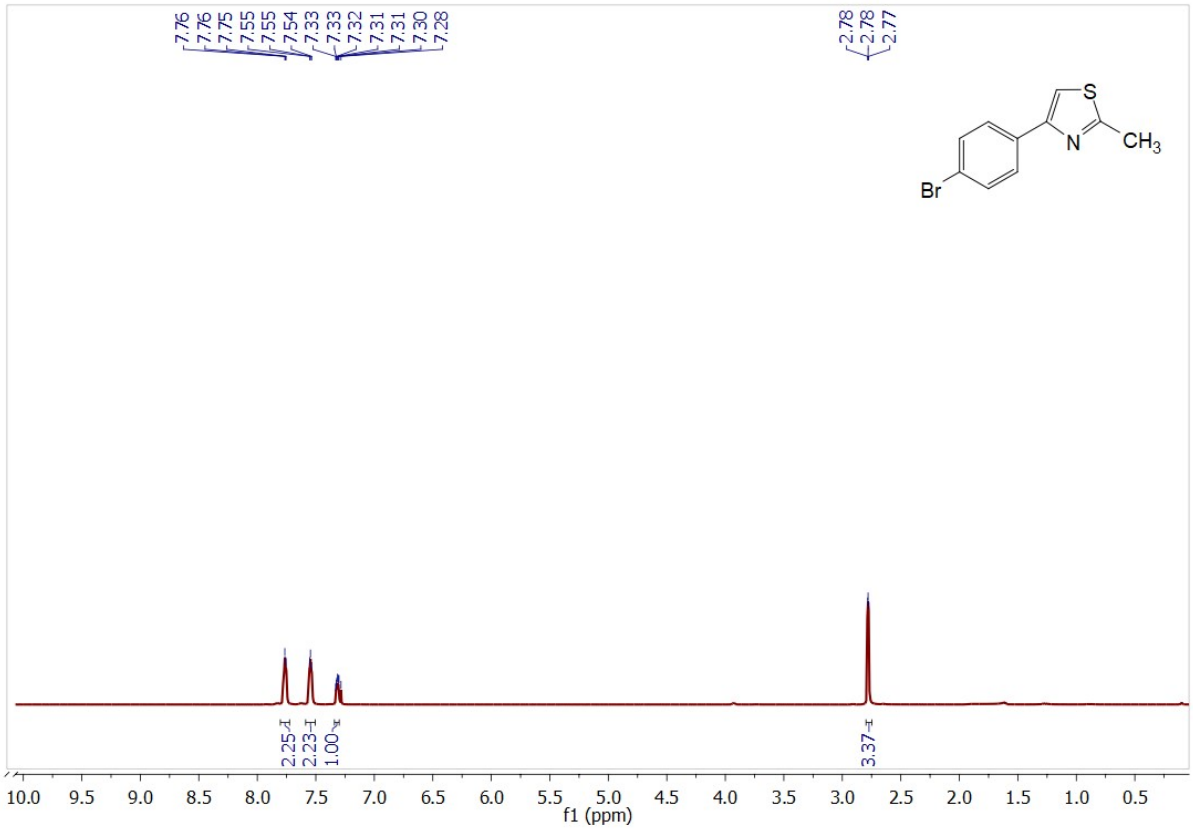


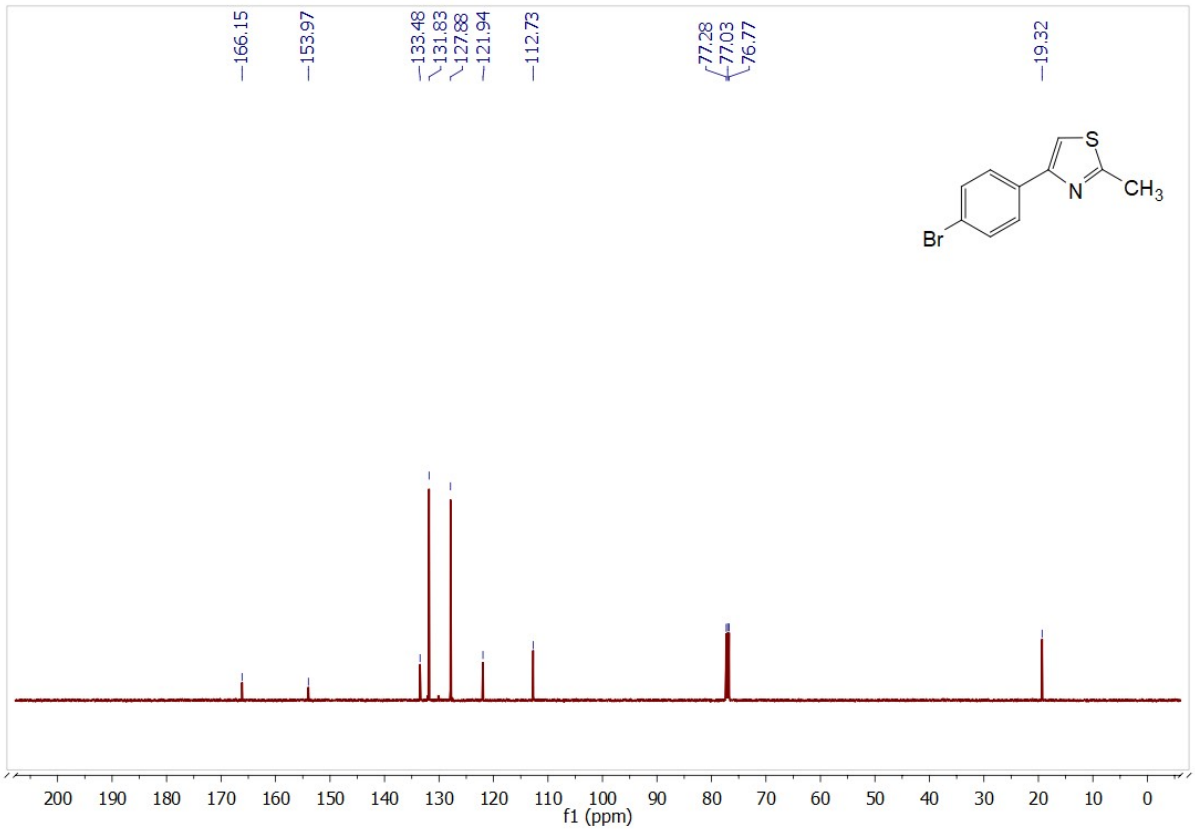
^{1}H & ^{13}C NMR Spectra 2-Methyl-4-phenylthiazole (4g)



