Supporting Information

Silver-Catalyzed Decarboxylative Cyclization for the Synthesis of Substituted Pyrazoles from 1,2-Diaza-1,3-dienes and *α*-Keto Acids

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Table of Contents

1. General Information SI-3

2. Experimental Section ……..…….....SI-3

3. Optimization of Reaction Conditions …….……...….SI-4

4. Synthetic Procedure and Characterization of Pyrazole Compounds……

…….....SI-6-SI-16

5. Radical Trapping Experiments……..……SI-17

6. Gram-Scale Experiments……...……...….SI-18

7. Synthetic Utility ……..……..….....SI-18-SI-22

8. X-ray Crystal Structure of Compound 3a…….……SI-22

9. References…….……SI-24

10. Spectral Data (^{1}H NMR, ^{13}C NMR and ^{19}F NMR)……...SI-26-SI-73

11. LCMS Data……SI-74-SI-75

1. General Information

Reagent Information. All reactions were performed using borosil sealed tube vial under nitrogen atmosphere. unless otherwise noted. All the chemicals were purchased from Sigma Aldrich, Alfa Aesar and TCI-India. All solvents were used further distillation. Oil bath was used for all required reactions with magnetic stirring. Silica gel (100-200 mesh) was used for column chromatography obtained from Merck. Hexane and ethyl acetate mixture was used as a gradient elution for column chromatography. The eluting solvent for the purification of each compound was determined by thin-layer chromatography (TLC) on glass plates coated with silica gel 60 F_{254} and visualized by ultraviolet light /or with iodine.

Analytical Information. All isolated compounds were characterized by **^{1}H NMR**, **^{13}C NMR** and **^{19}F NMR** spectroscopy, and HRMS. Unless otherwise stated, all Nuclear Magnetic Resonance spectra were recorded on a Bruker 300 MHz, 400 MHz and 500 MHz instrument. NMR spectra are reported in parts per million (ppm), and were measured relative to the signals for residual solvent (7.26 ppm for ^{1}H NMR and 77.16 ppm for ^{13}C NMR in $CDCl_3$) in the deuterated solvent, unless otherwise stated. Melting points were measured with a Büchi B-540 apparatus. All ^{13}C NMR spectra were obtained with ^{1}H decoupling. High-resolution mass spectra (HRMS) were recorded using Q-TOF mass spectrometer of the SAIF Division in CSIR-CDRI Lucknow.

2. Experimental Section.

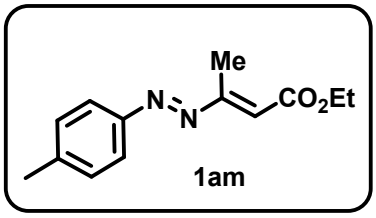
2.1 General procedure for preparation of 1,2-diaza-1,3-dienes derivatives:

The starting material 3-(phenyldiazenyl)but-2-enenitrile derivatives (**1a-1q)** was prepapared according to general procedure via reported method.[1]

2.2 General procedure for preparation of ethyl-3-(phenyldiazenyl)but-2-enoate derivatives:

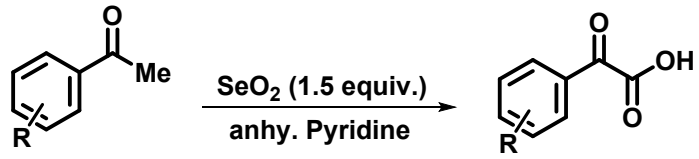
The compound was prepared from ethyl 2-chloroacetoacetate by general proceture. A mixture of sodium acetate (2.0 mmol) in water (3 mL) and phenylhydrazine (1.1 mmol) in ethanol (4 mL) was added rapidaly with stirring to a solution of ethyl 2-chloroacetoacetate (1 mmol) in ethanol (3 mL). After 1h the reaction mixture was filterd to give the desired 1,2-diaza-1,3-dienes in good yield.[2]

ethyl-3-(p-tolyldiazenyl)but-2-enoate (1am): Yield, 69 % Red solid; **M. P.:** 92-94 ˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.75 (dd, J = 6.6 Hz, 1.6 Hz, 2H), 7.29 (d, J = 8.0 Hz, 2H), 6.76 (d, J = 1.1 Hz, 1H), 4.29 (q, J = 7.1 Hz, 2H), 2.43 (s, 3H), 2.41 (s, 3H), 1.36 (t, J = 7.1, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)**: δ 167.0, 164.5, 150.5, 142.7, 129.9, 126.4, 123.2, 60.6, 21.6, 14.4, 11.7; **HRMS(ESI)**: calcd for $C_{13}H_{17}N_2O_2$ $[M+H]^+$ 233.1290, found 233.1278.



1am

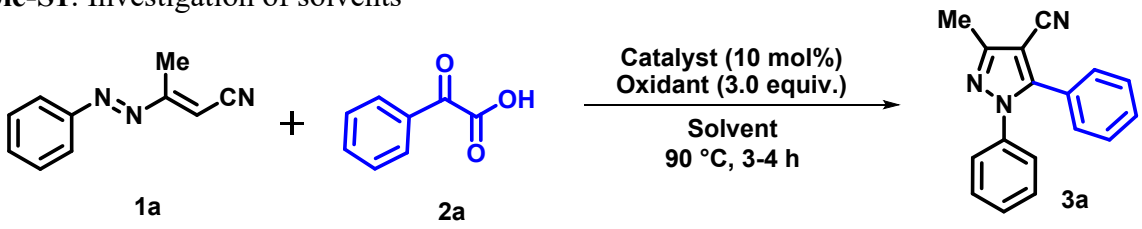
2.3 General procedure for preparation of α-ketoacids:



To a substituted methyl aryl ketones (5.0 mmol), SeO_2 (6.0 mmol), 20 mL of dry pyridine were added in a 50 mL round bottom flask. The reaction mixture was stirred at 110 ºC for 1 h in an oil bath, then reduce the temperature to 90 ºC for 4 h. The desired products were isolated by column chromatography on silica gel using (ethyl acetate/hexane = 1:20) to give α-ketoacids in 65-90% yield. All α-ketoacids are known compounds.[3-5]

3. Optimization of Reaction Conditions

Table-S1: Investigation of solvents[a]

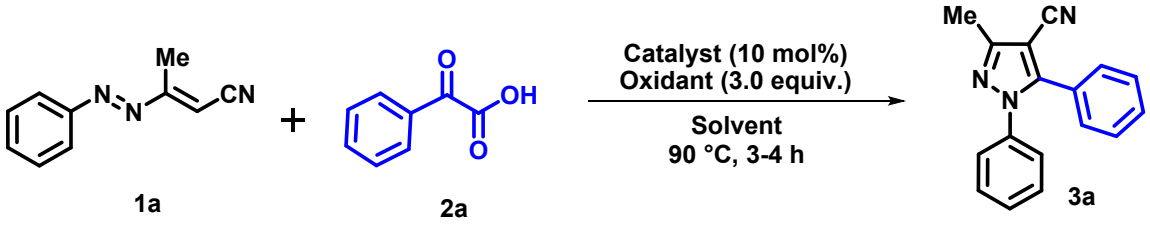


Entry	Catalyst (mol %)	Oxidant (equiv.)	Solvent	Yield (%)[b]
1	Ag_2O (10)	$(NH_4)_2S_2O_8$ (3)	THF:H_2O	40
2	Ag_2O (10)	$(NH_4)_2S_2O_8$ (3)	DMF:H_2O	45
3	Ag_2O (10)	$(NH_4)_2S_2O_8$ (3)	1,4-Dioxane:H_2O	60
4	Ag_2O (10)	$(NH_4)_2S_2O_8$ (3)	EtOH:H_2O	NR

5	Ag_2O (10)	$(NH_4)_2S_2O_8$ (3)	$CH_3CN:H_2O$	86
6	Ag_2O (10)	$(NH_4)_2S_2O_8$ (3)	CH_3CN	40
7	Ag_2O (10)	$(NH_4)_2S_2O_8$ (3)	DMF	15
8	Ag_2O (10)	$(NH_4)_2S_2O_8$ (3)	1,4-Dioxane	18

[a]Reaction conditions: **1a** (0.25 mmol), **2a** (2.0 equiv.), oxidant (3.0 equiv.), and catalyst (10 mol%) in 2 mL of solvent (3:1) were stirred at 90 ˚C in sealed tube vial under inert atmosphere. [b]Isolated yields after column chromatography.

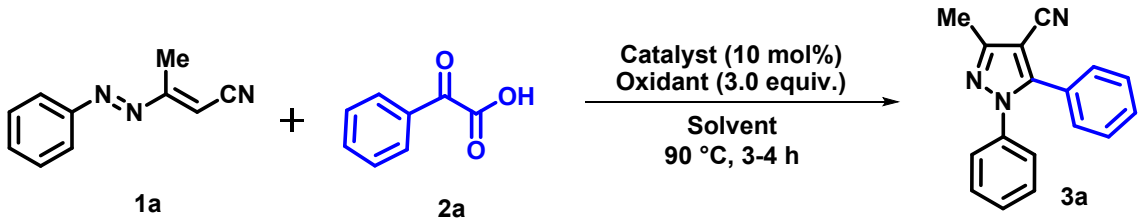
Table-S2: Investigation of Oxidizing reagent[a]



Entry	Catalyst (mol %)	Oxidant (equiv.)	Solvent	Yield (%)[b]
1	Ag_2O (10)	$Na_2S_2O_8$ (3)	$CH_3CN:H_2O$	50
2	Ag_2O (10)	$K_2S_2O_8$ (3)	$CH_3CN:H_2O$	65
3	Ag_2O (10)	$(NH_4)_2S_2O_8$ (3)	$CH_3CN:H_2O$	86

[a]Reaction conditions: **1a** (0.25 mmol), **2a** (2.0 equiv.), oxidant (3.0 equiv.), and catalyst (10 mol%) in 2 mL of solvent (3:1) were stirred at 90 ˚C in sealed tube vial under inert atmosphere. [b]Isolated yields after column chromatography.

Table-S3: Investigation of Catalyst[a]



Entry	Catalyst (mol %)	Oxidant (equiv.)	Solvent	Yield (%)[b]
1	Ag_3PO_4 (10)	$(NH_4)_2S_2O_8$ (3)	$CH_3CN:H_2O$	50
2	$AgNO_3$ (10)	$(NH_4)_2S_2O_8$ (3)	$CH_3CN:H_2O$	73
3	AgOAc (10)	$(NH_4)_2S_2O_8$ (3)	$CH_3CN:H_2O$	76

4	Ag_2O (10)	$(NH_4)_2S_2O_8$ (3)	$CH_3CN:H_2O$	86
5	Ag_2CO_3 (10)	$(NH_4)_2S_2O_8$ (3)	$CH_3CN:H_2O$	NR
6[c]	Ag_2O (10)	$(NH_4)_2S_2O_8$ (3)	$CH_3CN:H_2O$	NR

[a]Reaction conditions: **1a** (0.25 mmol), **2a** (2.0 equiv.), oxidant (3.0 equiv.), and catalyst (10 mol%) in 2 mL of solvent (3:1) were stirred at 90 ˚C in sealed tube vial under inert atmosphere. [b]Isolated yields after column chromatography. [c]Reaction at room temperature. NR- No reaction

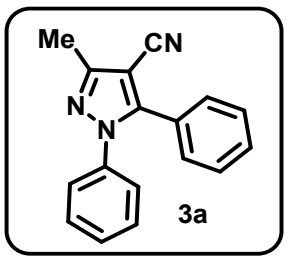
4. Synthetic Procedure and Characterization of Pyrazole Compounds.

4.1. General procedure for the synthesis of substituted pyrazoles:

To a solution of 1,2-Diaza-1,3-dienes (42.7 mg, 0.25 mmol), α-keto acids (75.0 mg, 0.50 mmol), ammonium persulfate (171 mg, 3.0 equiv.) in CH_3CN/H_2O (3:1) and silver oxide (5.7 mg, 0.10 mmol) in a sealed tube vial was added. Then, the vial was degassed with nitrogen for 5 min and the resulting mixture was stirred in a preheated oil bath at 90 °C for 4 h. After completion of the reaction (monitored by TLC) the reaction mixture was cooled down to room temperature. The resulting mixture was extracted with ethyl acetate (3 × 15 mL) in water and organic phase was dried over anhydrous Na_2SO_4. The organic layer was concentrated in *vacuo* and crude product was purified by silica gel column chromatography (100-200 mesh) by using ethyl acetate/hexane solvent system to give the desired product.

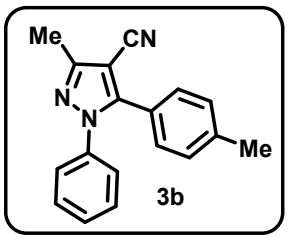
4.2. Characterization of substituted pyrazoles compounds:

3-methyl-1,5-diphenyl-1H-pyrazole-4-carbonitrile (3a): Yield, 86%; yellow solid;



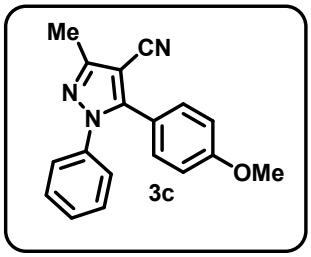
M. P.: 104-106 ˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.43-7.39 (m, 3H), 7.37-7.32 (m, 5H), 7.28-7.25 (m, 2H), 2.53 (s, 3H)); **^{13}C NMR (100 MHz, $CDCl_3$)**: δ 152.8, 148.0, 138.9, 130.1, 129.3, 129.1, 129.1, 128.6, 127.2, 125.4, 114.5, 93.9, 12.7; **HRMS (ESI)**: calcd for $C_{17}H_{13}N_3[M+H]^+$ 260.1188, found 260.1177.

3-methyl-1-phenyl-5-(p-tolyl)-1H-pyrazole-4-carbonitrile (3b): Yield, 87%; yellow solid; **M. P.:** 109-111 ˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.35-7.33 (m, 3H), 7.25-7.23 (m, 2H), 7.21-7.15 (m, 4H), 2.49 (s, 3H), 2.35 (s, 3H); **^{13}C NMR (100 MHz, $CDCl_3$)**: δ 152.7, 148.2, 140.3, 138.9,

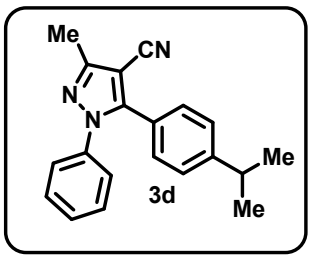


129.7, 129.3, 129.0, 128.5, 125.3, 124.3, 114.6, 93.6, 21.5, 12.7; **HRMS (ESI)**: calcd for $C_{18}H_{16}N_3[M+H]^+$ 274.1344, found 274.1335.

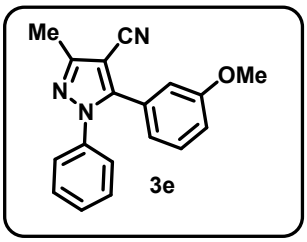
5-(4-methoxyphenyl)-3-methyl-1-phenyl-1H-pyrazole-4-carbonitrile (3c): Yield, 90%; yellow solid; oily product; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.36-7.34 (m, 2 H), 7.26-7.23 (m, 5H), 6.88 (dd, J = 6.8 Hz, 2.1 Hz, 2H), 3.82 (s, 3H), 2.48 (s, 3H); **^{13}C NMR (100 MHz, $CDCl_3$)**: 160.8, 152.7, 148.0, 138.9, 132.4, 130.5, 129.3, 128.4, 125.3, 119.3, 114.5, 93.3, 55.4, 12.7; **HRMS (ESI)**: calcd for $C_{18}H_{16}N_3O[M+H]^+$ 290.1293, found 290.1279.



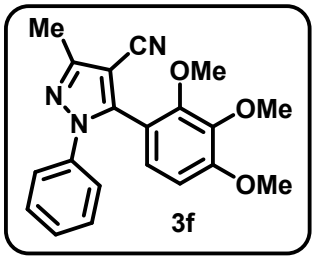
5-(4-isopropylphenyl)-3-methyl-1-phenyl-1H-pyrazole-4-carbonitrile (3d): Yield 89%; a yellow solid; **M. P.:** 114-116 ˚C; **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 7.35-7.34 (m, 3H), 7.26-7.23 (m, 2H), 7.22-7.20 (m, 4H), 2.94-2.86 (m, 1H), 2.49 (s, 3H), 1.24 (d, J = 6.9 Hz, 6H); **^{13}C NMR (125 MHz, $CDCl_3$)**: 152.7, 151.0, 148.2, 139.0, 129.2, 129.0, 128.5, 127.1, 125.4, 124.5, 114.7, 93.6, 34.0, 23.8, 12.7; **HRMS (ESI)**: calcd for $C_{20}H_{20}N_3[M+H]^+$ 302.1657, found 302.1644.



5-(3-methoxyphenyl)-3-methyl-1-phenyl-1H-pyrazole-4-carbonitrile (3e): Yield 87%; yellow colour solid; **M. P.:** 81-83 ˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.38-7.34 (m, 3H), 7.30-7.26 (m, 3H), 6.96-6.93 (m, 1H), 6.90-6.88 (m, 1H), 6.83-6.82 (m, 1H), 3.70 (s, 3H), 2.51 (s, 3H); **^{13}C NMR (100 MHz, $CDCl_3$)**: 159.8, 152.8, 147.8, 138.8, 130.1, 129.3, 128.6, 128.2, 125.3, 121.4, 116.2, 114.4, 114.2, 93.9, 55.3, 12.7; **HRMS (ESI)**: calcd for $C_{18}H_{16}N_3O[M+H]^+$ 290.1293, found 290.1285.

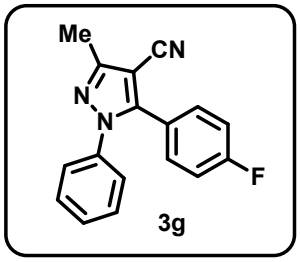


3-methyl-1-phenyl-5-(2,3,4-trimethoxyphenyl)-1H-pyrazole-4-carbonitrile (3f): Yield 88%; yellow solid; **M. P.:** 171-173 ˚C, **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 7.39-7.37 (m, 3H), 7.30-7.28 (m, 2H), 6.50 (s, 2H), 3.86 (s, 3H), 3.66 (s, 6H), 2.49 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)**: δ 153.5, 152.8, 147.9, 139.5, 139.0, 129.4, 128.7, 125.6, 122.0, 114.6, 106.5, 93.4, 61.0, 56.2,

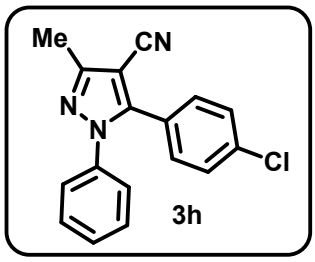


12.7; **HRMS (ESI)**: calcd for $C_{20}H_{20}N_3O_3[M+H]^+$ 350.1505, found 350.1495

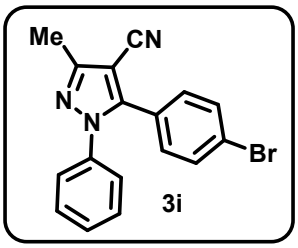
5-(4-fluorophenyl)-3-methyl-1-phenyl-1H-pyrazole-4-carbonitrile (3g): Yield 83%; yellow solid; **M. P.:** 117-119 ˚C; **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 7.37-7.35 (m, 3H), 7.31-7.29 (m, 2H), 7.24-7.22 (m, 2H), 7.07 (t, J = 8.4 Hz, 2H), 2.49 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)**: δ 163.5 (d, $J_{C\text{-}F}$ = 250.0 Hz), 152.8, 146.9, 138.6, 131.2 (d, $J_{C\text{-}F}$ = 8.4 Hz), 129.4, 128.7, 125.3, 123.3 (d, $J_{C\text{-}F}$ = 3.4 Hz), 116.4 (d, $J_{C\text{-}F}$ = 22.0 Hz), 114.3, 93.9, 12.7; **^{19}F NMR (376 MHz, $CDCl_3$):** -109.4 (s); **HRMS (ESI)**: calcd for $C_{17}H_{13}FN_3[M+H]^+$ 278.1094, found 278.1084.



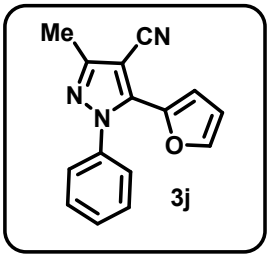
5-(4-chlorophenyl)-3-methyl-1-phenyl-1H-pyrazole-4-carbonitrile (3h):. Yield 81%; yellow solid; oily product; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.51 (dd, J = 6.6 Hz, 1.8 Hz, 2H), 7.38-7.35 (m, 3H), 7.24-7.22 (m, 2H), 7.19-7.16 (m, 2H), 2.49 (s, 3H); **^{13}C NMR (100 MHz, $CDCl_3$)**: δ 152.9, 146.7, 138.6, 136.4, 130.4, 129.4, 128.8, 125.6, 125.3, 120.3, 114.2, 94.0, 12.7; **HRMS (ESI)**: calcd for $C_{17}H_{13}ClN_3[M+H]^+$ 294.0798, found 294.0786.



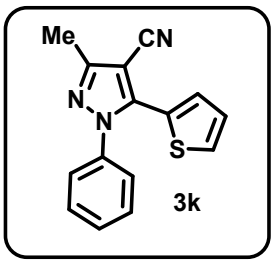
5-(4-bromophenyl)-3-methyl-1-phenyl-1H-pyrazole-4-carbonitrile (3i): Yield 78%; yellow solid; oily product; **^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.51 (d, J = 8.3 Hz, 2H), 7.37-7.36 (m, 3H), 7.24-7.22 (m, 2H), 7.18 (d, J = 8.3 Hz, 2H), 2.49 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$):** δ 152.9, 146.7, 138.5, 132.4, 130.6, 129.5, 128.8, 126.1, 125.3, 124.7, 114.2, 94.0, 12.7; HRMS (ESI): calcd for $C_{17}H_{13}BrN_3[M+H]^+$ 338.0293, found 338.0295.



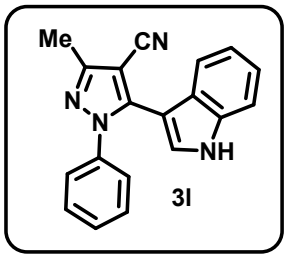
5-(furan-2-yl)-3-methyl-1-phenyl-1H-pyrazole-4-carbonitrile (3j): Yield 75%; yellow solid; **M. P.:** 191-193 ˚C; **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 7.48-7.46 (m, 4H), 7.38-7.37 (m, 2H), 6.42-6.40 (m, 2H), 2.47 (s, 3H); **^{13}C NMR (100 MHz, $CDCl_3$)**: 152.9, 144.3, 141.4, 139.3, 138.6, 129.5, 129.4, 126.0, 114.1, 112.5, 111.8, 91.6, 12.6; **HRMS (ESI)**: calcd for $C_{15}H_{12}N_3O[M+H]^+$ 250.0980, found 250.0965.



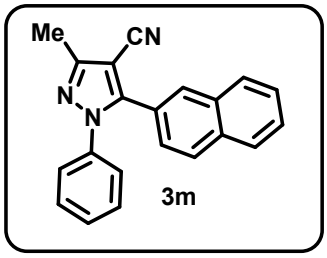
3-methyl-1-phenyl-5-(thiophen-2-yl)-1H-pyrazole-4-carbonitrile (3k): Yield, 77%; yellow solid; **M. P.:** 206-208 ˚C; **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 7.46-7.42 (m, 3H), 7.39 (dd , J = 5.0 Hz, 1.1 Hz, 1H), 7.36-7.34 (m, 2H), 7.32 (dd , J = 3.7 Hz, 1.0 Hz, 1H), 7.05-7.03 (m, 1H), 2.47 (s, 3H); **^{13}C NMR (100 MHz, $CDCl_3$)**: 152.8, 142.3, 138.5, 129.9, 129.6, 129.5, 129.2, 127.7, 127.3, 126.5, 114.4, 93.0, 12.7; **HRMS (ESI)**: calcd for $C_{15}H_{12}N_3S[M+H]^+$ 266.0752, found 266.0743.



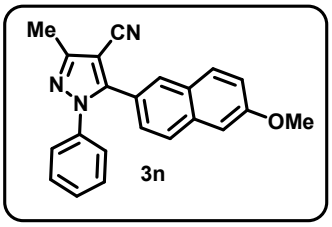
5-(1H-indol-3-yl)-3-methyl-1-phenyl-1H-pyrazole-4-carbonitrile (3l): Yield 73%; brown red solid; **M. P.:** 184-186 ˚C; **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 8.80 (s, 1H), 7.36-7.32 (m, 4H), 7.27-7.24 (m, 3H), 7.16-7.13 (m, 1 H), 7.05 (d, J = 8.0 Hz, 1H), 6.97-6.94 (m, 1H), 2.52 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)**: 152.9, 143.8, 139.5, 136.0, 129.2, 128.2, 125.9, 124.6, 124.5, 123.1, 121.0, 120.0, 115.2, 111.7, 103.5, 93.7, 12.9; **HRMS (ESI)**: calcd for $C_{19}H_{15}N_4[M+H]^+$ 299.1297, found 299.1281.



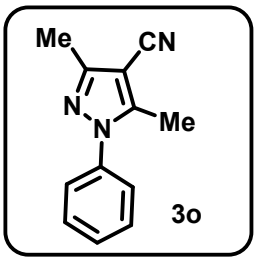
3-methyl-5-(naphthalen-2-yl)-1-phenyl-1H-pyrazole-4-carbonitrile (3m): Yield 86%; Light yellow solid; **M. P.:** 119-121 ˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.97 (d, J = 1.3 Hz, 1H), 7.84-7.81 (m, 2H), 7.78 (d, J = 8.6 Hz, 1H), 7.57-7.50 (m, 2H), 7.33-7.31 (m, 3H), 7.29-7.27 (m, 2H), 7.22 (dd, J = 8.5 Hz, 1.8 Hz 1H), 2.54 (s, 3H); **^{13}C NMR (100 MHz, $CDCl_3$)**: 152.9, 147.9, 138.9, 133.5, 133.0, 129.3, 128.8, 128.6, 128.6, 127.8, 127.7, 127.0, 125.6, 125.3, 124.5, 114.5, 94.2, 12.8; **HRMS (ESI)**: calcd for $C_{21}H_{16}N_3[M+H]^+$ 310.1344, found 310.1332.



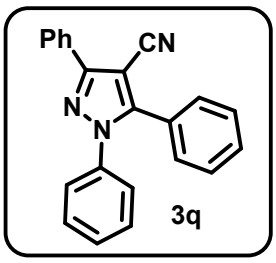
5-(6-methoxynaphthalen-2-yl)-3-methyl-1-phenyl-1H-pyrazole-4-carbonitrile (3n): Yield 87%; white solid; **M. P.:** 149-151 ˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.86 (d, J = 1.2 Hz, 1H), 7.71 (d, J = 9.0 Hz, 1H), 7.66 (d, J = 8.6 Hz, 1H), 7.33-7.31 (m, 3H), 7.29-7.27 (m, 2H), 7.21-7.18 (m, 2H), 7.10 (d, J = 2.3 Hz, 1H), 3.91 (s, 3H), 2.53 (s, 3H); **^{13}C NMR (100 MHz, $CDCl_3$)**: 159.1, 152.8, 148.1, 138.0, 136.5, 135.1, 131.9, 129.6, 128.5, 128.3, 125.3, 111.9, 60.0, 21.1, 14.4, 14.1; **HRMS (ESI)**: calcd for $C_{22}H_{18}N_3O[M+H]^+$ 340.1450, found 340.1442.



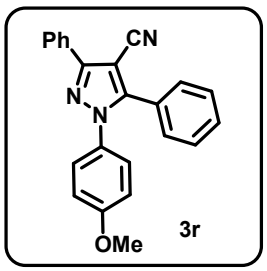
3,5-dimethyl-1-phenyl-1H-pyrazole-4-carbonitrile (3o): Yield, 63%; yellow solid; **M. P.:** 89-91 ˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.52-7.48 (m, 3H), 7.47-7.43 (m, 1H), 7.41-7.39 (m, 2H), 2.44 (s, 3H), 2.41 (s, 3H); **^{13}C NMR (100 MHz, $CDCl_3$)**: δ 151.9, 145.8, 138.4, 129.5, 128.9, 125.0, 114.3, 93.7, 12.6, 11.9; **HRMS (ESI)**: calcd for $C_{12}H_{12}N_3[M+H]^+$198.1031, found 198.1023.



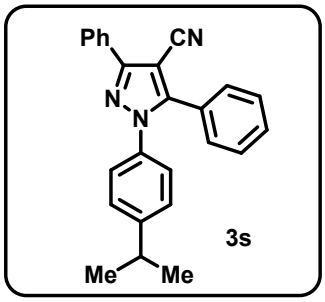
1,3,5-triphenyl-1H-pyrazole-4-carbonitrile (3q): Yield, 85%; Light yellow solid; **M. P.:** 169-171 ˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 8.03 (dd, J = 8.4 Hz, 1.5 Hz, 2H), 7.44-7.39 (m, 3H), 7.37-7.30 (m, 5H), 7.29-7.24 (m, 5H); **^{13}C NMR (100 MHz, $CDCl_3$)**: δ 153.5, 149.5, 138.8, 130.6, 130.2, 129.6, 129.4, 129.3, 129.1, 129.0, 128.7, 127.0, 127.0, 125.4, 115.2, 91.6; **HRMS (ESI)**: calcd for$C_{22}H_{16}N_3[M+H]^+$ 322.1344, found 322.1331.



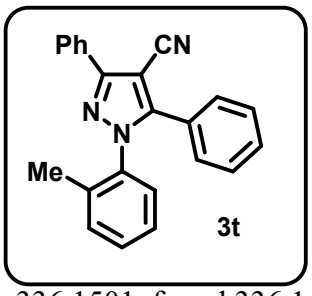
1-(4-methoxyphenyl)-3,5-diphenyl-1H-pyrazole-4-carbonitrile (3r): Yield, 86% White solid; **M. P.:** 154-156 ˚C; **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 8.10-8.08 (m, 2H), 7.51-7.44 (m, 3H), 7.43-7.39 (m, 5H), 7.26-7.23 (m, 2H), 6.87 (dd, J = 6.8, Hz, J = 2.1, Hz, 2H), 3.82 (s, 3H); **^{13}C NMR (100 MHz, $CDCl_3$)**: δ 159.7, 153.2, 149.3, 131.9, 130.7, 130.1, 129.6, 129.4, 129.1, 129.0, 127.1, 126.8, 115.4, 114.5, 91.0, 55.6; **HRMS (ESI)**: calcd for $C_{23}H_{18}N_3O[M+H]^+$ 352.1450, found 352.1437



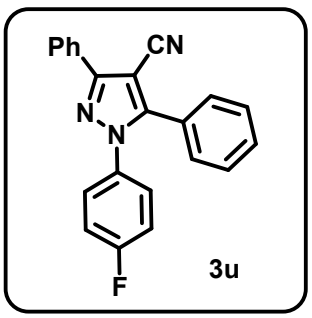
1-(4-isopropylphenyl)-3,5-diphenyl-1H-pyrazole-4-carbonitrile (3s): Yield 84%; White solid; **M. P.:** 164-166 ˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 8.12-8.10 (m, 2H), 7.52-7.48 (m, 2H), 7.48-7.45 (m, 2H), 7.44-7.39 (m, 5H), 7.23 (dd, J = 6.2 Hz, J = 2.6 Hz, 3H), 2.98-2.88 (m, 1H), 2.50 (d, J = 6.9 Hz, 6H); **^{13}C NMR (125 MHz, $CDCl_3$)**: 153.4, 149.8, 149.3, 136.6, 130.7, 130.1, 129.6, 129.4, 129.1, 129.0, 127.3, 127.1, 127.0, 125.3, 115.4, 91.3, 33.9, 23.9; **HRMS (ESI)**: calcd for $C_{25}H_{22}N_3$ $[M+H]^+$ 364.1814, found 364.1811.



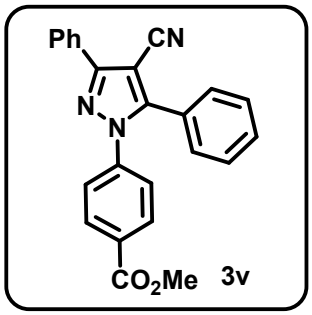
3,5-diphenyl-1-(o-tolyl)-1H-pyrazole-4-carbonitrile (3t): Yield 84%; White solid; **M. P.:** 189-191 ˚C; **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 8.10 (d, J = 7.4 Hz, 2H), 7.50-7.42 (m, 3H), 7.38-7.34 (m, 6H), 7.25-7.23 (m, 3H), 2.04 (s, 3H); **^{13}C NMR (100 MHz, $CDCl_3$)**: 153.4, 150.6, 138.0, 135.4, 131.4, 130.7, 130.1, 129.9, 129.6, 129.0, 128.8, 128.0, 127.0, 126.8, 115.5, 89.9, 17.8; **HRMS (ESI)**: calcd for $C_{23}H_{18}N_3[M+H]^+$ 336.1501, found 336.1493.



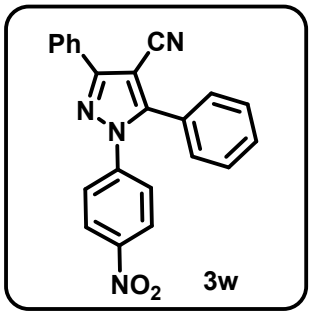
1-(4-fluorophenyl)-3,5-diphenyl-1H-pyrazole-4-carbonitrile (3u): Yield 81%; Light yellow solid; **M. P.:** 154-156 ˚C; **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 8.01 (d, J = 7.0 Hz, 2H), 7.44-7.41 (m, 2H), 7.40-7.33 (m, 4H), 7.37 (dd, J = 7.7 Hz, J = 1.2 Hz, 2H), 7.26-7.23 (m, 2H), 7.07 (t, J = 8.2 Hz, 2H); **^{13}C NMR (125 MHz, $CDCl_3$)**: δ 162.3 (d, $J_{C\text{-}F}$ = 248.0 Hz), 153.5, 149.5, 134.9, 130.5, 130.4, 129.8, 129.3 (d, $J_{C\text{-}F}$ = 12.9 Hz), 129.0, 127.3 (d, $J_{C\text{-}F}$ = 8.7 Hz), 127.0, 126.8, 116.4 (d, $J_{C\text{-}F}$ = 22.9 Hz), 115.1, 91.6; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -109.4 (s); **HRMS (ESI)**: calcd for $C_{22}H_{15}FN_3[M+H]^+$340.1250, found 340.1245.



methyl 4-(4-cyano-3,5-diphenyl-1H-pyrazol-1-yl)benzoate (3v): Yield 72%; Light yellow solid; **M. P.:** 92-93 ˚C; **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 8.11-8.09 (m, 2H), 8.04 (dd, J = 6.8 Hz, 1.8 Hz, 2H), 7.53-7.45 (m, 5H), 7.44-7.37 (m, 5H), 3.92 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)**: 163.3, 161.3, 153.5, 149.5, 134.9, 130.5, 130.4, 129.8, 129.3, 129.2, 129.0, 127.3, 127.0, 126.8, 116.4, 115.1, 91.6, 29.8; **HRMS (ESI)**: calcd for $C_{24}H_{18}N_3O_2[M+H]^+$ 380.1399, found 380.1395.

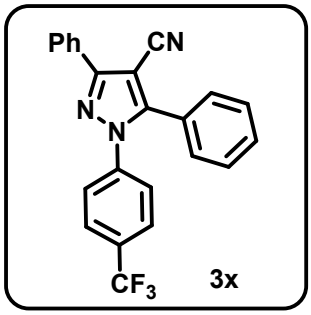


1-(4-nitrophenyl)-3,5-diphenyl-1H-pyrazole-4-carbonitrile (3w): Yield 73%; yellow solid; **M. P.:** 174-176 ˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 8.23 (dd, J = 6.9 Hz, 2.0 Hz, 2H), 8.10 (dd, J = 8.2 Hz, 1.8 Hz, 2H), 7.55-7.51 (m, 5H), 7.50-7.46 (m, 3H), 7.40 (dd, J = 7.9 Hz, 1.2 Hz, 2H), **^{13}C NMR (100 MHz, $CDCl_3$)**: 154.3, 150.1, 147.0, 143.5, 131.0, 130.2, 130.0, 129.6, 129.3, 129.2, 127.0, 126.4,

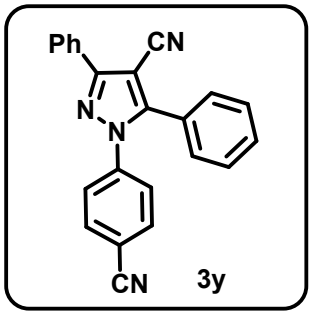


125.4, 124.8, 114.5, 93.4; **HRMS (ESI)**: calcd for $C_{22}H_{15}N_4O_2[M+H]^+$ 367.1195, found 367.1185.

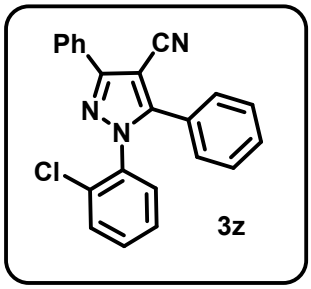
3,5-diphenyl-1-(4-(trifluoromethyl)phenyl)-1H-pyrazole-4-carbonitrile (3x): Yield, 75% White solid; **M. P.:** 149-151 ˚C; **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 8.10 (dd, J = 8.3 Hz, 1.5 Hz, 2H), 7.64 (d, J = 8.4 Hz, 2H), 7.53-7.48 (m, 5H), 7.48-7.45 (m, 3H), 7.39 (dd, J = 7.9 Hz, 1.2 Hz, 2H); **^{13}C NMR (125 MHz, $CDCl_3$)**: 153.9, 149.8, 141.5, 132.2, 130.7, 130.3 (q, $J_{C\text{-}F}$ = 11.6 Hz), 131.0, 129.9, 129.4, 129.3, 129.1, 127.6, 127.2, 126.6, 126.5 (q, $J_{C\text{-}F}$= 3.5 Hz), 126.1, 125.3, 119.0, 114.8, 92.6; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -62.6 (s); **HRMS (ESI)**: calcd for $C_{23}H_{15}F_3N_3[M+H]^+$ 390.1218, found 390.1215.

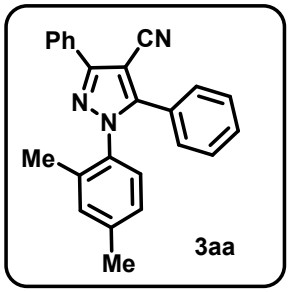


1-(4-cyanophenyl)-3,5-diphenyl-1H-pyrazole-4-carbonitrile (3y): Yield 77%; White solid; **M. P.:** 179-181 ˚C; **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 8.09 (d, J = 8.4 Hz, 2H), 7.66 (d, J = 8.6 Hz, 2H), 7.53-7.50 (m, 3H), 7.49-7.46 (m, 5H), 7.39 (d, J = 7.0 Hz, 2H); **^{13}C NMR (100 MHz, $CDCl_3$)**: 154.2, 149.9, 142.1, 133.2, 130.9, 130.1, 129.6, 129.3, 129.1, 127.0, 126.5, 126.1, 125.4, 117.8, 114.5, 112.2, 93.1; **HRMS (ESI)**: calcd for $C_{23}H_{15}N_4[M+H]^+$ 347.1297, found 347.1293.



1-(2-chlorophenyl)-3,5-diphenyl-1H-pyrazole-4-carbonitrile (3z): Yield 78%; White solid; **M. P.:** 114-116 ˚C; **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 8.09 (dd, J = 8.5 Hz, 1.5 Hz, 2H), 7.51-7.45 (m, 5H), 7.43-7.39 (m, 2H), 7.38-7.36 (m, 5H), **^{13}C NMR (100 MHz, $CDCl_3$)**: 153.8, 151.5, 136.6, 132.1, 131.2, 130.7, 130.5, 130.3, 129.8, 129.7, 129.2, 129.0, 128.8, 127.9, 127.0, 126.5 115.2, 90.5; HRMS (ESI): calcd for $C_{22}H_{15}ClN_3[M+H]^+$ 356.0955, found 356.0952.

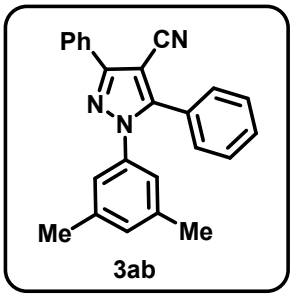




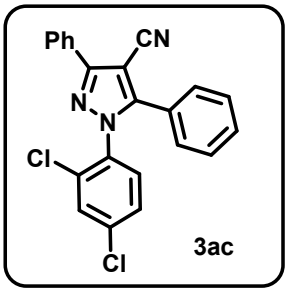
1-(2,4-dimethylphenyl)-3,5-diphenyl-1H-pyrazole-4-carbonitrile (3aa): Yield 80%; Light yellow solid; **M. P.:** 169-171 ˚C; **^{1}H NMR**

(500 MHz, $CDCl_3$): δ 8.11 (d, J = 7.1 Hz, 2H), 7.50-7.42 (m, 3H), 7.38-7.35 (m, 5H), 7.14 (d, J = 7.9 Hz, 1H), 7.06-7.04 (m, 2H), 2.35 (s, 3H) 2.00 (s, 3H); **^{13}C NMR (100 MHz, $CDCl_3$)**: 153.3, 150.5, 140.0, 135.5, 134.9, 132.0, 130.8, 130.0, 129.5, 128.9, 127.7, 127.6, 127.0, 126.9, 115.6, 89.8, 21.3, 17.7; **HRMS (ESI)**: calcd for $C_{24}H_{20}N_3[M+H]^+$ 350.1657, found 350.1643

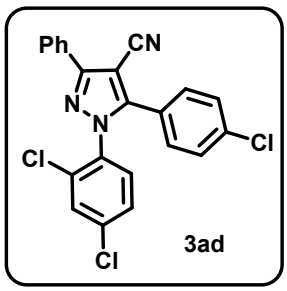
1-(3,5-dimethylphenyl)-3,5-diphenyl-1H-pyrazole-4-carbonitrile (3ab): Yield 81% Light yellow solid; **M. P.:** 169-171 ˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.99 (d, J = 8.1 Hz, 2H), 7.43-7.37 (m, 5H), 7.30 (d, J = 7.9 Hz, 2H), 7.21 (d, J = 8.4 Hz, 2H), 7.16 (d, J = 8.2 Hz, 2H), 2.42 (s, 3H), 2.37 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)**: 153.4, 149.2, 139.6, 138.8, 136.4, 130.1 129.9, 129.7, 129.4, 129.0, 127.9, 127.2, 126.9, 125.3, 115.5, 91.1, 21.5, 21.2; **HRMS (ESI)**: calcd for $C_{24}H_{20}N_3[M+H]^+$ 350.1657, found 350.1652.