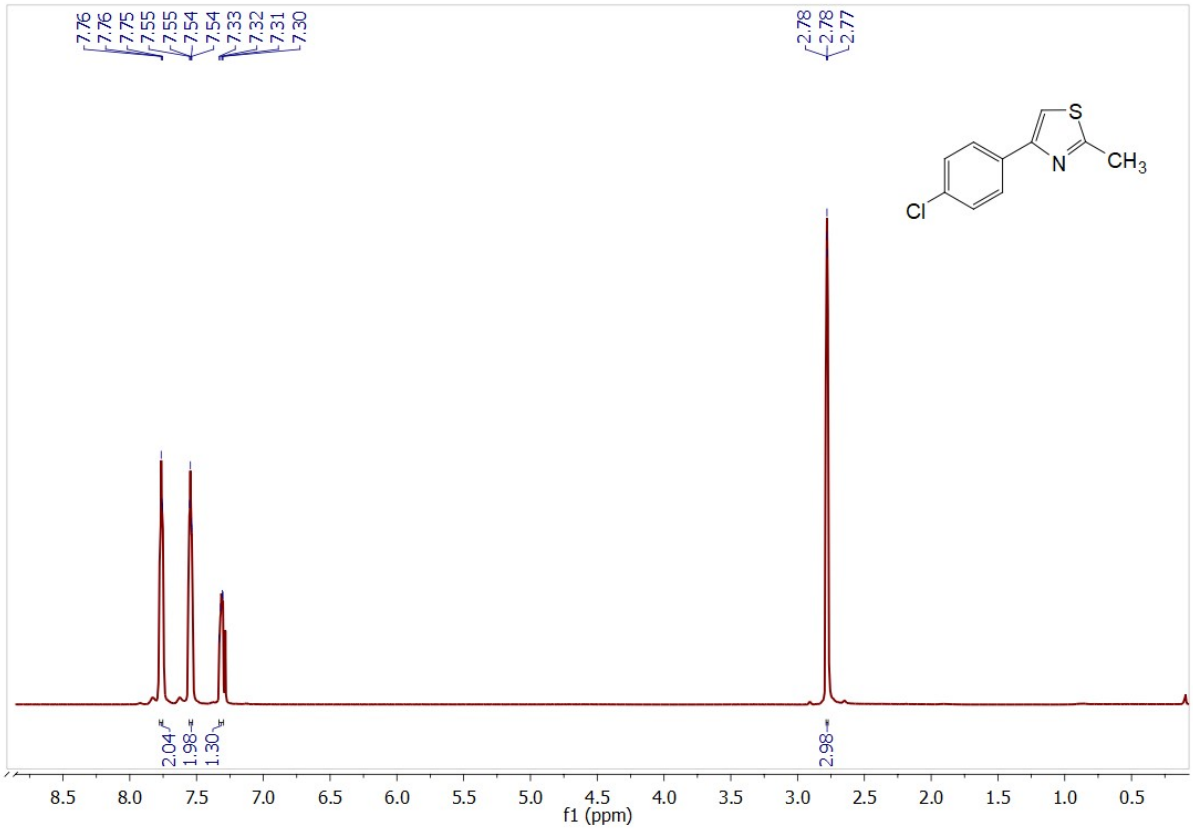


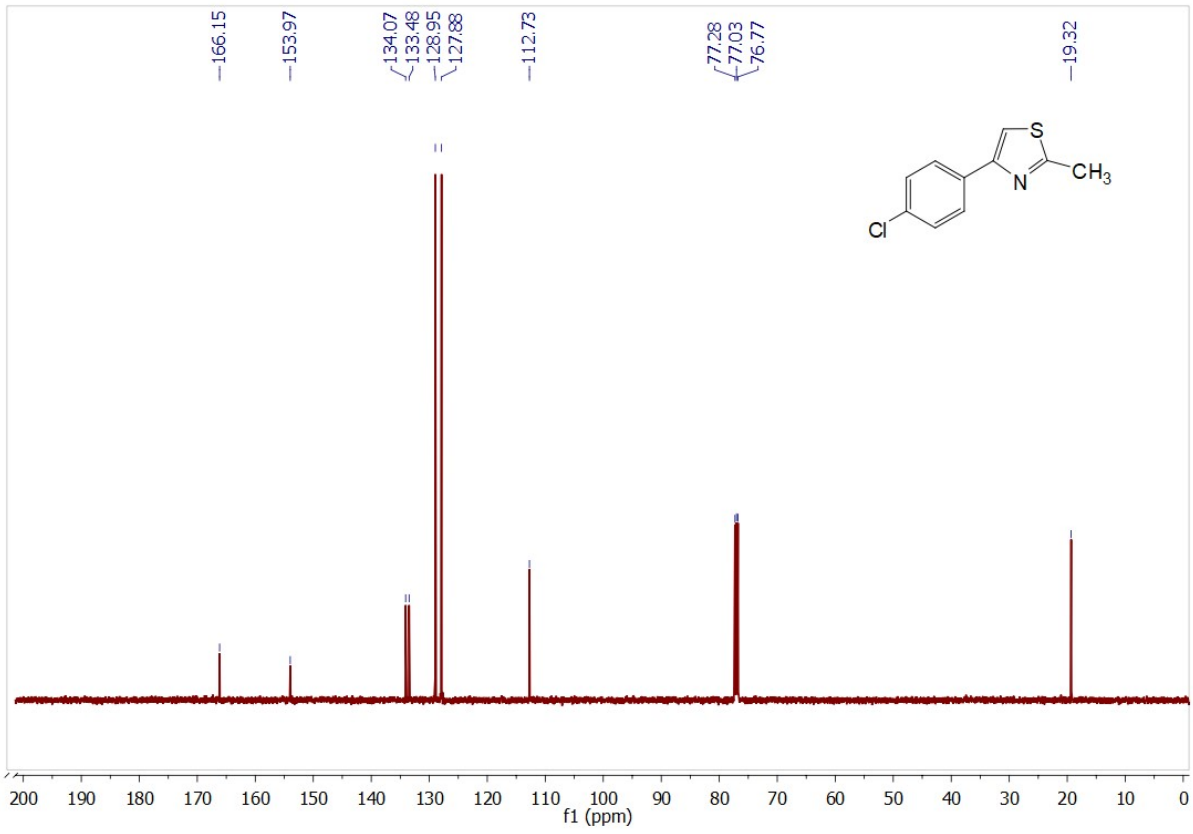
^{1}H & ^{13}C NMR Spectra 4-(p-bromophenyl)-2-methyl-thiazole (4h)