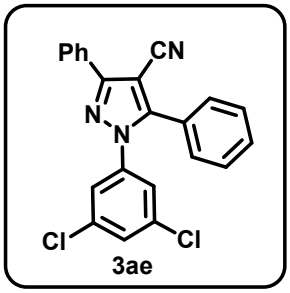
1-(2,4-dichlorophenyl)-3,5-diphenyl-1H-pyrazole-4-carbonitrile (3ac): Yield 70%; Light yellow solid; **M. P.:** 149-151 ˚C; **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 8.09 (d, J = 7.6 Hz, 2H), 7.51-7.42 (m, 5H), 7.40-7.34 (m, 6H); **^{13}C NMR (125 MHz, $CDCl_3$)**: 154.0, 151.6, 136.7, 135.3, 133.1, 130.1, 130.6, 130.6, 130.5,130.3, 129.8, 129.1, 129.0, 128.8, 128.3, 127.0, 126.3, 115.0, 90.8; **HRMS (ESI)**: calcd for $C_{22}H_{14}Cl_2N_3[M+H]^+$ 390.0565, found 390.0565.



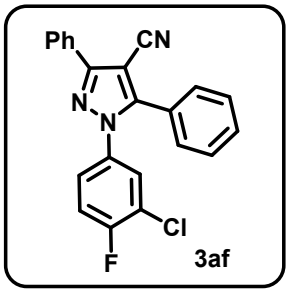
5-(4-chlorophenyl)-1-(2,4-dichlorophenyl)-3-phenyl-1H-pyrazole-4-carbonitrile (3ad): Yield 72%; Light yellow solid; **M. P.:** 159-161 ˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 8.07 (dd, J = 8.2 Hz, 1.7 Hz, 2H), 7.53-7.46 (m, 4H), 7.53 (s, 1H), 7.40-7.37 (m, 3H), 7.31 (dd, J = 6.6 Hz, 2.1 Hz, 2H); **^{13}C NMR (125 MHz, $CDCl_3$)**: 154.1, 150.4, 137.0, 136.9, 135.1, 132.9, 130.7, 130.5, 130.1, 130.0, 130.0, 129.6, 129.1, 128.4, 127.0, 124.8, 114.7, 91.0; **HRMS (ESI)**: calcd for $C_{22}H_{13}Cl_3N_3[M+H]^+$ 424.0175, found 424.0178.



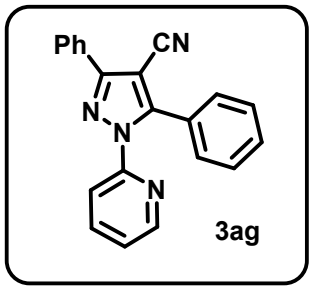
1-(3,5-dichlorophenyl)-3,5-diphenyl-1H-pyrazole-4-carbonitrile (3ae): Yield 72%; yellow solid; **M. P.:** 187-188 ˚C; **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 8.09 (dd, J = 8.3 Hz, 1.5 Hz, 2H), 7.53-7.50 (m, 5H), 7.49-7.47 (m, 1H), 7.41 (dd, J = 7.9 Hz, 1.3 Hz, 2H), 7.36 (t, J = 1.8 Hz, 1H), 7.26-7.26 (m, 2H); **^{13}C NMR (125 MHz, $CDCl_3$)**: 154.0, 149.8, 140.2, 135.6, 130.9, 130.1, 130.0, 129.5, 129.3 129.1, 128.8, 127.0, 126.3, 123.7, 114.6, 92.6; **HRMS (ESI)**: $C_{22}H_{14}Cl_2N_3[M+H]^+$ 390.0565, found 390.0565.



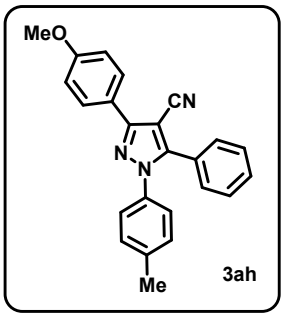
1-(3-chloro-4-fluorophenyl)-3,5-diphenyl-1H-pyrazole-4-carbonitrile (3af): Yield 73%; yellow solid; **M. P.:** 79-81 ˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 8.08 (d, J = 6.9 Hz, 2H), 7.55-7.51 (m, 2H), 7.49-7.45 (m, 5H), 7.40-7.38 (m, 2H), 7.11 (d, J = 6.2 Hz, 2H); **^{13}C NMR (125 MHz, $CDCl_3$)**: 157.9 (d, $J_{C\text{-}F}$ =250 Hz), 153.8, 149.7, 135.3 (d, $J_{C\text{-}F}$ = 3.0 Hz), 130.7, 130.2, 129.9, 129.4, 129.3, 129.1, 127.8, 126.5, 125.0 (d, $J_{C\text{-}F}$ = 7.7 Hz), 122.1 (d, $J_{C\text{-}F}$ = 18.9 Hz), 117.0 (d, $J_{C\text{-}F}$ = 22.5 Hz), 114.8, 92.1; **^{19}F NMR (376 MHz, $CDCl_3$):** δ -109.4 (s); **HRMS (ESI)**: calcd for $C_{22}H_{14}ClFN_3[M+H]^+$ 374.0860 found 374.0855 .



3,5-diphenyl-1-(pyridin-2-yl)-1H-pyrazole-4-carbonitrile (3ag): Yield 68%; Light yellow solid; **M. P.:** 109-111 ˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 8.38-8.36 (m, 1H), 8.12 (dd, J = 8.3 Hz, 1.6 Hz, 2H), 7.86-7.81 (m, 1H), 7.62 (d, J = 8.0 Hz, 1H), 7.52-7.46 (m, 3H), 7.45-7.41 (m, 5H), 7.33-7.29 (m, 1H); **^{13}C NMR (100 MHz, $CDCl_3$)**: 153.7, 151.4, 150.3, 148.8, 138.8, 133.8, 130.4, 130.3, 130.1, 129.8, 129.4, 129.3, 129.0, 128.8, 128.6, 127.5, 127.1, 123.8, 119.4, 115.0, 92.6; **HRMS (ESI)**: calcd for $C_{21}H_{15}N_4[M+H]^+$ 323.1297, found 323.1286.

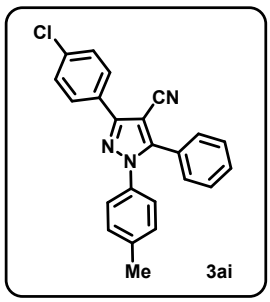


3-(4-methoxyphenyl)-5-phenyl-1-(p-tolyl)-1H-pyrazole-4-carbonitrile (3ah): Yield 75% White solid; **M. P.:** 159-161 ˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 8.04 (dd, J = 6.8 Hz, 2.0 Hz, 2H), 7.43-7.36 (m, 5H), 7.19 (dd, J = 6.4 Hz, 1.8 Hz, 2H), 7.15 (d, J = 8.4 Hz, 2H), 7.01 (dd, J = 6.8 Hz, 2.0 Hz, 2H), 3.87 (s, 3H), 2.36 (s, 3H); **^{13}C NMR (100 MHz, $CDCl_3$)**: δ 160.7, 153.2, 149.1, 138.8, 136.4, 130.1, 129.8, 129.3, 129.0, 128.4,



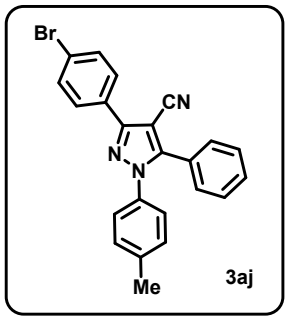
127.2, 125.2, 123.4, 115.6, 114.4, 90.8, 55.5, 21.2; **HRMS (ESI)**: calcd for $C_{24}H_{20}N_3O[M+H]^+$ 366.1606, found 366.1595

3-(4-chlorophenyl)-5-phenyl-1-(p-tolyl)-1H-pyrazole-4-carbonitrile (3ai): Yield 73%



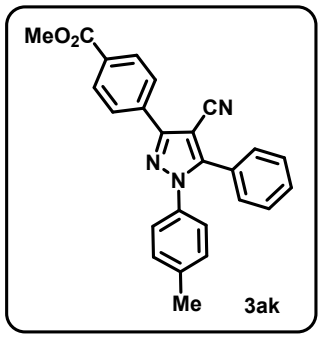
Light yellow solid; **M. P.:** 85-87 ˚C, **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 8.05 (dd, J = 6.7 Hz, 1.9 Hz, 2H), 7.46 (dd, J = 6.8 Hz, 1.9 Hz, 2H), 7.44-7.39 (m, 3H), 7.38-7.36 (m, 2H), 7.20-7.16 (m, 4H), 2.37 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)**: δ 152.1, 149.5 139.0, 136.3 135.6, 130.2, 129.9, 129.3, 129.2, 129.1, 128.2, 126.9, 125.2, 115.1, 91.2, 21.3; **HRMS (ESI)**: calcd for $C_{23}H_{17}ClN_3[M+H]^+$ 370.1111, found 370.1107.

3-(4-bromophenyl)-5-phenyl-1-(p-tolyl)-1H-pyrazole-4-carbonitrile (3aj) Yield 71%

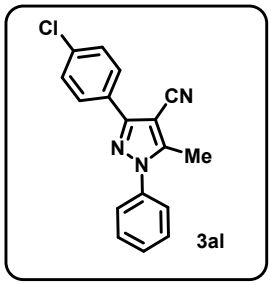


White solid. **M. P.:** 159-161 ˚C; **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 7.98 (dd, J = 6.7 Hz, 1.9 Hz, 2H), 7.62 (dd, J = 6.7 Hz, 1.9 Hz, 2H), 7.44-7.35 (m, 5H), 7.20-7.15 (m, 4H), 2.37 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)**: δ 152.2, 149.5, 139.0, 136.3, 132.2, 130.2, 129.9, 129.3, 129.1, 128.4, 126.9, 125.2, 123.9, 115.1, 91.2, 21.3; **HRMS (ESI)**: calcd for $C_{23}H_{17}BrN_3[2M+H]^+$ 416.0585, found 416.0586.

methyl 4-(4-cyano-5-phenyl-1-(p-tolyl)-1H-pyrazol-3-yl)benzoate (3ak): Yield, 67%



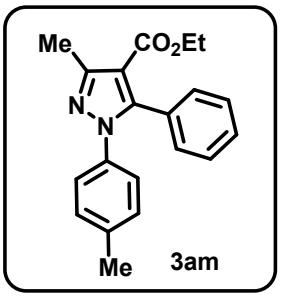
Light yellow solid; **M. P.:** 154-156 ˚C; **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 8.20-8.14 (m, 4H), 7.45-7.37 (m, 5H), 7.21-7.16 (m, 4H), 3.95 (s, 3H), 2.38 (s, 3H); **^{13}C NMR (100 MHz, $CDCl_3$)**: δ 166.8, 152.1, 149.6, 139.1, 136.2, 134.9, 133.8, 130.9, 130.3, 130.3, 129.9, 129.3, 129.1, 128.6, 126.9, 126.8, 125.2, 115.0, 91.6, 52.4, 21.3; **HRMS(ESI)**: calcd for $C_{25}H_{20}N_3O_2$ $[M+H]^+$ 394.1556, found 394.1544.



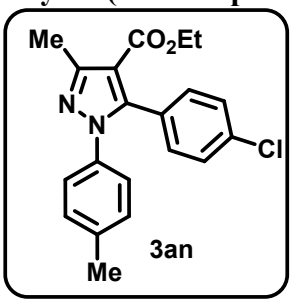
3-(4-chlorophenyl)-5-methyl-1-phenyl-1H-pyrazole-4-carbonitrile (3al): Yield, 81% Light yellow solid; **M. P.:** 147-149

˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.98 (dd, J = 6.6 Hz, 2.0 Hz, 2H), 7.55-7.47 (m, 5H), 7.44 (dd, J = 6.6 Hz, 2.0 Hz, 2H), 2.53 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)**: δ 151.5, 147.5, 138.3, 135.5, 129.7, 129.3, 129.3, 129.2, 128.0, 125.2, 114.9, 91.4, 12.0; **HRMS(ESI)**: calcd for $C_{17}H_{13}ClN_3$ $[M+H]^+$ 294.0798, found 294.0798.

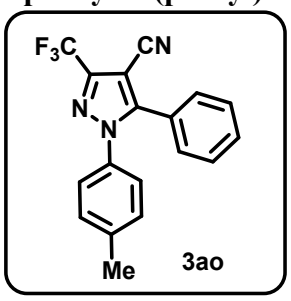
ethyl 3-methyl-1,5-diphenyl-1H-pyrazole-4-carboxylate (3am): Yield, 72% Light yellow solid; **M. P.:** 102-104 ˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.34-7.28 (m, 3H), 7.25-7.22 (m, 2H), 7.04 (m, 4H), 4.14 (q, J = 7.1 Hz, 2H), 2.59 (s, 3H), 2.29 (s, 3H), 1.12 (t, J = 7.1, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)**: δ 164.0, 151.7, 146.3, 137.6, 136.8, 130.5, 130.1, 129.4, 128.8, 127.9, 125.2, 111.8, 59.8, 21.1, 14.3, 14.0; **HRMS(ESI)**: calcd for $C_{20}H_{21}N_2O_2$$[M+H]^+$ 321.1603, found 321.1596.



ethyl 5-(4-chlorophenyl)-3-methyl-1-(p-tolyl)-1H-pyrazole-4-carboxylate (3an) : Yield, 69%; white solid; **M. P.:** 89-91 ˚C; **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 7.28 (d, J = 8.4 Hz, 2H), 7.17 (d, J = 8.3 Hz, 2H), 7.07-7.02 (m, 4H), 4.16 (q, J = 7.1 Hz, 2H), 2.57 (s, 3H), 2.30 (s, 3H), 1.16 (t, J = 7.1 Hz, 3H); **^{13}C NMR (100 MHz, $CDCl_3$)**: δ 163.8, 151.8, 145.1, 129.5, 128.9, 125.0, 114.3, 93.7, 12.6, 11.9; **HRMS (ESI)**: calcd for $C_{20}H_{20}ClN_2O_2$ $[M+H]^+$ 355.1208, found 355.1222.



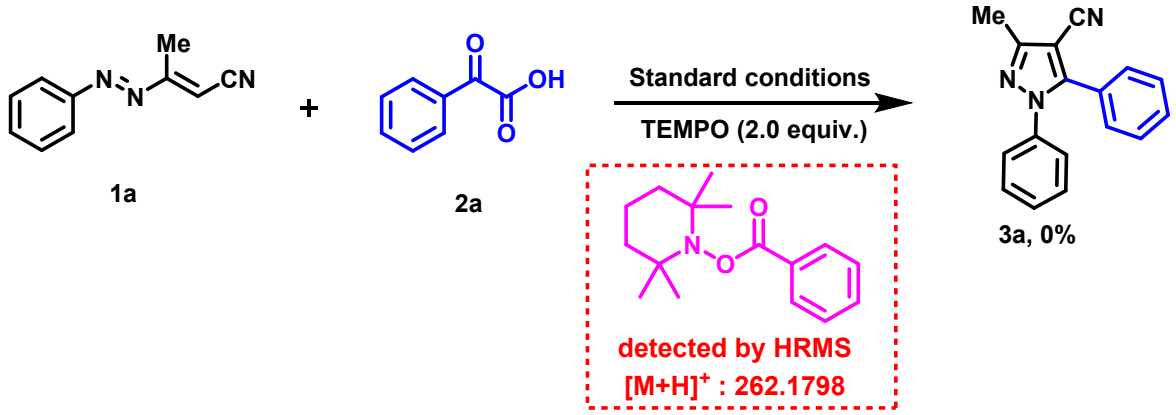
5-phenyl-1-(p-tolyl)-3-(trifluoromethyl)-1H-pyrazole-4-carbonitrile (3ao): Yield, 65% yellow solid; oily product; **^{1}H NMR (300 MHz, $CDCl_3$)**: δ 7.47-7.39 (m, 3H), 7.34 (dd, J = 7.9 Hz, 1.2 Hz, 2H), 7.20-7.13 (m, 4H), 2.38 (s, 3H); **^{13}C NMR (75 MHz, $CDCl_3$)**: 149.7, 144.4 (q, $J_{C\text{-}F}$ = 39.0 Hz), 140.0, 135.6, 130.8, 130.1, 130.0 (q, $J_{C\text{-}F}$= 272.0 Hz), 129.3 (d, $J_{C\text{-}F}$= 3.0 Hz), 125.8, 125.8, 125.2, 121.7, 118.3, 111.3, 92.0, 21.2; **^{19}F NMR (282 MHz, $CDCl_3$):** δ -62.3 (s); **HRMS (ESI)**: calcd for $C_{18}H_{13}F_3N_3$ $[M+H]^+$ 328.1062, found 328.1072.



5. Radical Trapping Experiments:

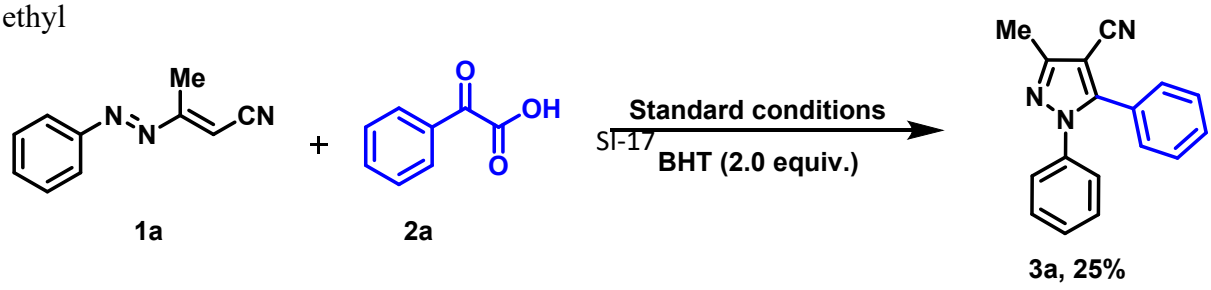
5.1. With TEMPO as a radical scavengers:

A solution of 1,2-Diaza-1,3-dienes (42.7 mg, 0.25 mmol), α-keto acids (75.0 mg, 0.50 mmol), ammonium persulfate (171 mg, 3.0 equiv.), silver oxide (5.7 mg, 0.10 mmol) and TEMPO (2.0 equiv.) in CH_3CN/H_2O (3:1) was taken in a sealed tube vial. Then, the vial was degassed with nitrogen for 5 min. and the resulting mixture was stirred in a preheated oil bath at 90 °C for 4 h. After completion of the reaction (monitored by TLC) the reaction mixture was cooled down to room temperature. The resulting mixture was extracted with ethyl acetate (3 × 15 mL) in water and organic phase was dried over anhydrous Na_2SO_4. The organic layer was concentrated in *vacuo* and crude product was purified by silica gel column chromatography to afford the product.



5.2. With BHT as a scavengers:

A solution of 1,2-Diaza-1,3-dienes (42.7 mg, 0.25 mmol), α-keto acids (75.0 mg, 0.50 mmol), ammonium persulfate (171 mg, 3.0 equiv.), silver oxide (5.7 mg, 0.10 mmol) and BHT (2.0 equiv.) in CH_3CN/H_2O (3:1) was taken in a sealed tube vial. Then, the vial was degassed with nitrogen for 5 min. and the resulting mixture was stirred in a preheated oil bath at 90 °C for 4 h. After completion of the reaction (monitored by TLC) the reaction mixture was cooled down to room temperature. The resulting mixture was extracted with ethyl

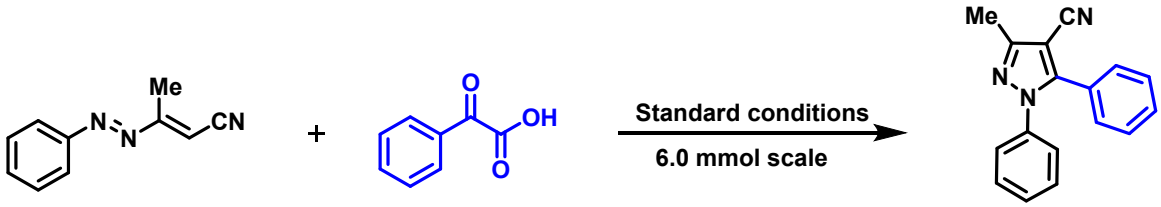


acetate (3 × 15 mL) in water and organic phase was dried over anhydrous Na_2SO_4.

The organic layer was concentrated in *vacuo* and crude product was purified by silica gel column chromatography to give the desired product **3a** in 25% yield.

6. Gram-scale experiments

To a solution of 1,2-Diaza-1,3-dienes (1.026 g, 6.0 mmol), phenyl glyoxylic acid (1.800 g, 12.0 mmol), ammonium persulfate (1.369 g, 3.0 equiv.) in CH_3CN/H_2O (3:1) and silver oxide (139.041 mg, 10 mol%) in a sealed tube vial was added. Then, the vial was degassed with nitrogen for 5 min. and the resulting mixture was stirred in a preheated oil bath at 90 °C for 4 h. After completion of the reaction (monitored by TLC) the reaction mixture was cooled down to room temperature. The resulting mixture was extracted with ethyl acetate (3 × 25 mL) in water and organic phase was dried over anhydrous Na_2SO_4. The organic layer was concentrated in *vacuo* and crude product was purified by silica gel column chromatography (100-200 mesh) by using ethyl acetate/hexane solvent system to give the desired product.



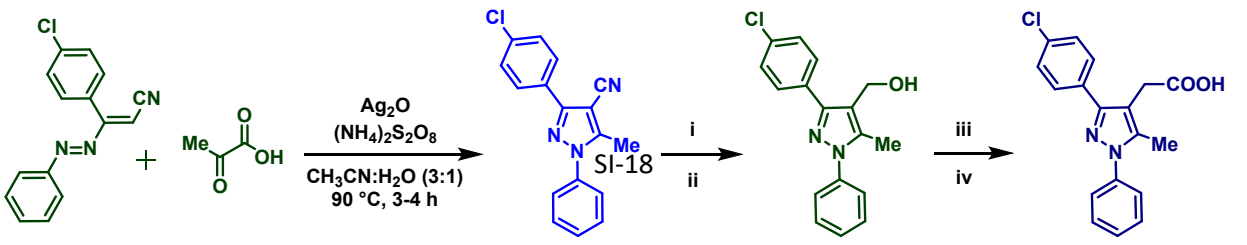
1a
1.026 g

2a
1.800 g

3a, 84% yield
1.306 g

7. Synthetic Utility

7.1. Synthesis of Lonazolac Derivatives:



1al **2o**

3al
yield 81%

4
yield 68%

Lonazolac derivative (5)
yield 55%

Reagents and conditions: (i) H_2SO_4, H_2O, 110 °C, 4 h; (ii) $LiAlH_4$, THF, rt, 4 h; (iii) $SOCl_2$, toluene, 120 °C, 12 h; (iv) NaCN, DMF, DMSO, 80 °C .

7.1.1. General procedure for the synthesis of cyano-pyrazoles (3al):

To a solution of 1,2-Diaza-1,3-diene **1al** (66.75 mg, 0.25 mmol), pyruvic acid **2o** (44.0 mg, 0.50 mmol), ammonium persulfate (171 mg, 3.0 equiv.) in CH_3CN/H_2O (3:1) and silver oxide (5.7 mg, 0.10 mmol) in a sealed tube vial was added. Then, the vial was degassed with nitrogen for 5 min. and the resulting mixture was stirred in a preheated oil bath at 90 °C for 4 h. After completion of the reaction (monitored by TLC) the reaction mixture was cooled down to room temperature. The resulting mixture was extracted with ethyl acetate (3 × 15 mL) in water and organic phase was dried over anhydrous Na_2SO_4. The organic layer was concentrated in *vacuo* and crude product was purified by silica gel column chromatography (100-200 mesh) by using ethyl acetate/hexane solvent system to give the desired product **3al** in 81% yield.

7.1.2. General procedure for the synthesis of alcohol (4):

A mixture of (1.0 mmol) of cyano-pyrazole (3al) in (5 mL) of 50% H_2SO_4 was heated to 110 °C and stirred for 4 h till completion of reaction. Water (10 mL) was added and the mixture was partially neutralized with ammonia to pH 2-3. The mixture was maintained at 0 °C for overnight, the precipitate solid were filtered off, and dried in the air.

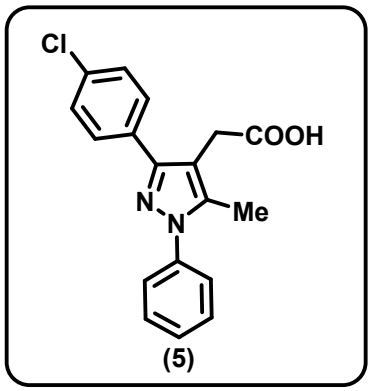
To an ice-cooled solution of obtained carboxylic acid (1.0 mmol) in dry THF (5 mL) was added $LiAlH_4$ (2.0 mmol) in portions, then the reaction was then stirred at room temperature for 4 h. After completion of the reaction, methanol (2 mL) was added and the solvent was evaporated on vacuum. H_2O (10 mL) was added slowly and the reaction mixture was extracted with EtOAc (2×10 mL), and dried over $MgSO_4$ and evaporated under reduced pressure to give the crude alcohol (**4**).

7.1.3. General procedure for the synthesis of Lonazolac Derivatives (5):

To an ice-cooled solution of (1.0 mmol) of pyrazole-alcohol (**4**) in dry toluene (5 mL) was added thionyl chloride (10 mmol) dropwise over 25 min. The reaction was stirred at 120 °C for 12 h and evaporated under reduced pressure to give the crude chloride as brown solid.

A mixture of (1.2 mmol) of sodium cyanide was placed in (25 mL) two-neck flask. (10 mL) of dimethyl sulfoxide was used as solvent and stirred at 80 °C to complete dissolved . After 30 min. a solution of obtained (1.0 mmol) pyrazole-chloride in N,N dimethylformamide was added dropwise, and further stirred the reaction for 3 h. After completion, the reaction was poured in water, extracted with EtOAc (3×5 mL), dried over anhydrous Na_2SO_4 and evaporated under reduced pressure to give the cyano pyrazole which was further purified by column chromatography. A mixture of the obtained cyano-derivative (1.0 mmol) in (5 mL) of 50% H_2SO_4 was heated to 110 °C and stirred for 4 h till completion of reaction. Water (10 ml) was added and the mixture was partially neutralized with ammonia to pH 2-3. The mixture was maintained at 0 °C for overnight, the precipitate solid were filtered off, and dried in the air. The crude product was purified by silica gel column chromatography (100-200 mesh) by using ethyl acetate/hexane solvent system to give the desired lonazolac derivative (**5**) in 55% yield.

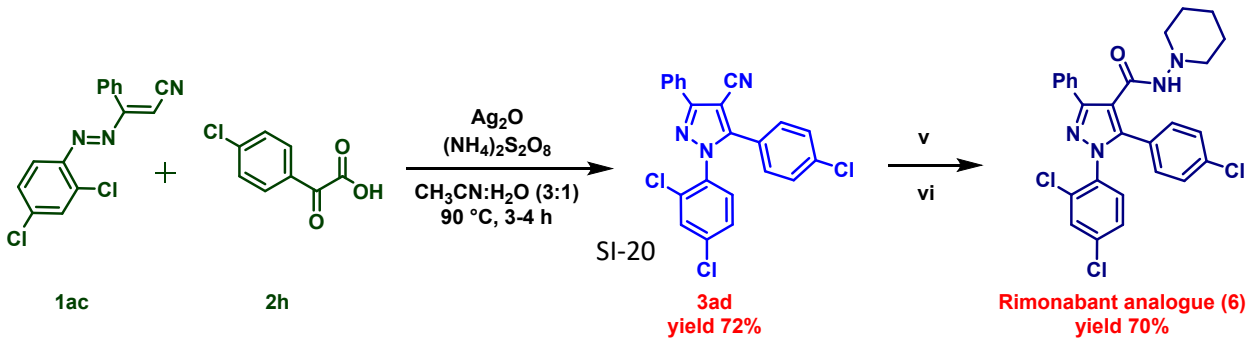
2-(3-(4-chlorophenyl)-5-methyl-1-phenyl-1H-pyrazol-4-yl)acetic acid (5): Yield, 55%



(5)

Light yellow solid; **M. P.:** 154-156 ˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.64 (d, J = 8.1 Hz, 2H), 7.48-7.45 (m, 4H), 7.40-7.38 (m, 3H), 3.57 (s, 2H), 2.32 (s, 3H); **^{13}C NMR (100 MHz, $CDCl_3$)**: δ 150.3, 139.7, 134.0, 131.8, 129.5, 129.2, 128.9, 128.0, 125.3, 29.8, 11.3; **HRMS(ESI)**: calcd for $C_{18}H_{16}ClN_2O_2$ $[M+H]^+$ 327.0895, found 327.0891.

7.2. Synthesis of Rimonabant Analogue



1ac 2h 3ad
yield 72%
Rimonabant analogue (6)
yield 70%

Reagents and conditions: (i) H_2SO_4, H_2O, 100 °C, overnight; (ii) 1-aminopiperidine, DIPEA, EDC, HOBt, CH_2Cl_2, 25 °C, 12 h.

7.2.1. General procedure for the synthesis of cyano-pyrazoles (3ad):

To a solution of 1,2-Diaza-1,3-diene **1ac** (75.28 mg, 0.25 mmol), 4-chlorophenylglyoxalic acid **2h** (92.28 mg, 0.50 mmol), ammonium persulfate (171 mg, 3.0 equiv.) in CH_3CN/H_2O (3:1) and silver oxide (5.7 mg, 0.10 mmol) in a sealed tube vial was added. Then, the vial was degassed with nitrogen for 5 min. and the resulting mixture was stirred in a preheated oil bath at 90 °C for 4 h. After completion of the reaction (monitored by TLC) the reaction mixture was cooled down to room temperature. The resulting mixture was extracted with ethyl acetate (3 × 15 mL) in water and organic phase was dried over anhydrous Na_2SO_4. The organic layer was concentrated in *vacuo* and crude product was purified by silica gel column chromatography (100-200 mesh) by using ethyl acetate/hexane solvent system to give the desired product **3ad** in 72% yield.

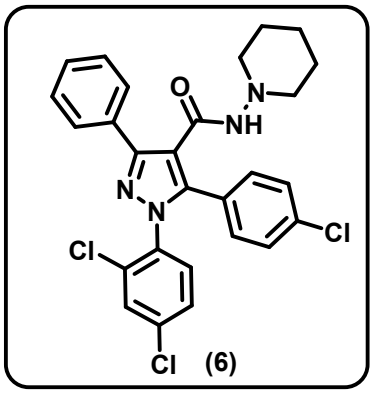
7.2.2. General procedure for the synthesis of Rimonabant Analogue (6):

A mixture of (1.0 mmol) of cyano-pyrazole **(3ad)** in (5 mL) of 50% H_2SO_4 was heated to 110 °C and stirred for 4 h till completion of reaction. Water (10 mL) was added and the mixture was partially neutralized with ammonia to pH 2-3. The mixture was maintained at 0 °C for overnight, the precipitate solid were filtered off, and dried in the air.

A solution of the obtained carboxylic acid (1.0 mmol) dissolved in dry dichloromethane (10 mL) was cooled to 0 °C and hydroxybenztriazole (HOBt, 1.5 mmol) was added and stirred for 5 min. To this solution, EDC (1.5 mmol) was added and continue stirring for 15 min. followed by the addition of 1-aminopiperidine (1.0 mmol), and DIPEA (2.0 equiv.) and the reaction was further stirred for 12 h. The reaction was quenched with saturated aqueous solution of NH_4Cl (5 mL), and 10 mL water was added. The resulting mixture was extracted with DCM (3 × 15 mL) and organic phase was dried over anhydrous Na_2SO_4. The organic layer was concentrated in *vacuo* and crude product was purified by silica gel column

chromatography (100-200 mesh) by using ethyl acetate/hexane solvent system to give the desired Rimonabant Analogue **(6)** in 70% yield.

5-(4-chlorophenyl)-1-(2,4-dichlorophenyl)-3-phenyl-N-(piperidin-1-yl)-1H-pyrazole-4-carboxamide (6): Yield, 70% white solid; **M. P.:** 248-251 ˚C; **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.82 (dd, J = 8.0 Hz, 1.7 Hz, 2H), 7.45-7.40 (m, 4H), 7.29 (d, J = 1.1 Hz, 2H), 7.27 (s, 3H), 7.26-7.25 (m, 1H), 6.24 (br s, 1H), 2.55 (m, 4H), 1.67-1.63 (m, 6H); **^{13}C NMR (125 MHz, $CDCl_3$)**: δ 161.5, 150.9, 144.5, 136.1, 136.7, 133.2, 131.6, 130.9, 130.8, 130.5, 130.5, 129.0, 128.9, 128.7, 128.0, 127.7, 126.5, 114.8, 57.7, 56.6, 25.5, 25.2, 23.2; **HRMS(ESI)**: calcd for $C_{27}H_{24}Cl_3N_4O$ $[M+H]^+$ 527.0986, found 527.1809.



8. X-ray crystal structure of compound 3a:

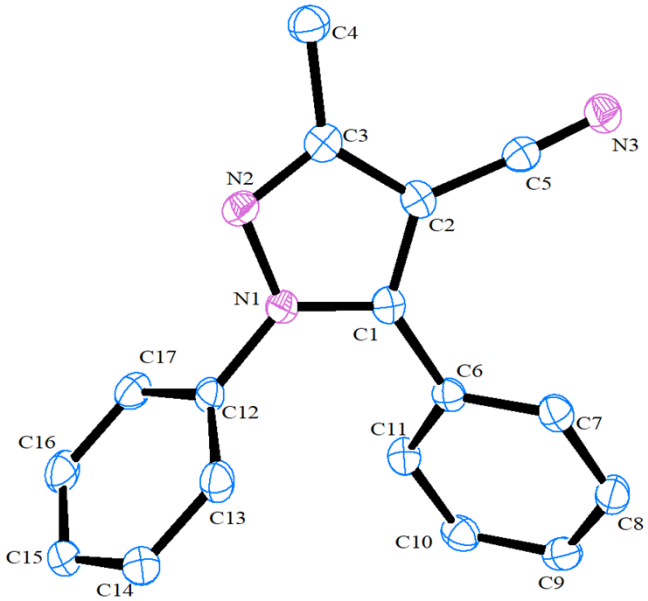


Figure 1: ORTEP diagram of **3a** with 50% ellipsoid probability, hydrogen atom were omitted for clarity.

Crystallization: Crystals of compound **3a** were grown from the solvent ethyl acetate/hexane by slow evaporation method.

X-Ray Data Collection and Structure Refinement Details:

The single crystal of **3a** suitable for Single-crystal X-ray differaction was collected at 100 K on a Bruker SMART APEX2,[1a] software suite CCD diffractometer using graphite monochromated MoK_α radiation (λ = 0.71073 Å). The structure was solved by the intrinsic phasing (SHELXT/XT) method, and refined was using *SHELXTL-2015*[1b] installed in the Olex2[1c] software suite. The non-hydrogen atoms were refined anisotropically, whereas the H atoms fixed to their geometrically ideal positions were refined isotropically. The PLATON program was applied for the validation of refinement.[1d]

1. (a) Bruker (**2005**). *APEX2*. Version 5.053. Bruker AXS Inc., Madison, Wisconsin, USA. (b) Sheldrick, G. M. SHELXT –Integrated space-group and crystal structure determination, *Acta Cryst*. **2015**, *A71*, 3. (c) Dolomanov, O. V. Bourhis, L. J. Gildea, R. J. Howard, J. A. K. H. Puschmann, *J. Appl. Cryst*. **2009,** *42,* 339. (d) Spek, A. L. (**2005**) PLATON, *A Multipurpose Crystallographic Tool*, Utrecht University, Utrecht, The Netherlands
2. Supplementary:

Table 1 Crystal data and structure refinement for **3a**.

Identification code	3a
Empirical formula	$C_{17}H_{13}N_3$
Formula weight	259.30
Temperature/K	100 (2)
Crystal system	monoclinic
Space group	$P2_1/c$
a/Å	21.011(3)
b/Å	7.5421(9)
c/Å	18.744(2)
α/°	90
β/°	116.488(4)
γ/°	90
Volume/Å^3	2658.5(6)

Z	8
ρ_{calc}g/cm^3	1.296
μ/mm^{-1}	0.079
F(000)	1088.0
Crystal size/mm^3	0.2 × 0.18 × 0.16
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	5.82 to 50.094
Index ranges	-25 ≤ h ≤ 25, -8 ≤ k ≤ 8, -22 ≤ l ≤ 22
Reflections collected	30986
Independent reflections	4624 [R_{int} = 0.0454, R_{sigma} = 0.0243]
Data/restraints/parameters	4624/0/364
Goodness-of-fit on F^2	1.140
Final R indexes [I>=2σ (I)]	R_1 = 0.0465, wR_2 = 0.1008
Final R indexes [all data]	R_1 = 0.0483, wR_2 = 0.1018
Largest diff. peak/hole / e Å^{-3}	0.23/-0.21
CCDC No.	2092505

9. References:

[1] Kumar, A.; Katiyar, S.; Kumar Jaiswal, A.; Kant, R.; Sashidhara, K. V. PIDA-Mediated Oxidative Aromatic C-N Bond Cleavage: Efficient Methodology for the Synthesis of 1,2-Diaza-1,3-Dienes under Ambient Conditions. *Tetrahedron Letters* **2021**, *77*, 153252.

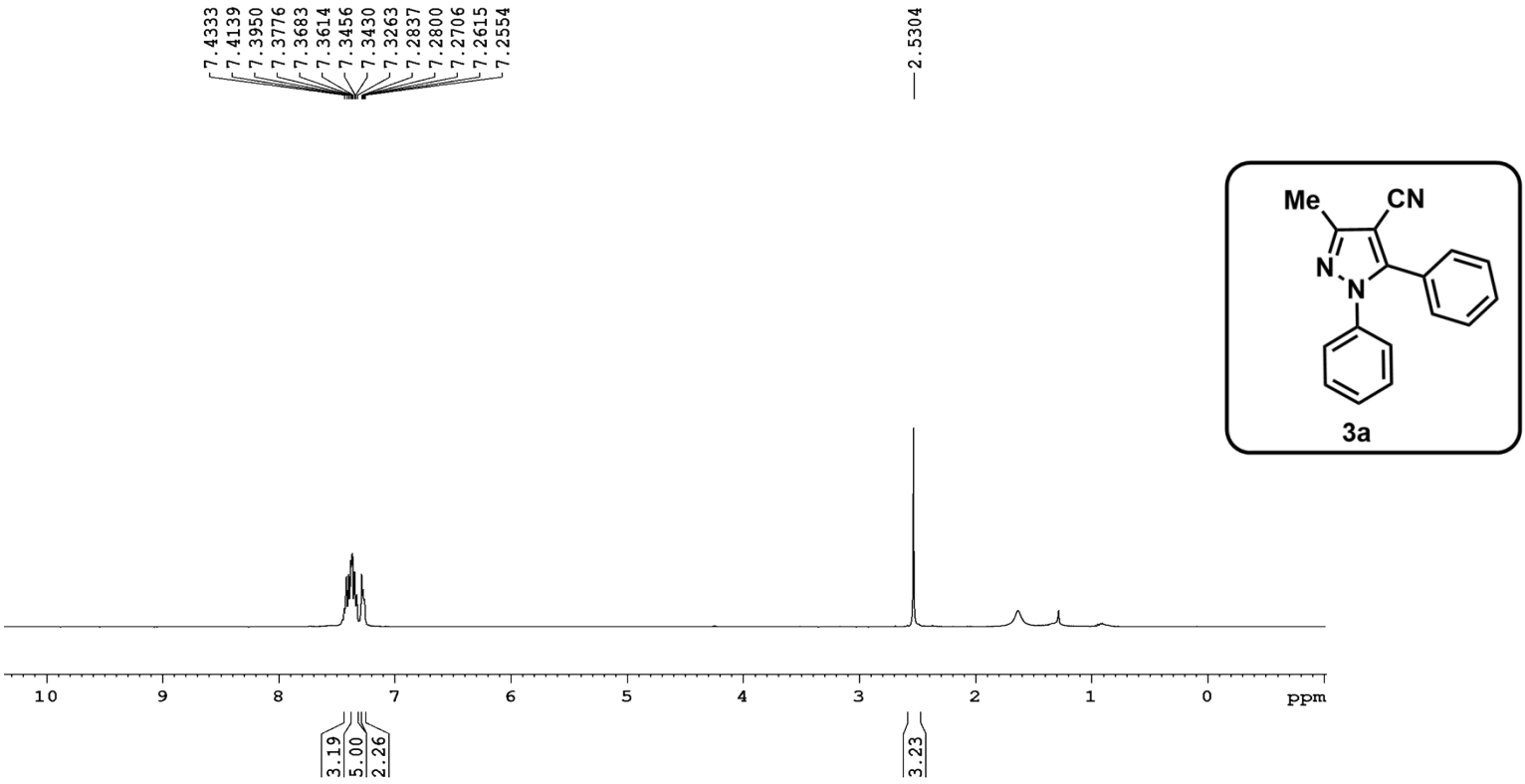
[2] Gilchrist, T L.; Sanchez Romero, O. A.; Wasson. R. C. *J. chem. Soc. Perkin Trans. I,* **1989**, 353.