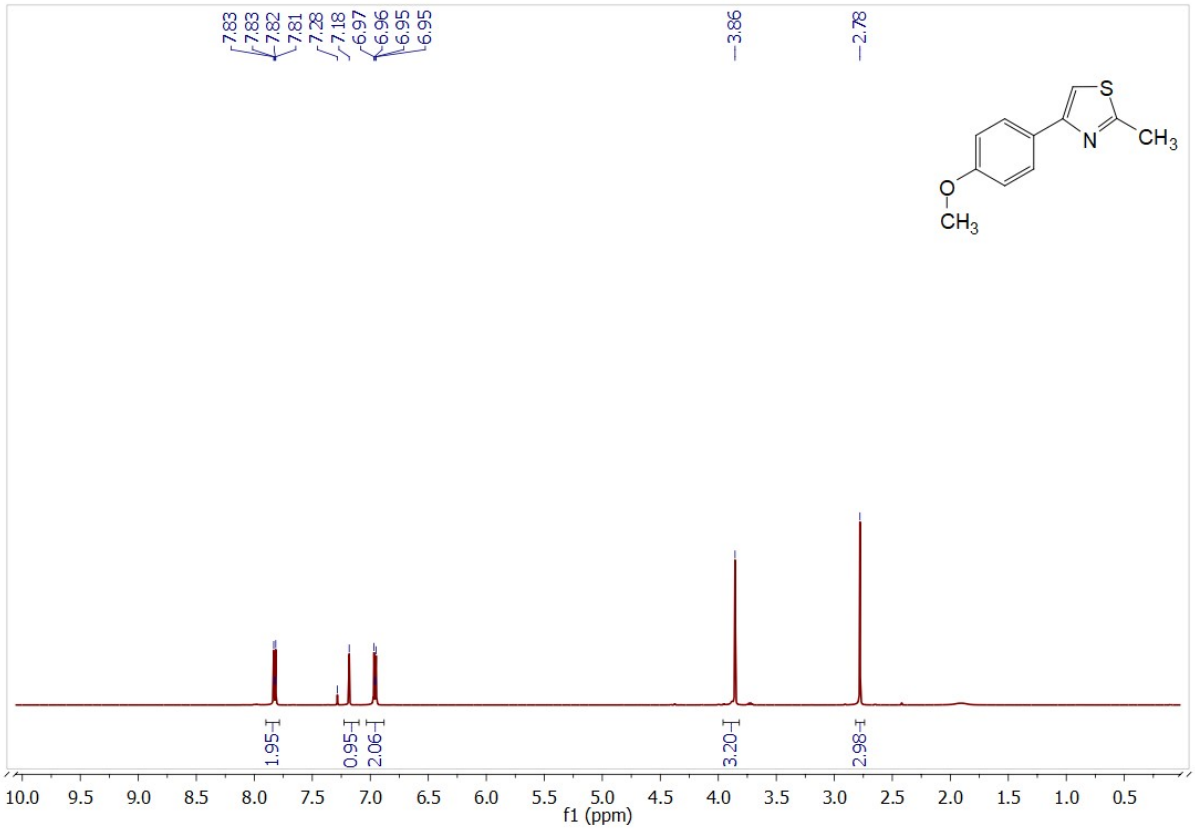


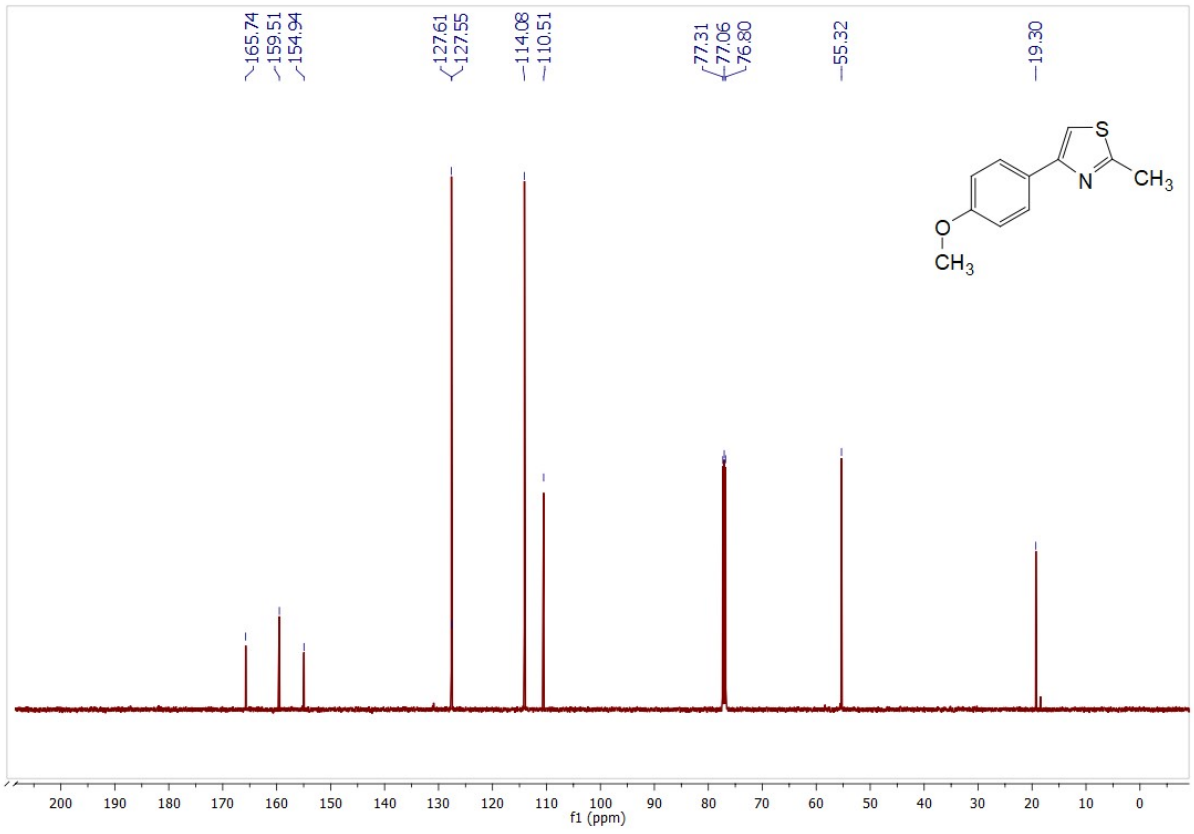
^{1}H & ^{13}C NMR Spectra 4-(p-chlorophenyl)-2-methyl-thiazole (4i)