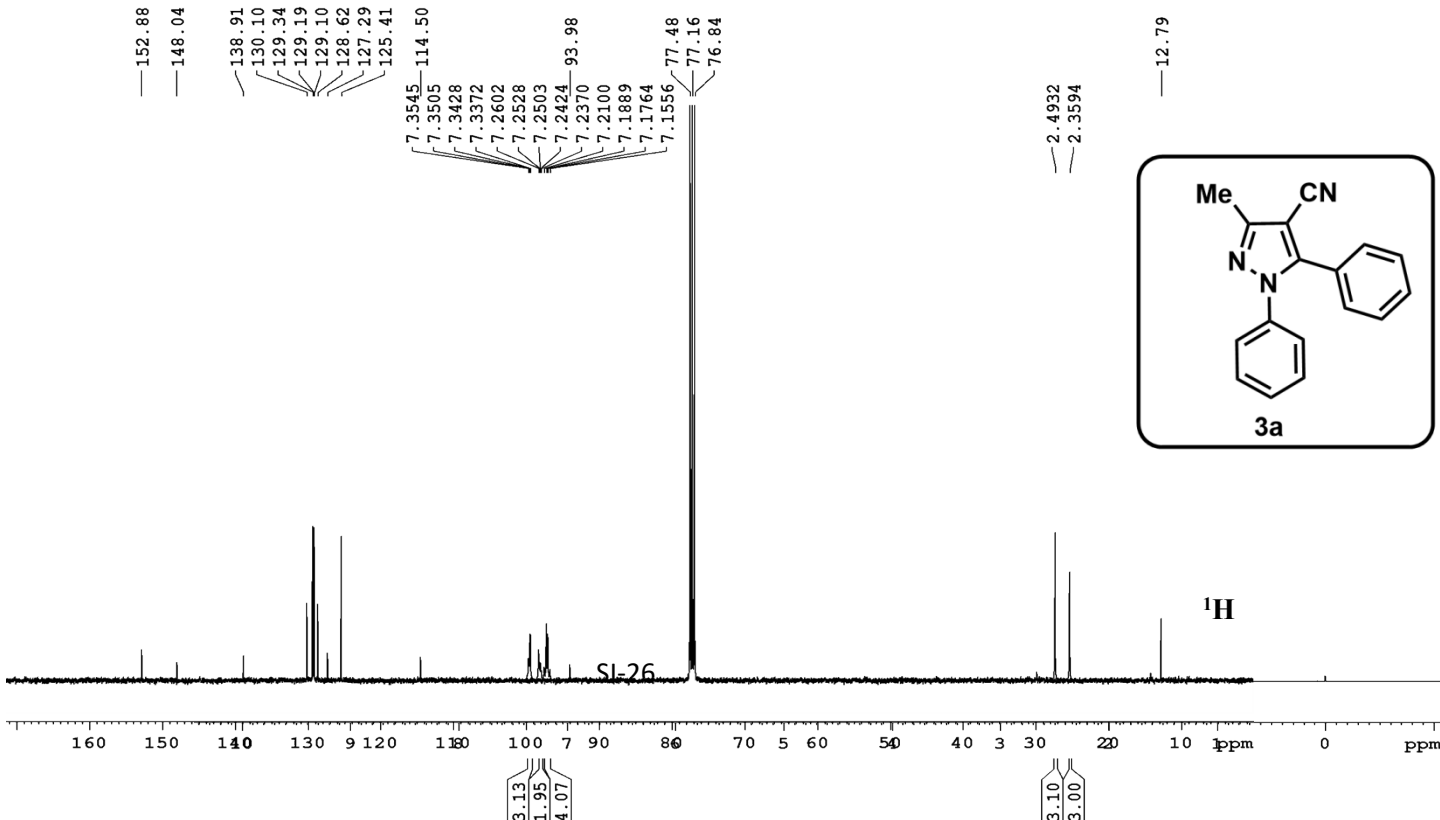
[3] Yang, N.; Zhang, H.; Yuan, G. KI-catalyzed reactions of aryl hydrazines with α-oxocarboxylic acids in the presence of CO_2: access to 1,3,4-oxadiazol-2(3H)-ones. *Org. Chem. Front*., **2019**, *6*, 532.

[4] Huang, H.; Zhang, G.; Chen, Y. Dual hypervalent Iodine(III) reagents and photoredox catalysis enable decarboxylative ynonylation under mild conditions. *Angew. Chem., Int. Ed.*, **2015**, *54*, 1.
[5] Zhu, Z.; Tang, X.; Li, J.; Li, X.; Wu, W.; Deng, G.; Jiang, H. *Chem. Commun*., **2017**, *53*, 3228.

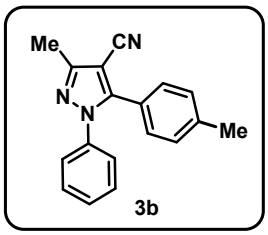
10. Spectral Data:

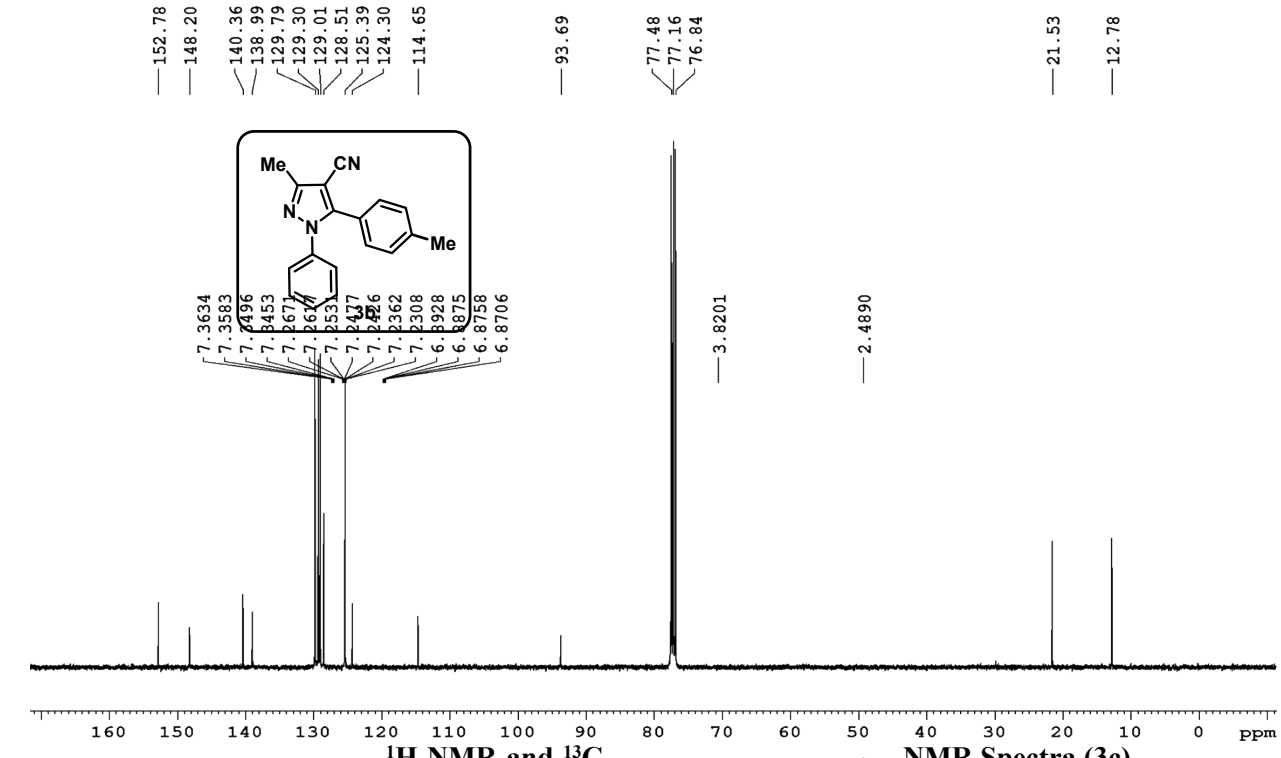
^{1}H NMR and ^{13}C NMR Spectra (3a)



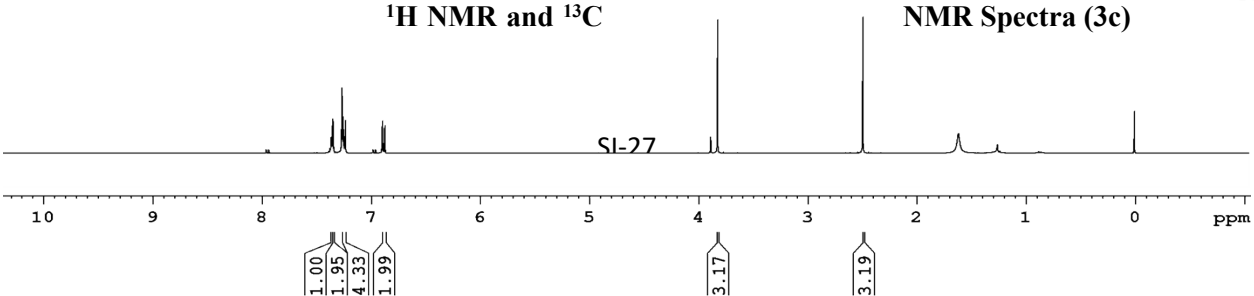


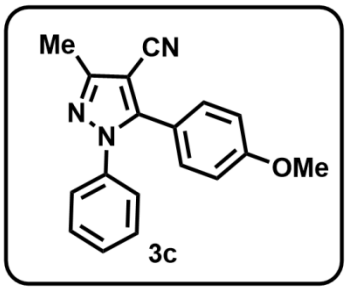
NMR and ^{13}C NMR Spectra (3b)

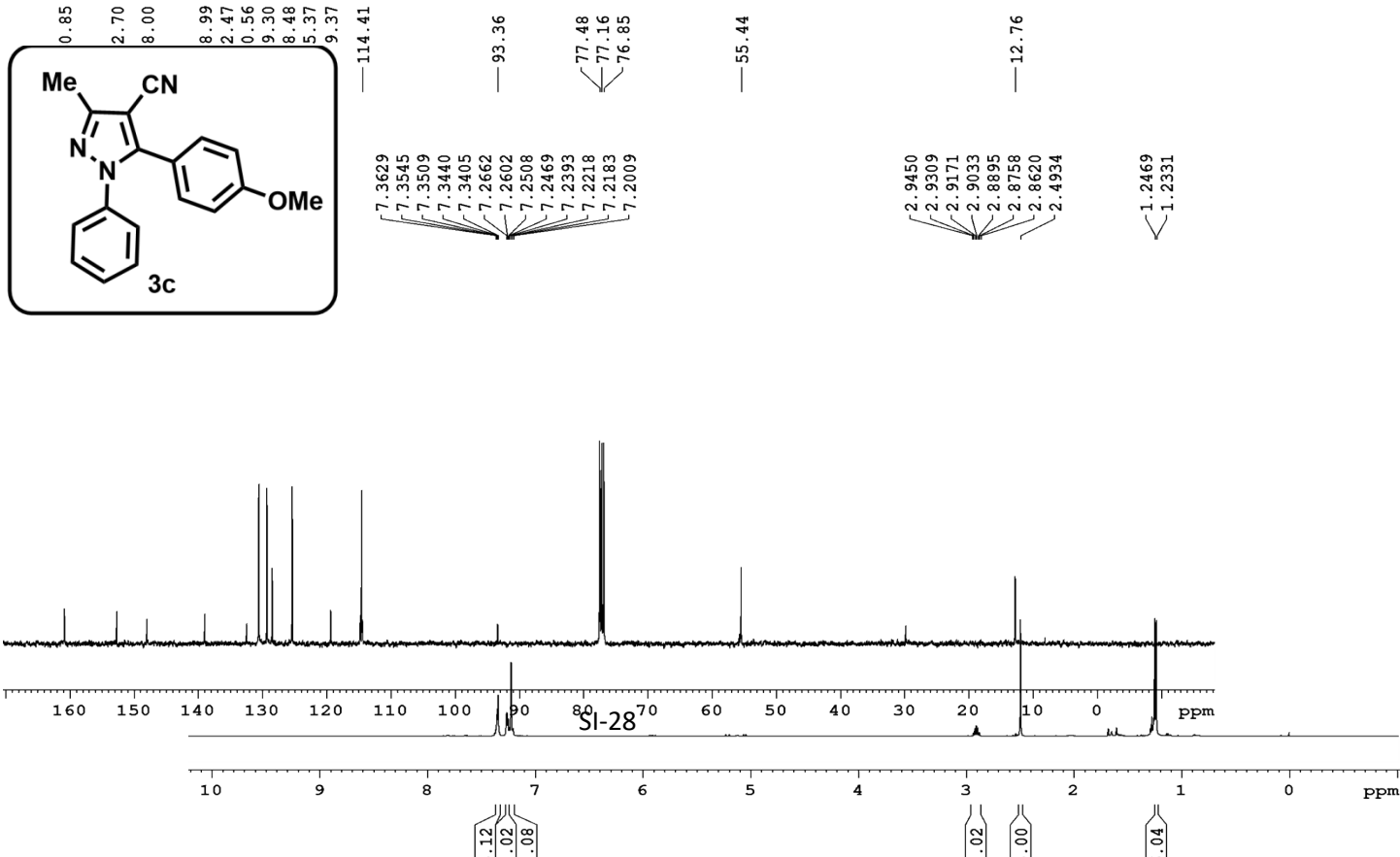


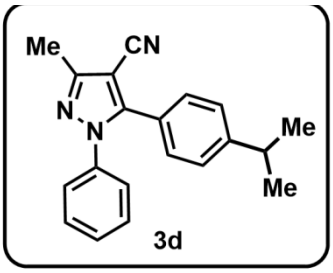


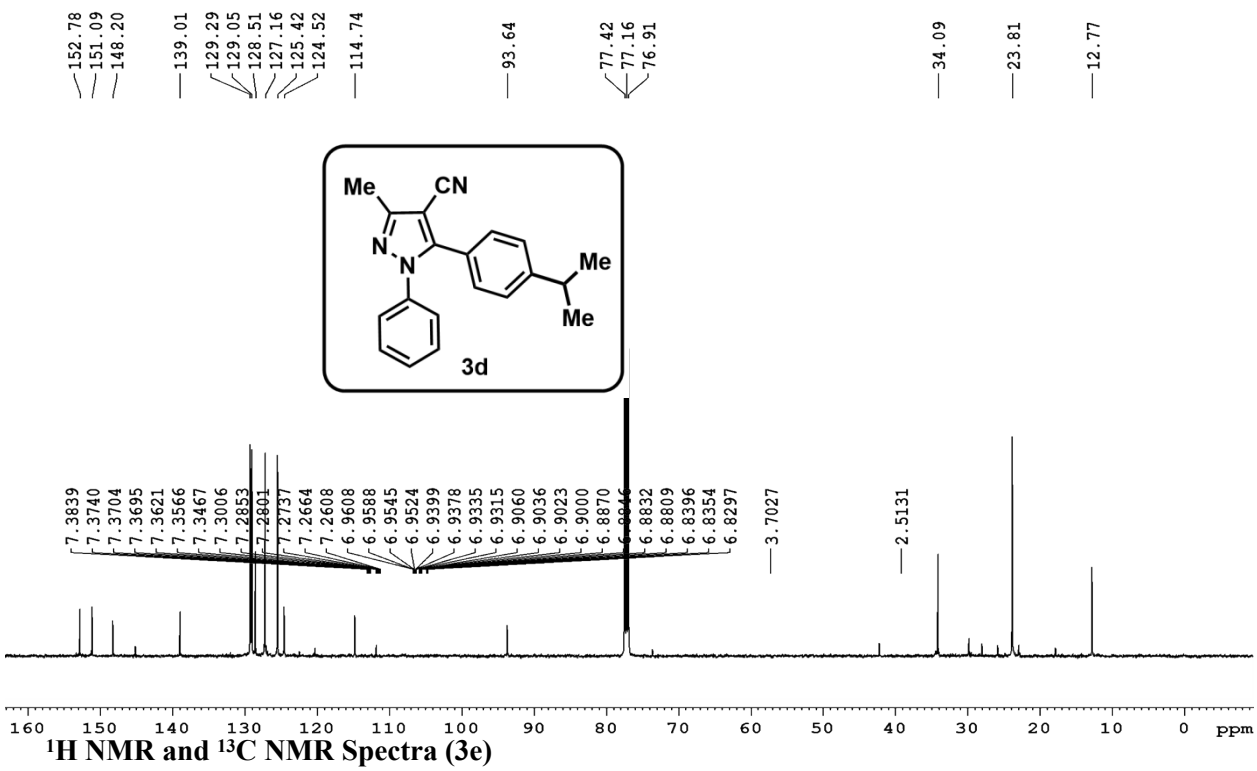
^{1}H NMR and ^{13}C NMR Spectra (3c)



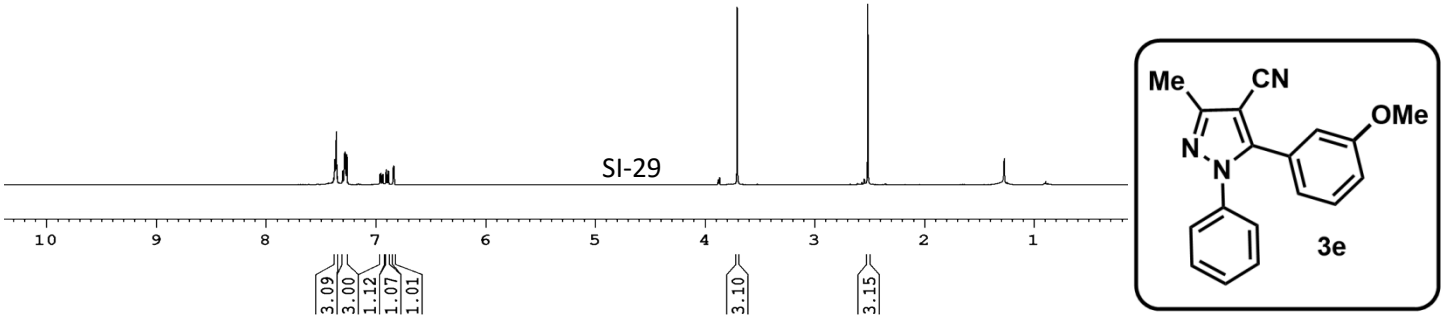

Me
CN
N
N
OMe
3c

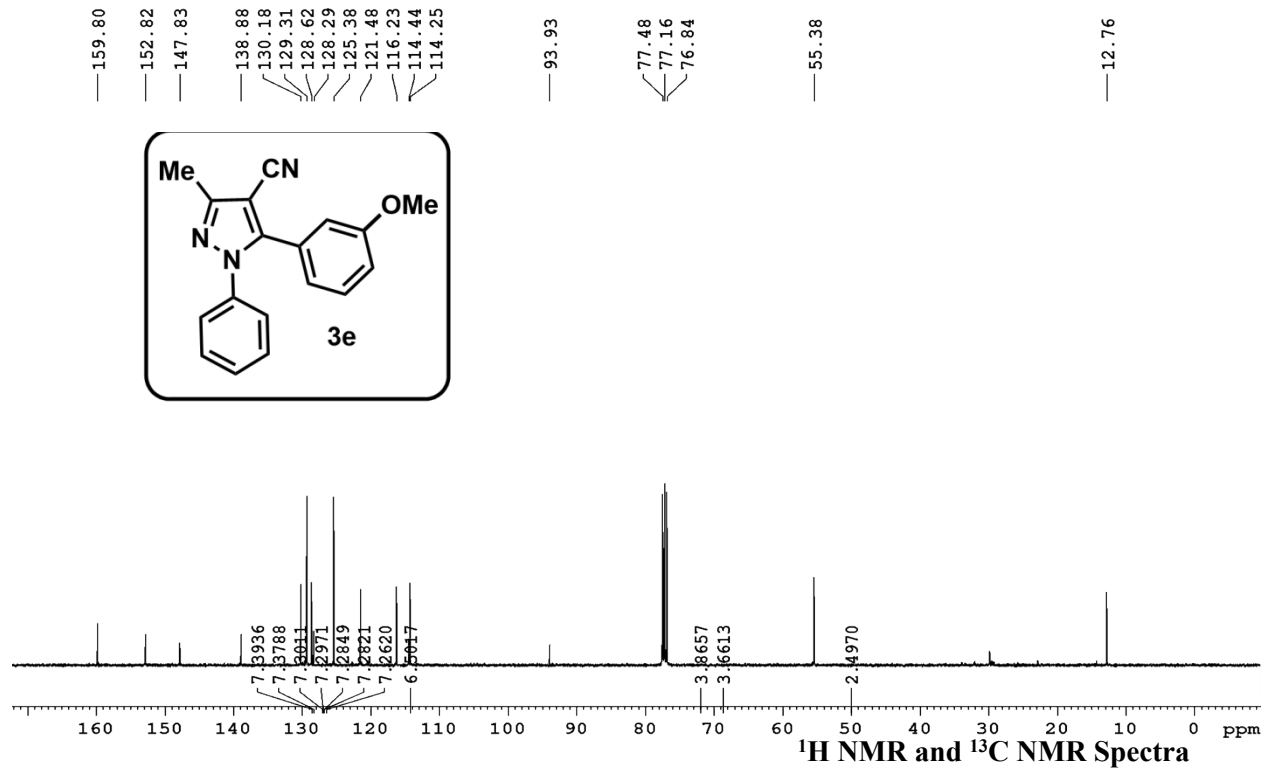

0.85
2.70
8.00
8.99
2.47
0.56
9.30
8.48
5.37
9.37
114.41
93.36
77.48
77.16
76.85
55.44
12.76
7.3629
7.3545
7.3509
7.3440
7.3405
7.2662
7.2602
7.2508
7.2469
7.2393
7.2218
7.2183
7.2009
2.9450
2.9309
2.9171
2.9033
2.8895
2.8758
2.8620
2.4934
1.2469
1.2331
Me
CN
N
N
OMe
3c
ppm
ppm
3.12
2.02
4.08
1.02
3.00
6.04





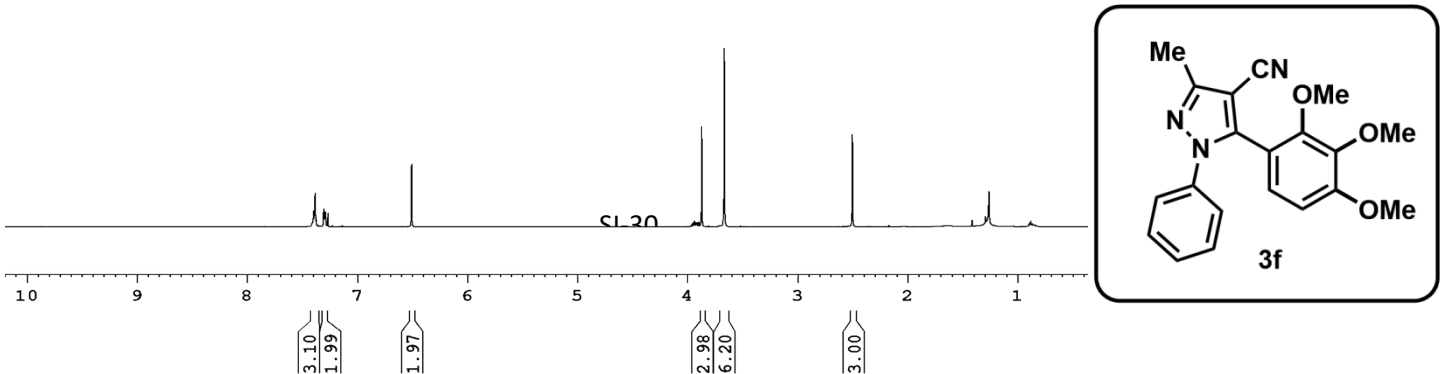
^{1}H NMR and ^{13}C NMR Spectra (3e)

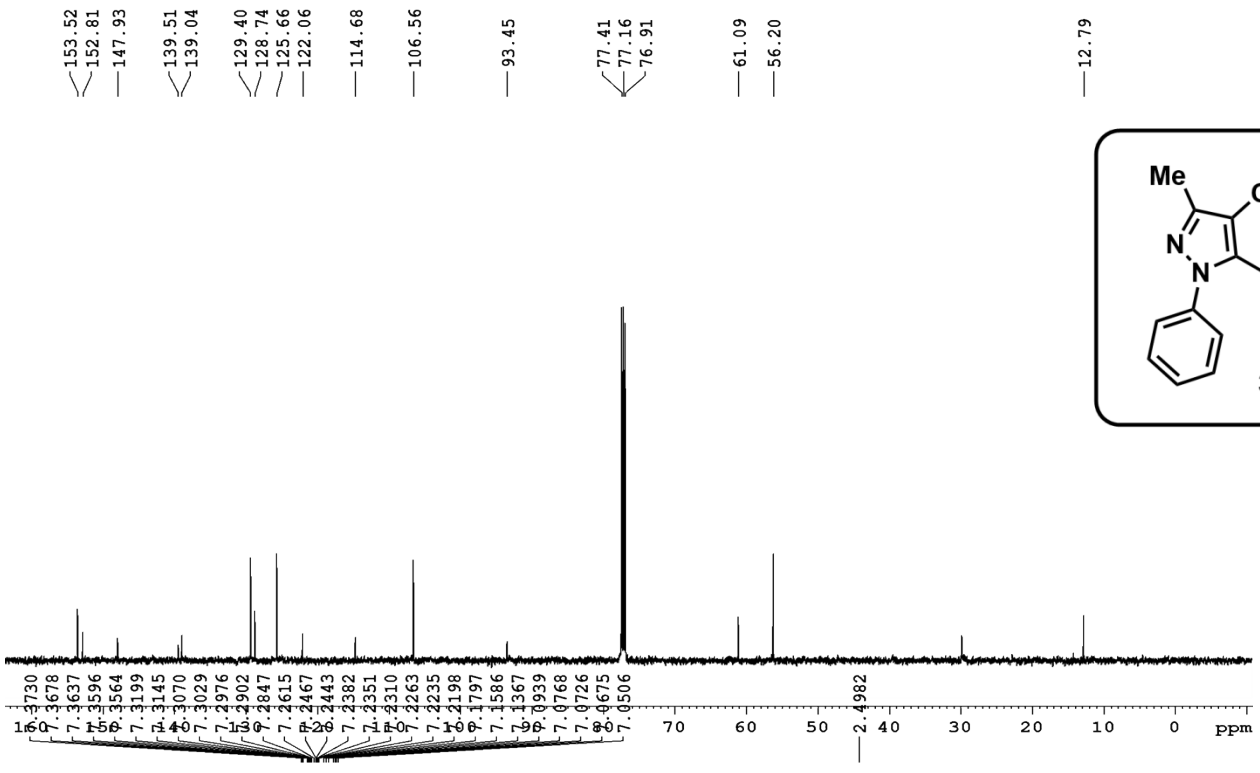




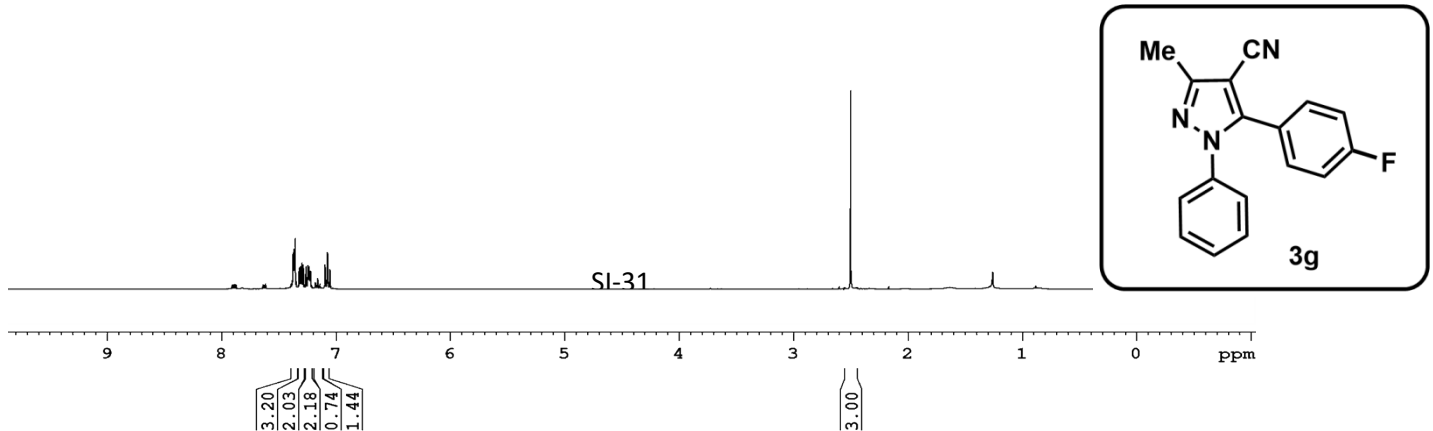
^{1}H NMR and ^{13}C NMR Spectra

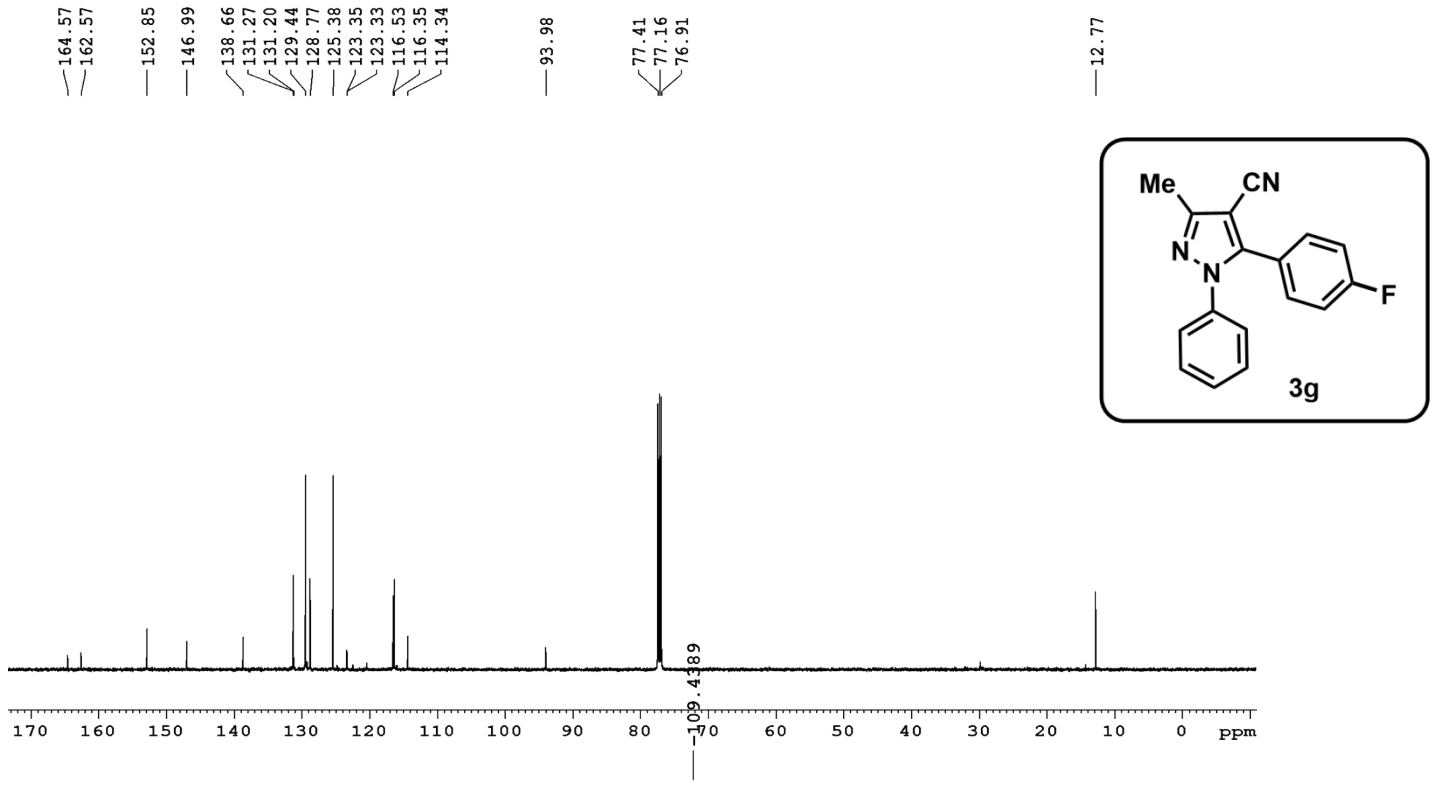
(3f)



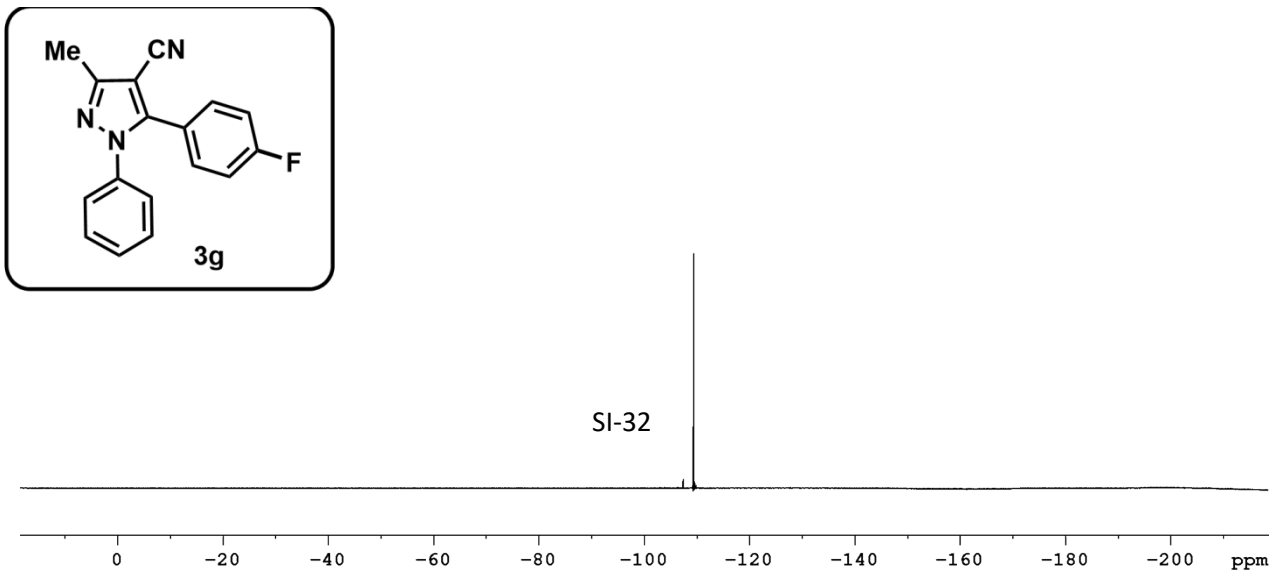


^{1}H NMR and ^{13}C NMR Spectra (3g)

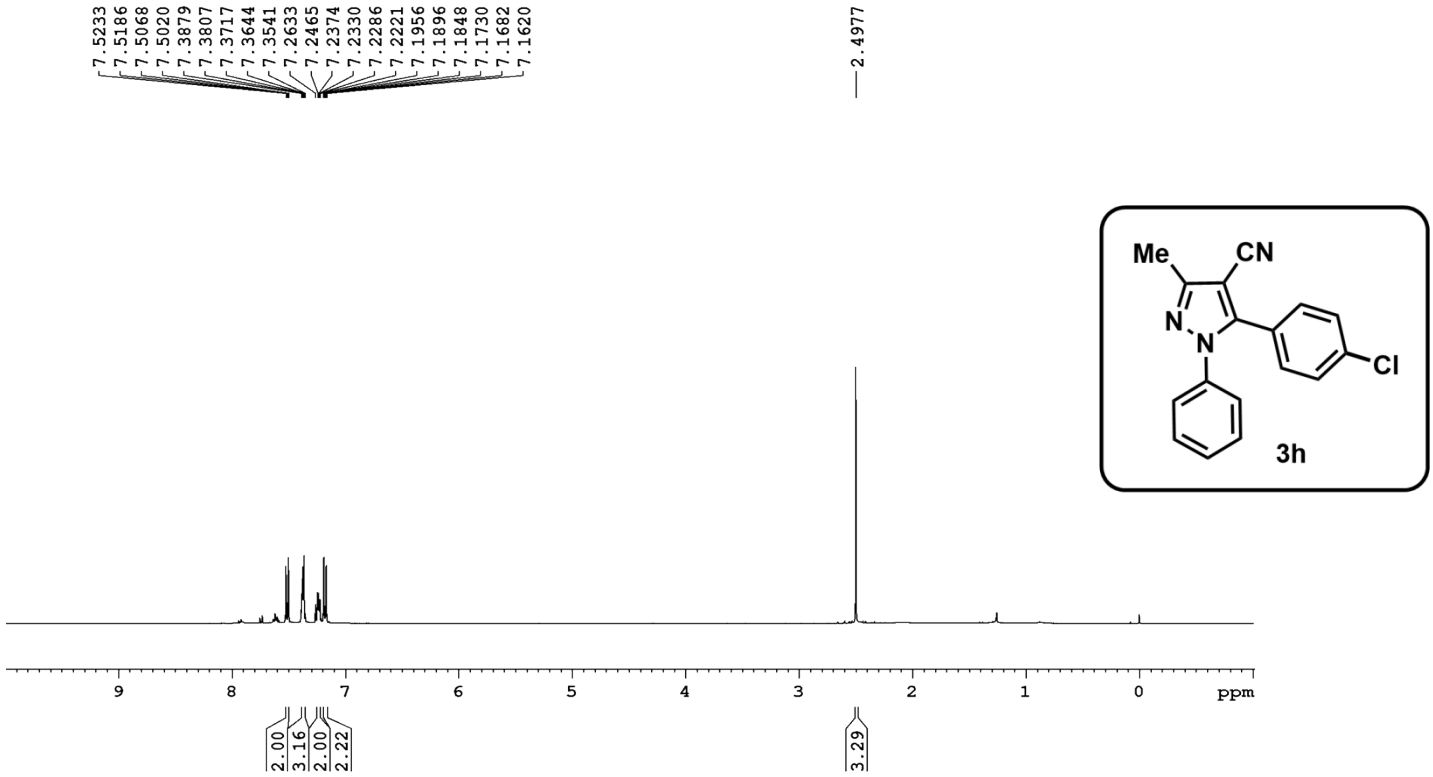


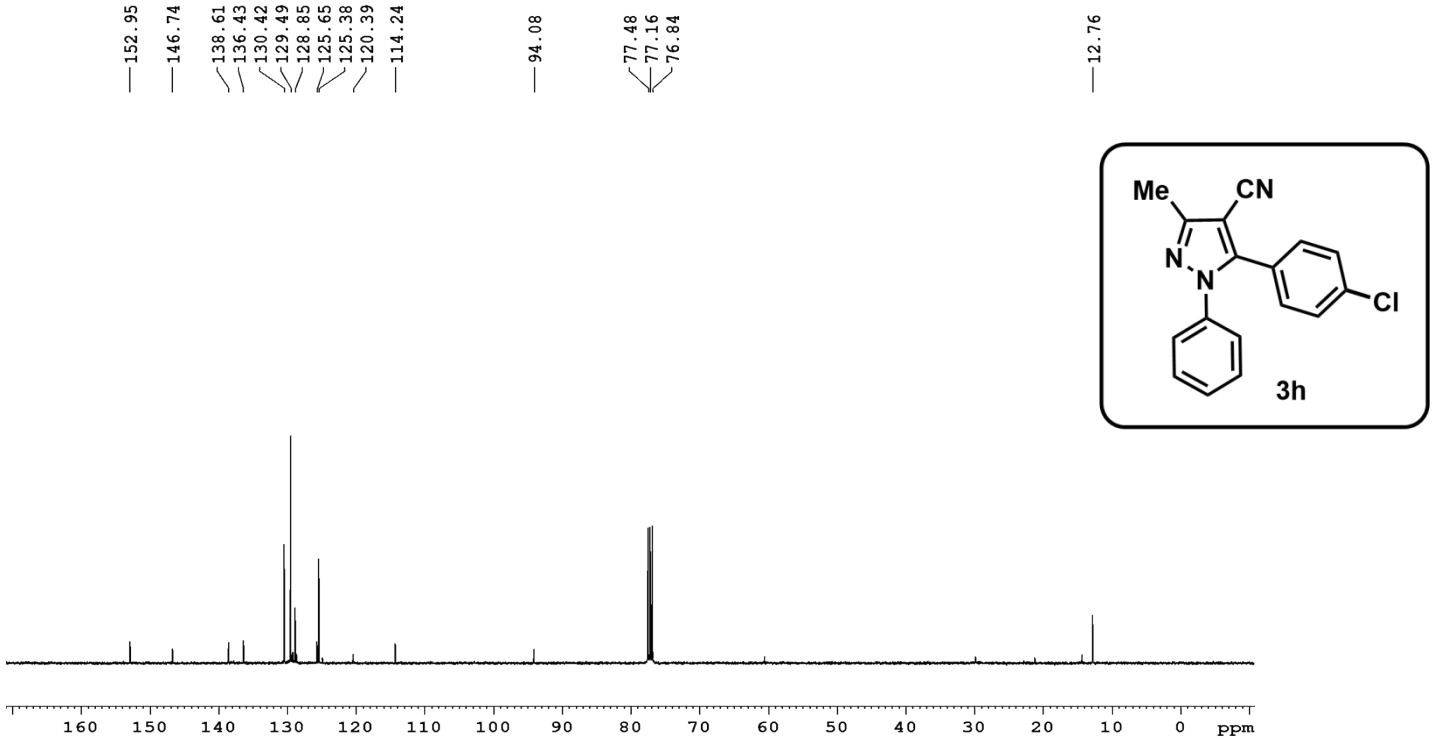


^{19}F NMR Spectra (3g)