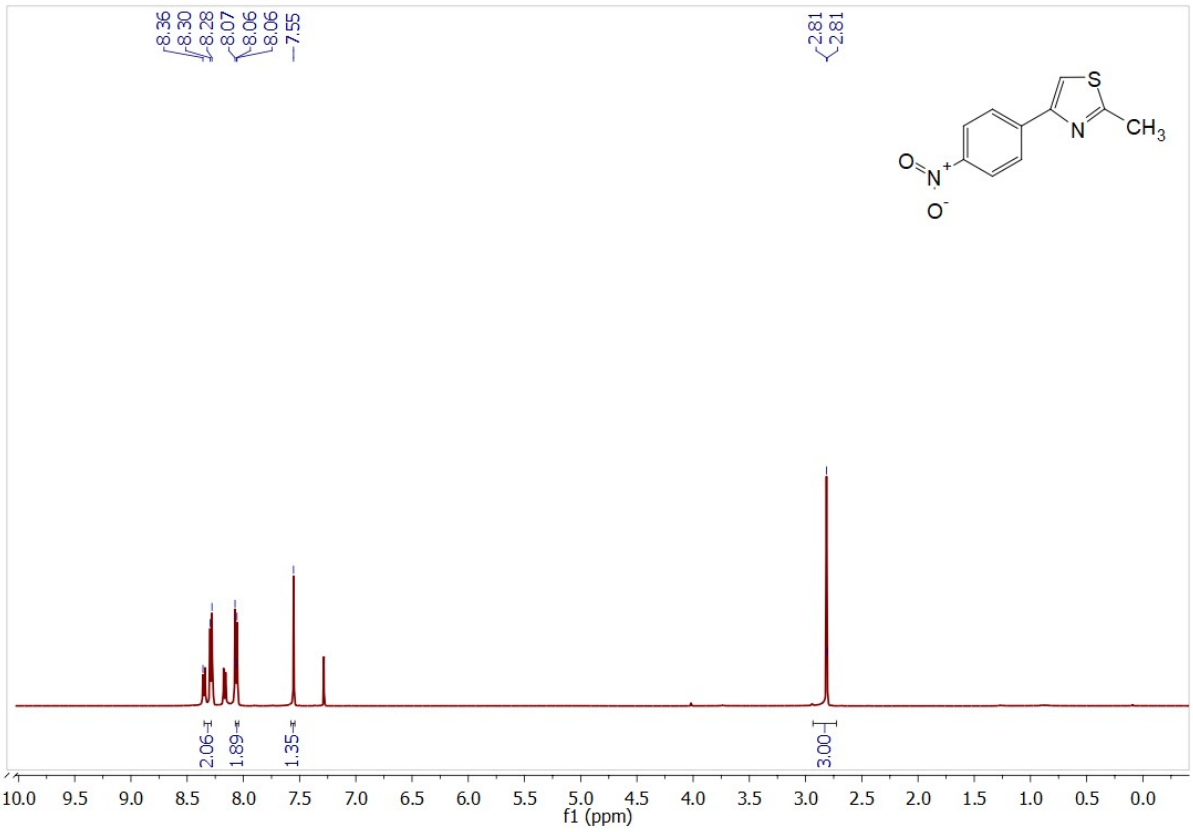


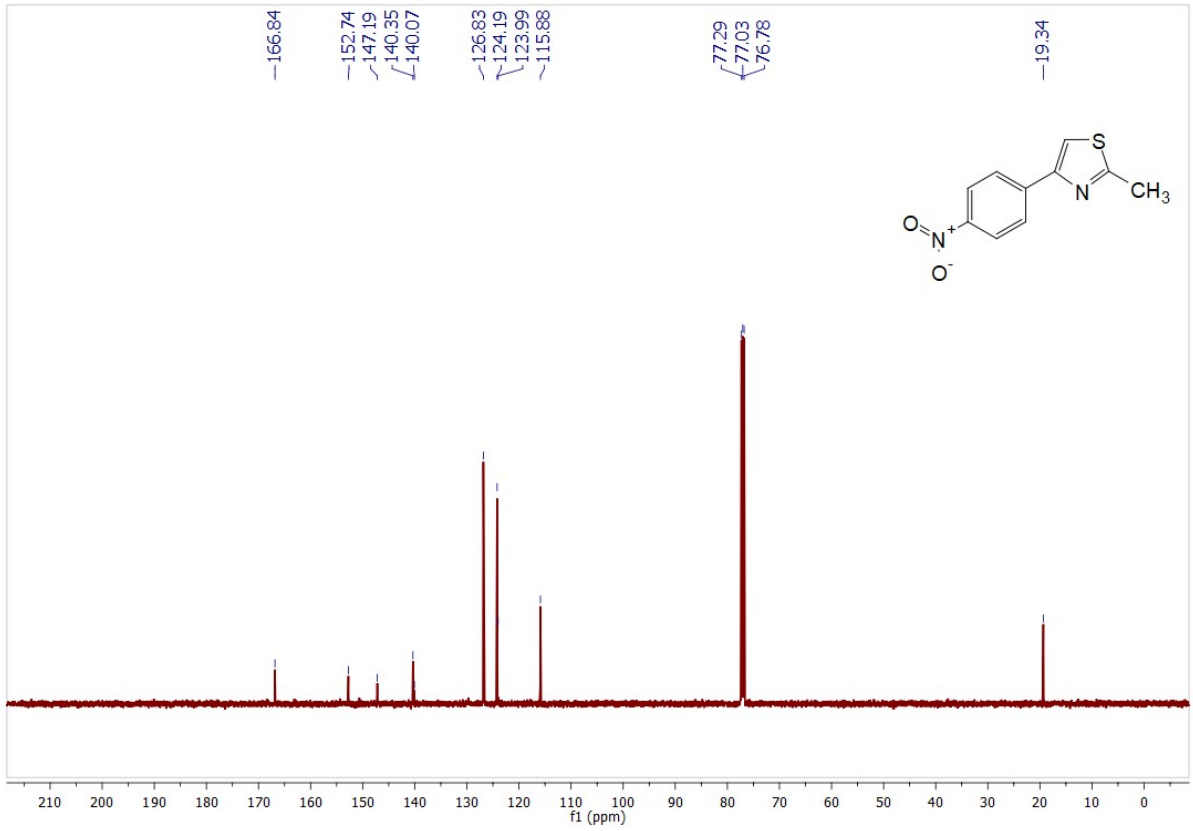
^{1}H & ^{13}C NMR Spectra 4-(p-methoxyphenyl)-2-methyl-thiazole (4j)