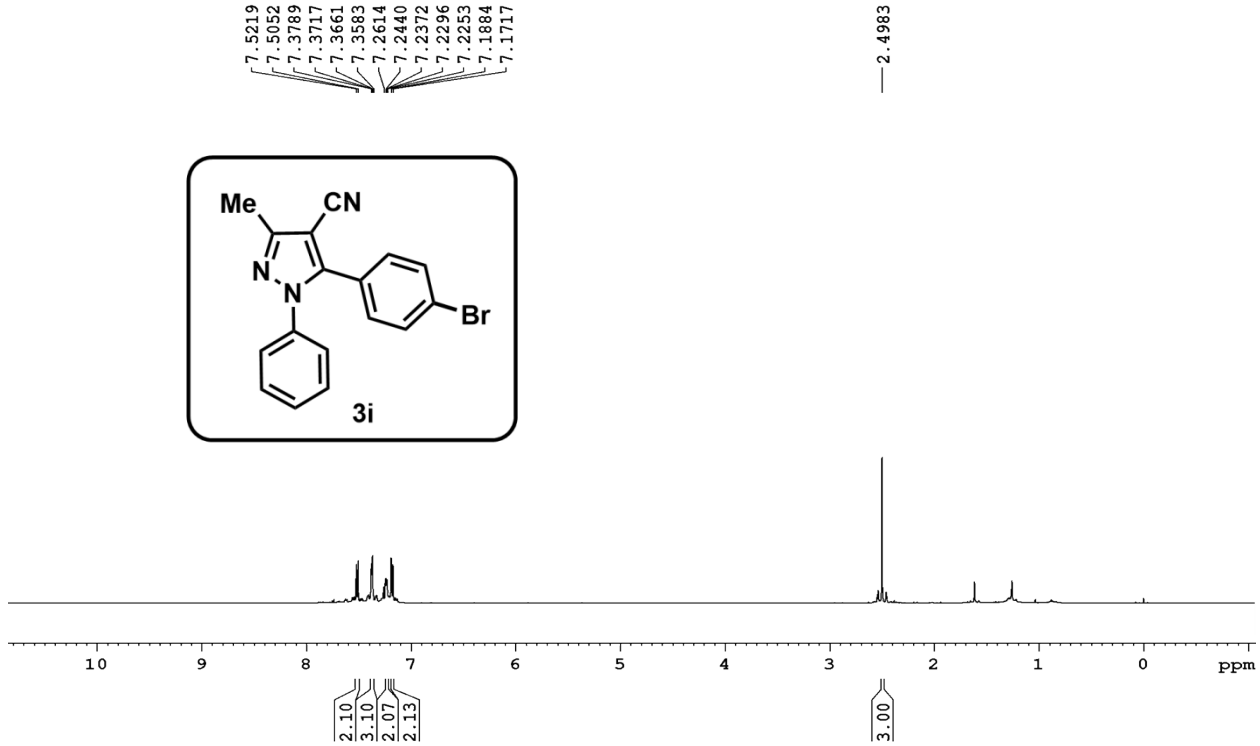


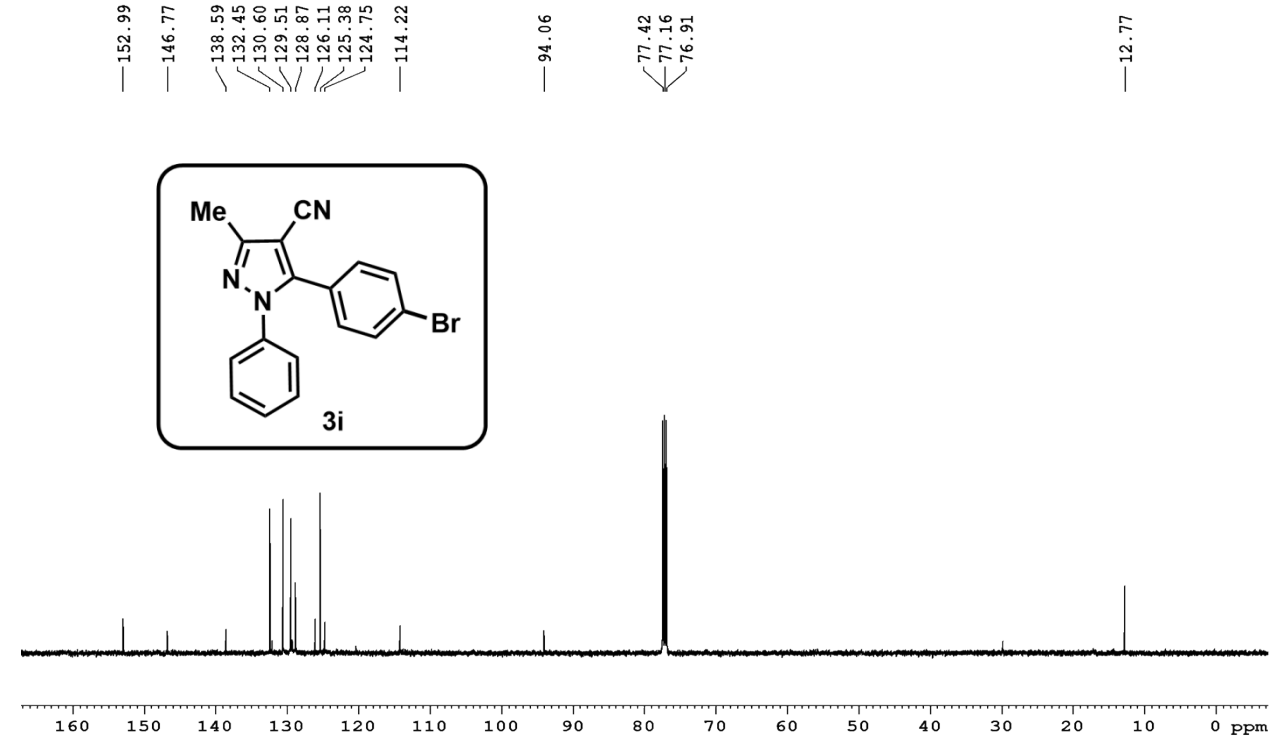
^{1}H NMR and ^{13}C NMR Spectra (3h)



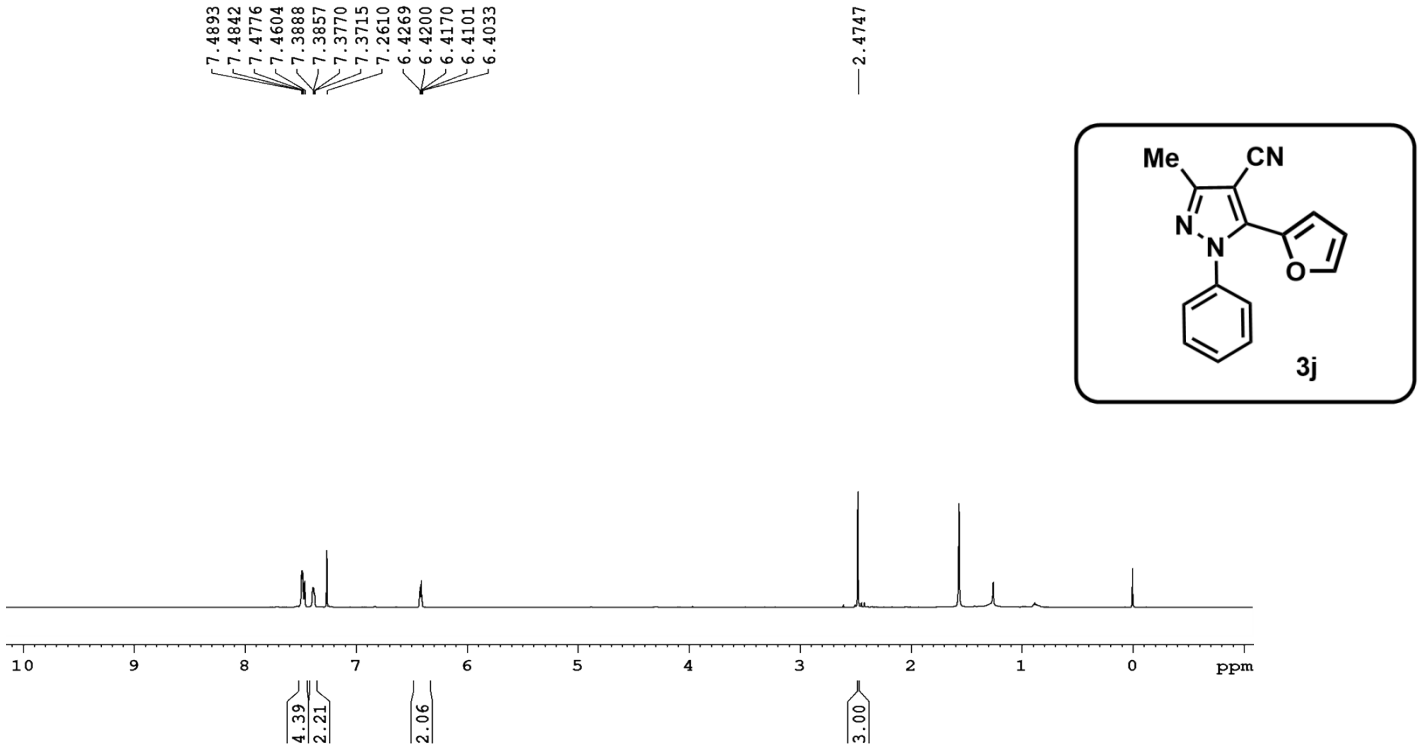


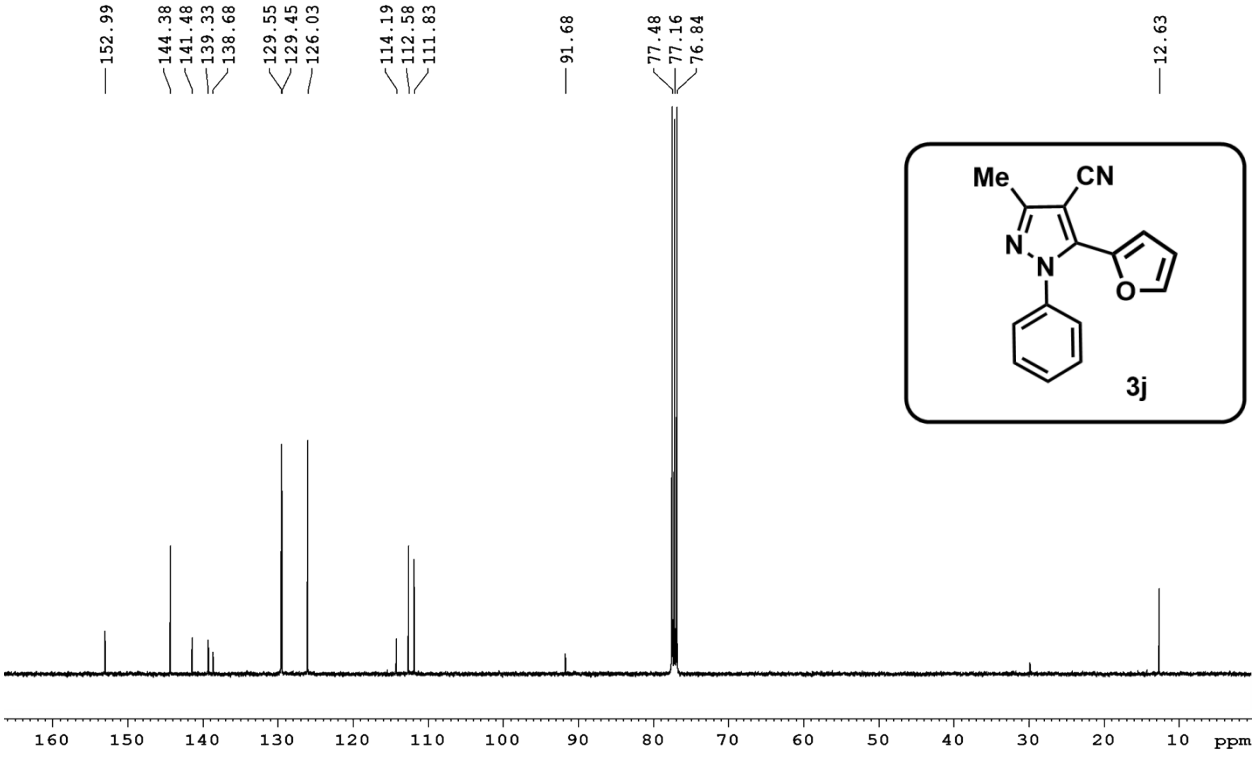
^{1}H NMR and ^{13}C NMR Spectra (3i)



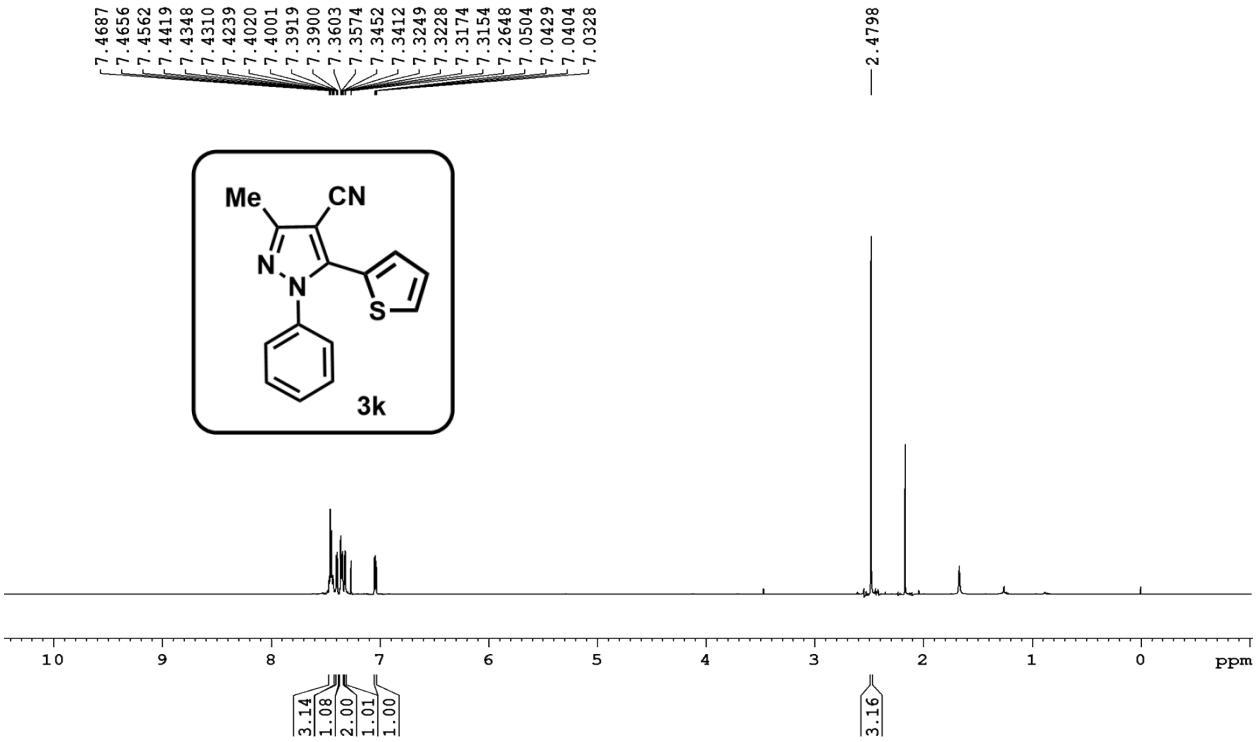


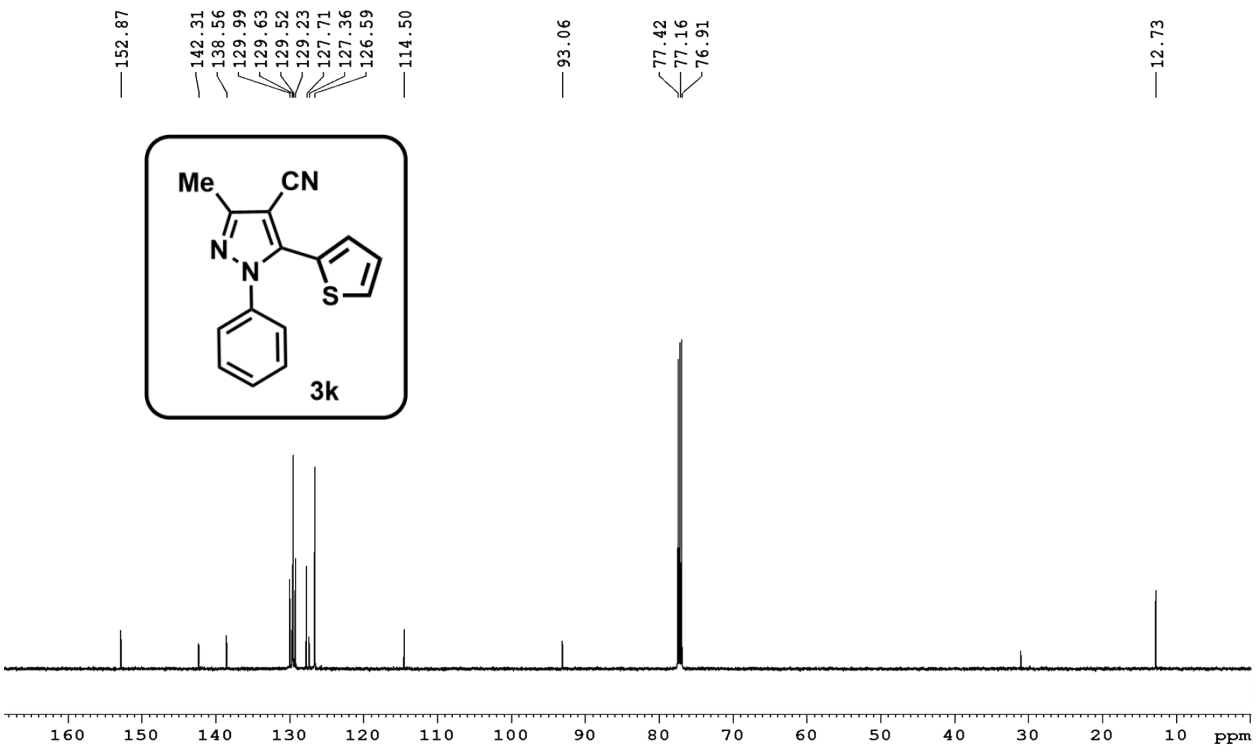
^{1}H NMR and ^{13}C NMR Spectra (3j)



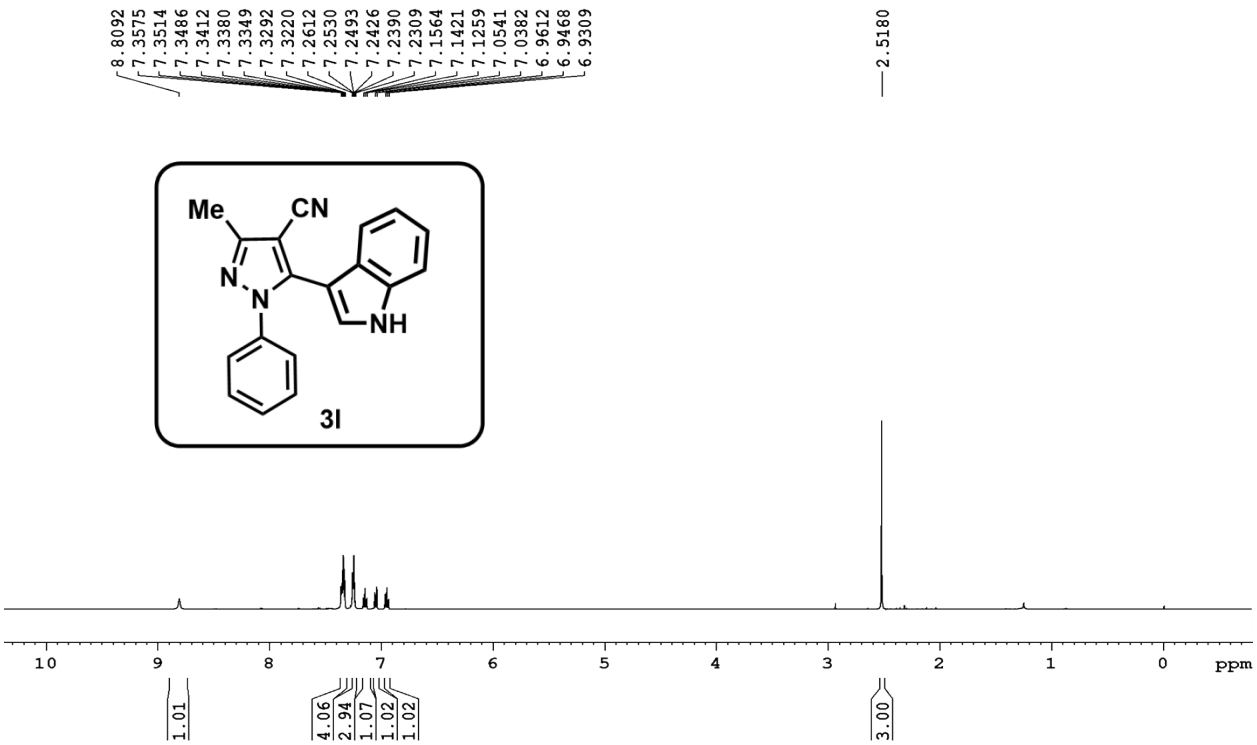


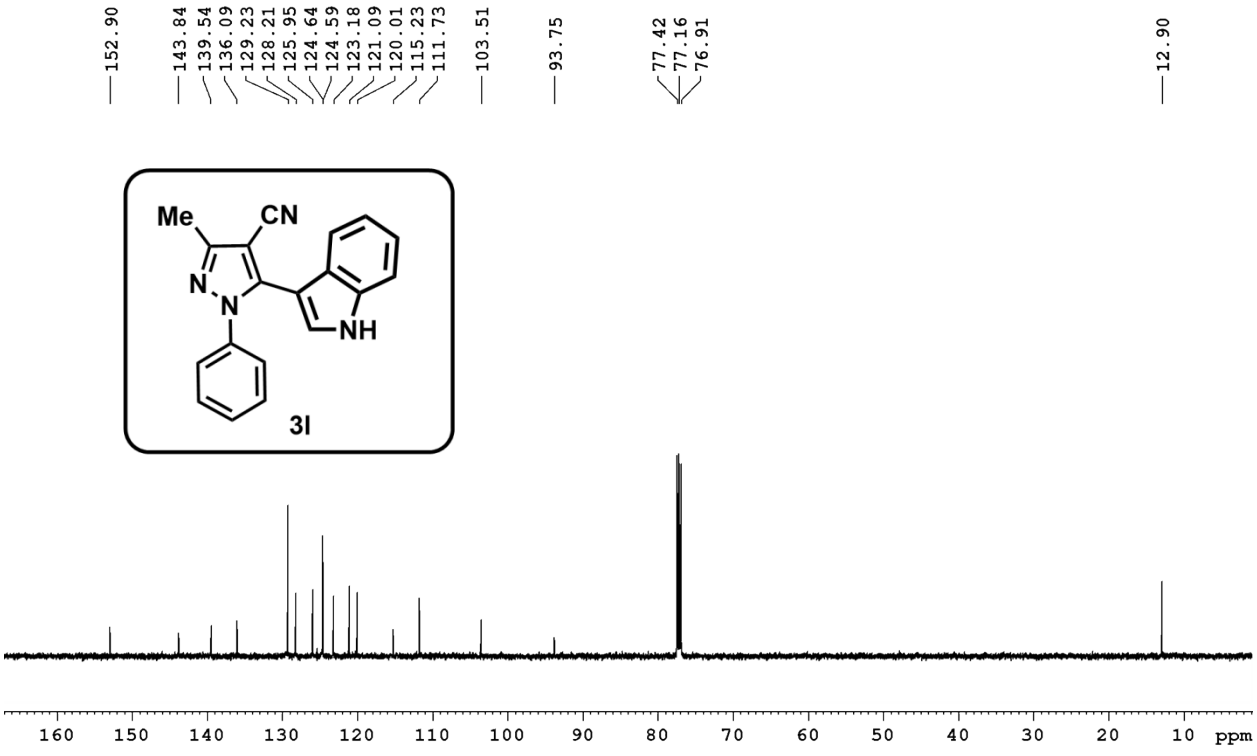
^{1}H NMR and ^{13}C NMR Spectra (3k)