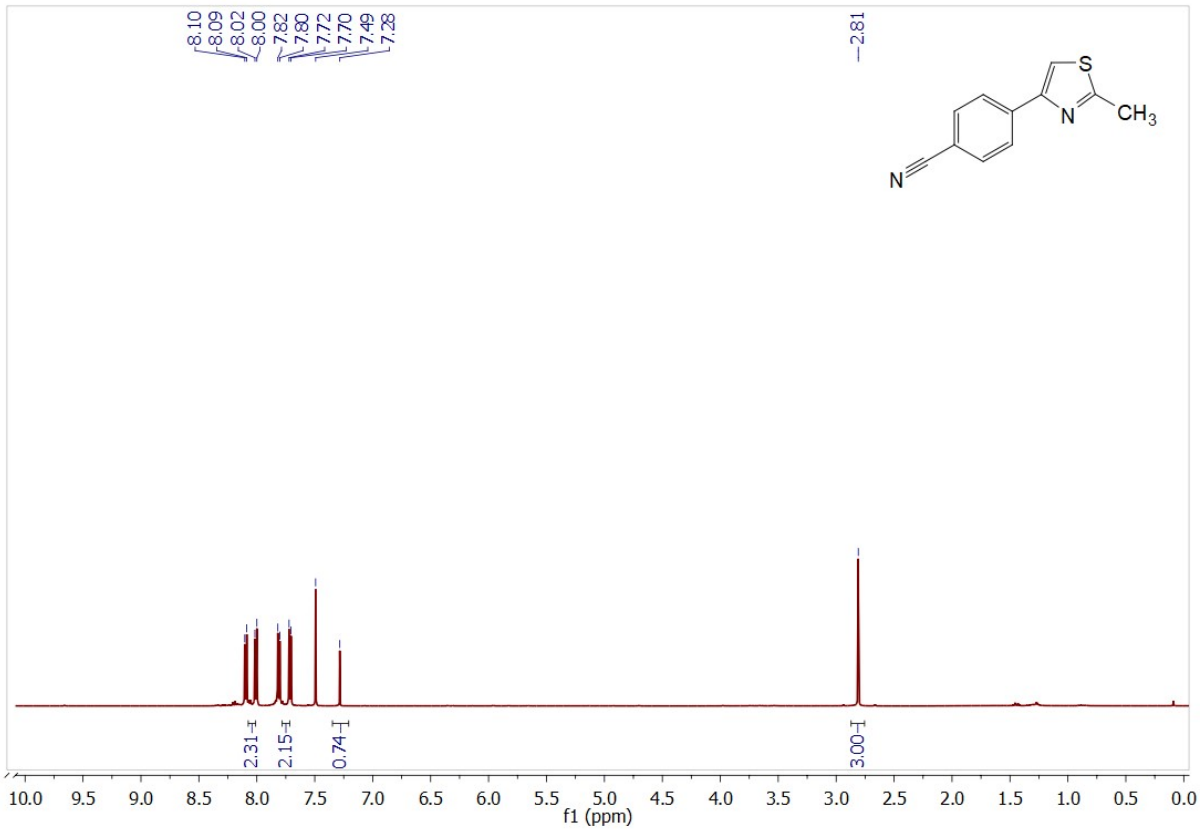


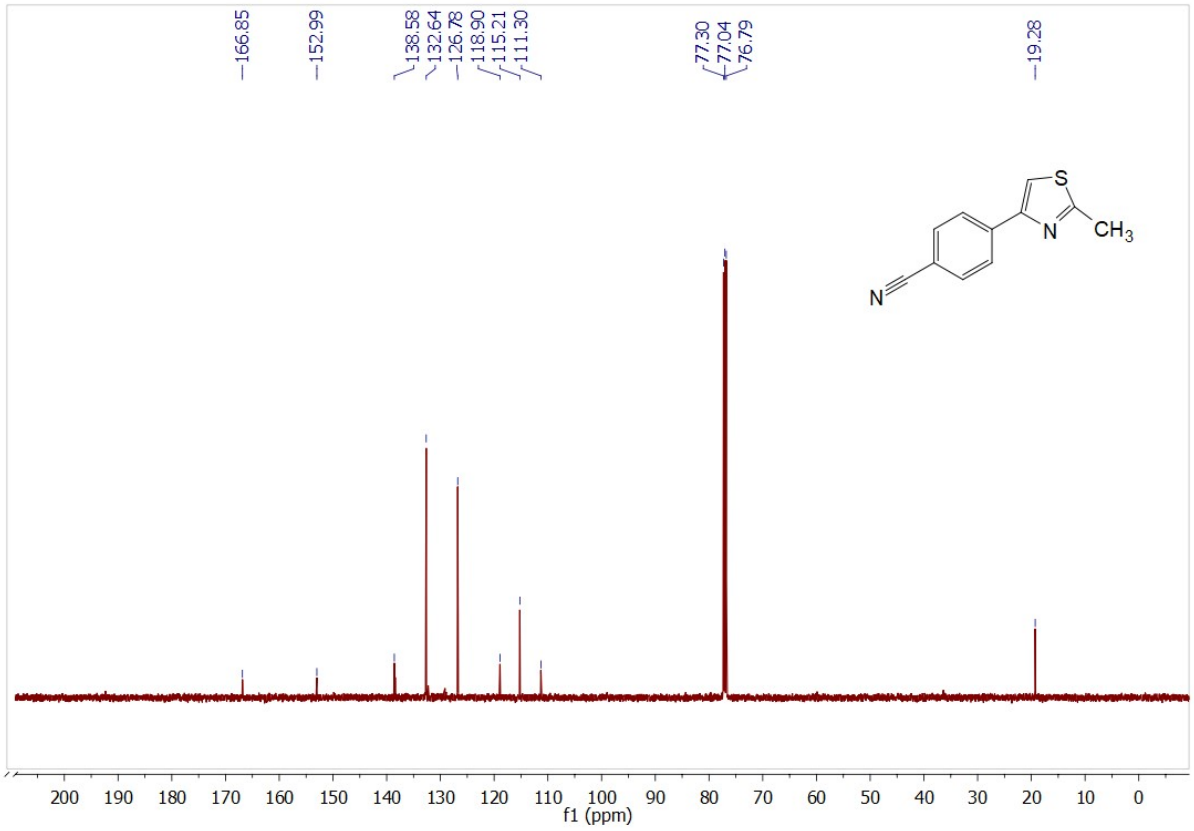
^{1}H & ^{13}C NMR Spectra 4-(p-nitrophenyl)-2-methyl-thiazole (4k)





^{1}H & ^{13}C NMR Spectra 4-(p-cyanophenyl)-2-methyl-thiazole (4l)


8.10
8.09
8.02
8.00
7.82
7.80
7.72
7.70
7.49
7.28
2.81
S
N
CH3
N
2.31
2.15
0.74
3.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


166.85
152.99
138.58
132.64
126.78
118.90
115.21
111.30
77.30
77.04
76.79
19.28
S
N
CH3
N
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

^{1}H & ^{13}C NMR Spectra 2-bromo-1-phenylethan-1-one (Figure 6, Intermediate C)