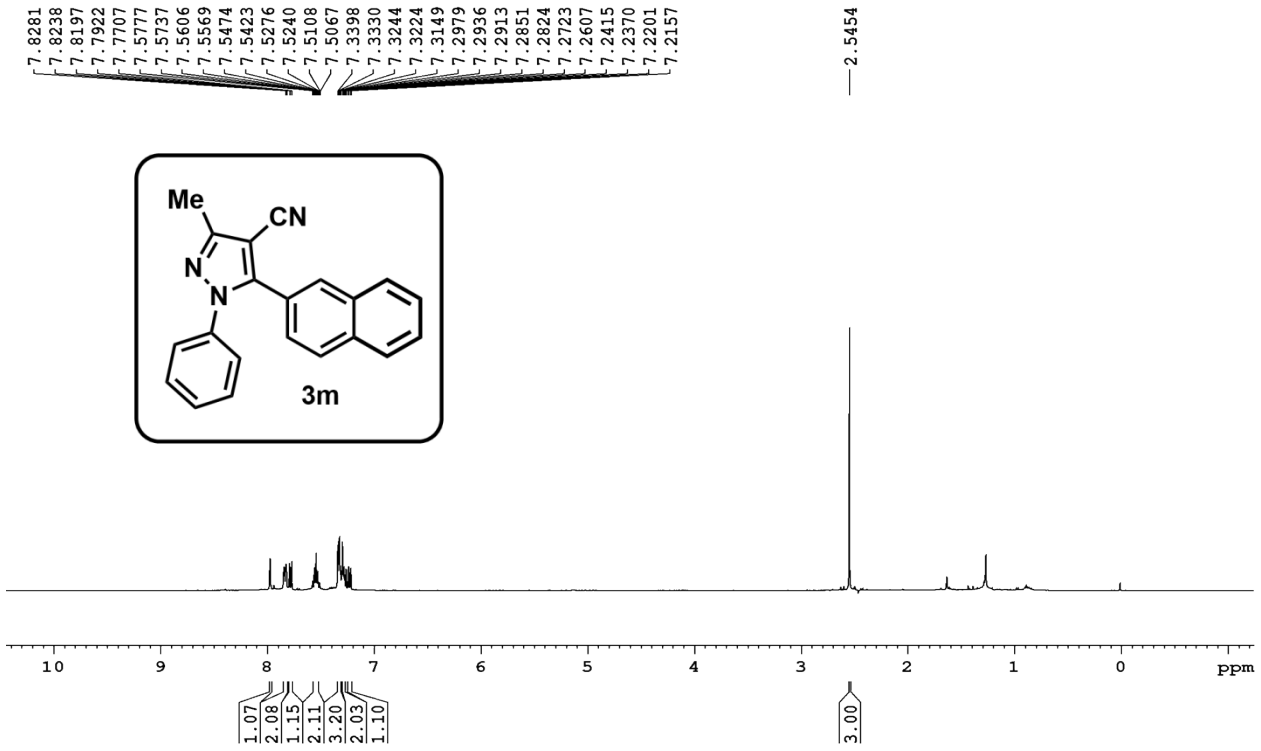


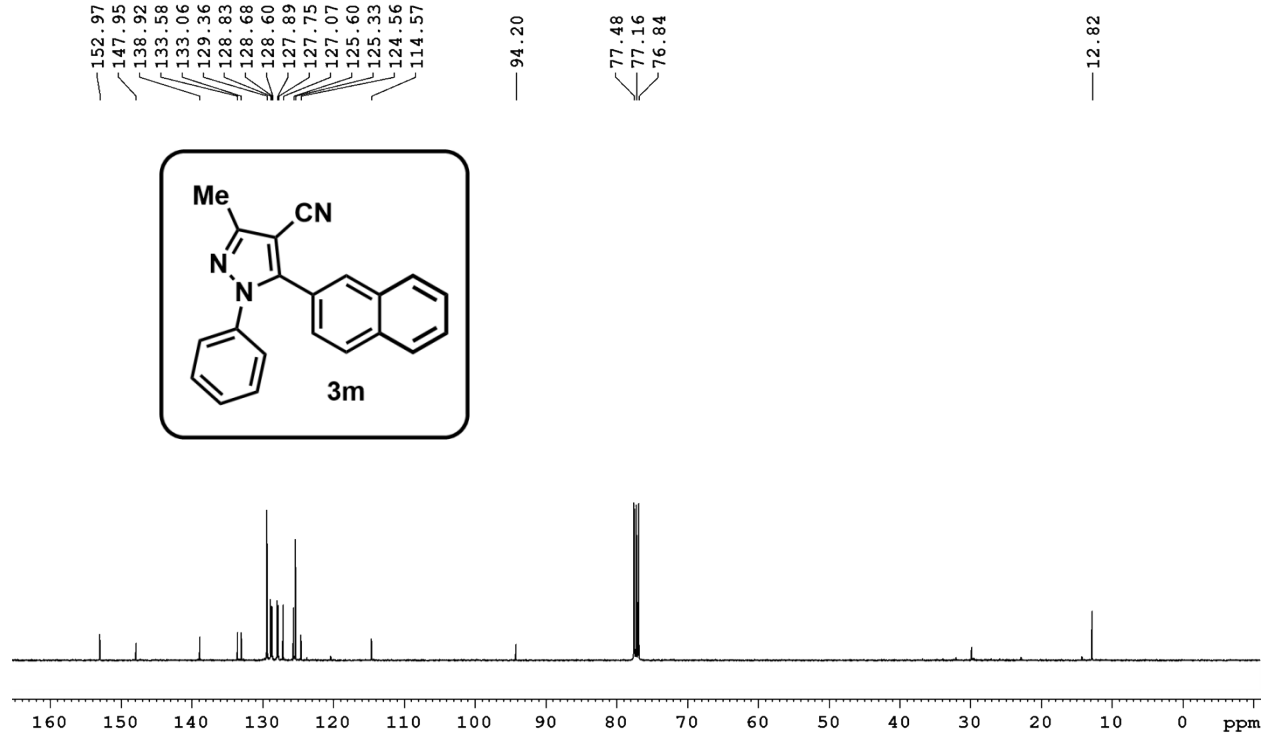
^{1}H NMR and ^{13}C NMR Spectra (3l)



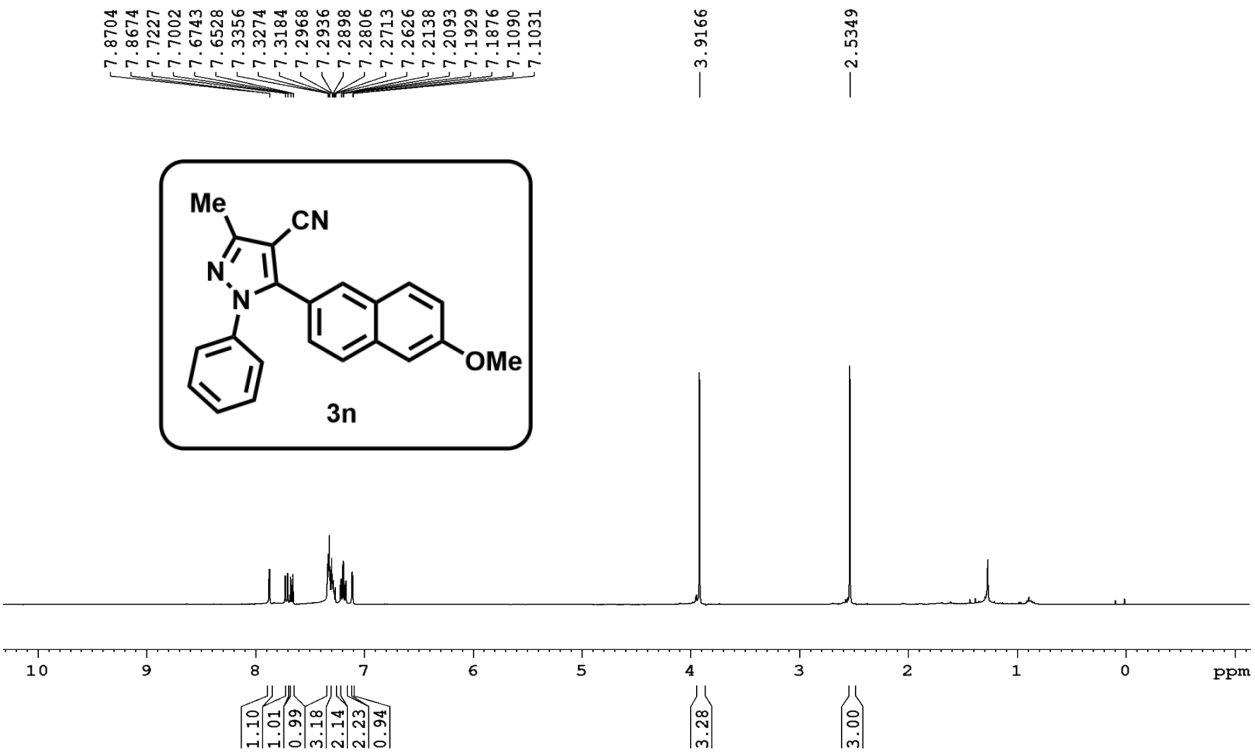


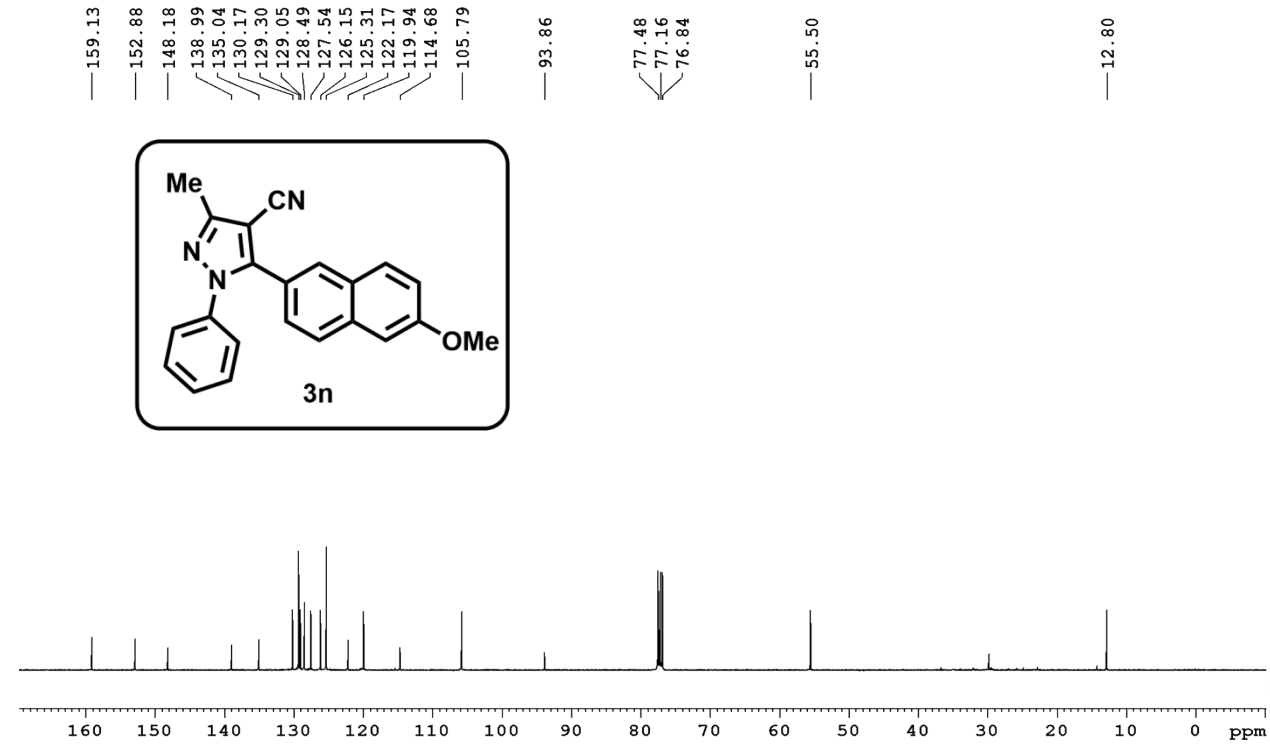
^{1}H NMR and ^{13}C NMR Spectra (3m)



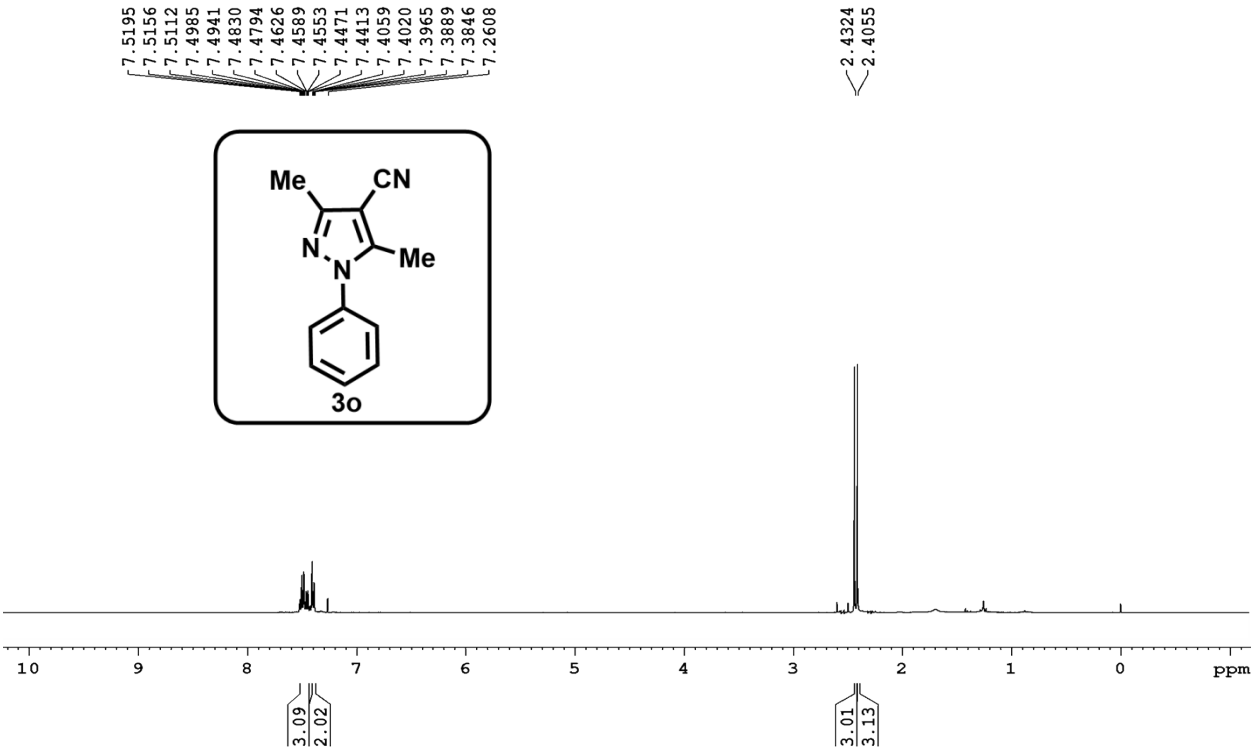


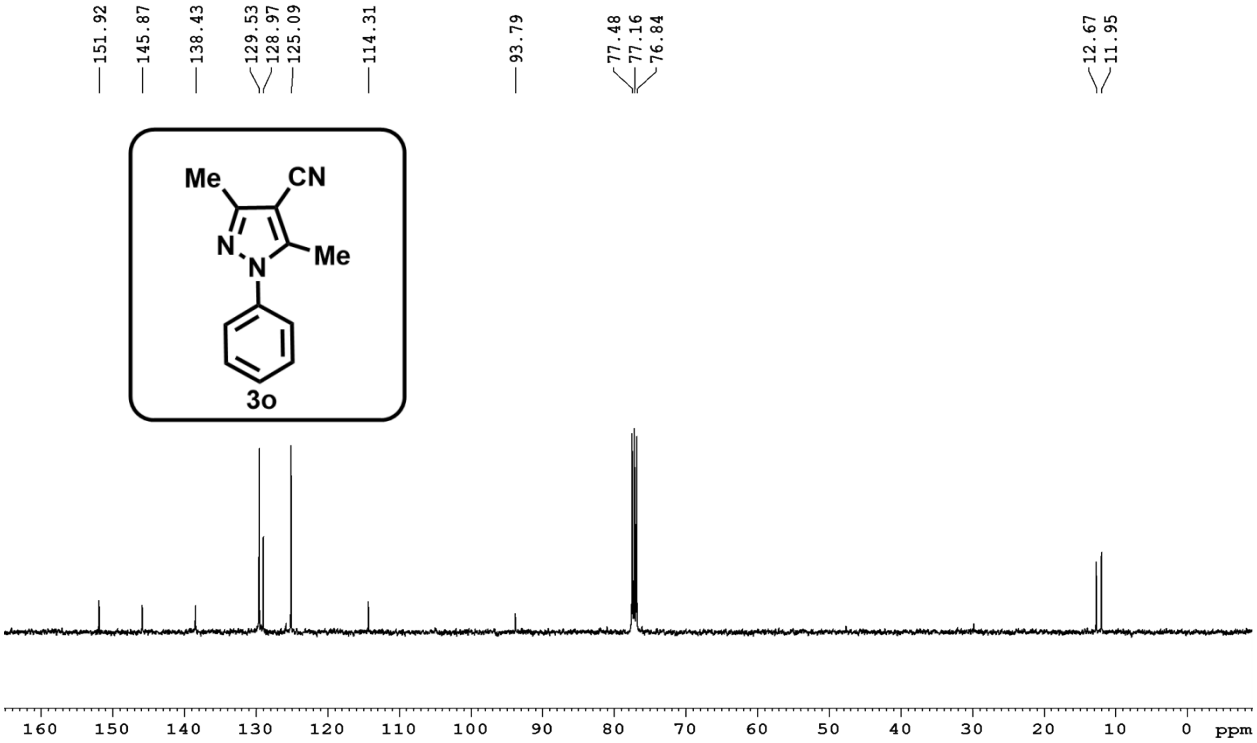
^{1}H NMR and ^{13}C NMR Spectra (3n)





^{1}H NMR and ^{13}C NMR Spectra (3o)





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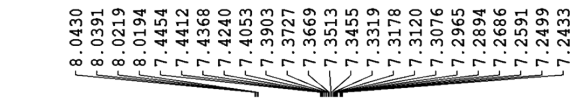
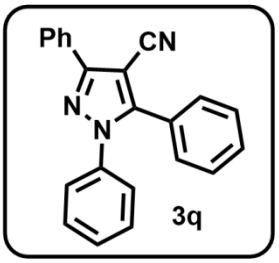
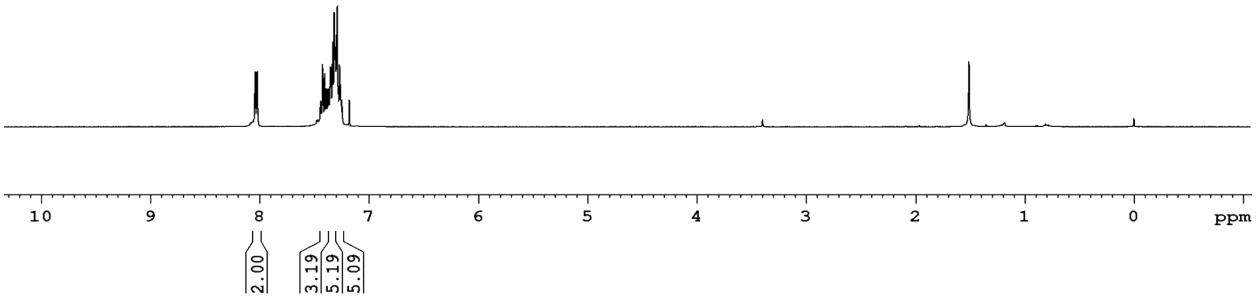
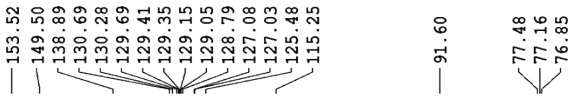
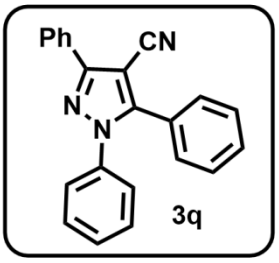
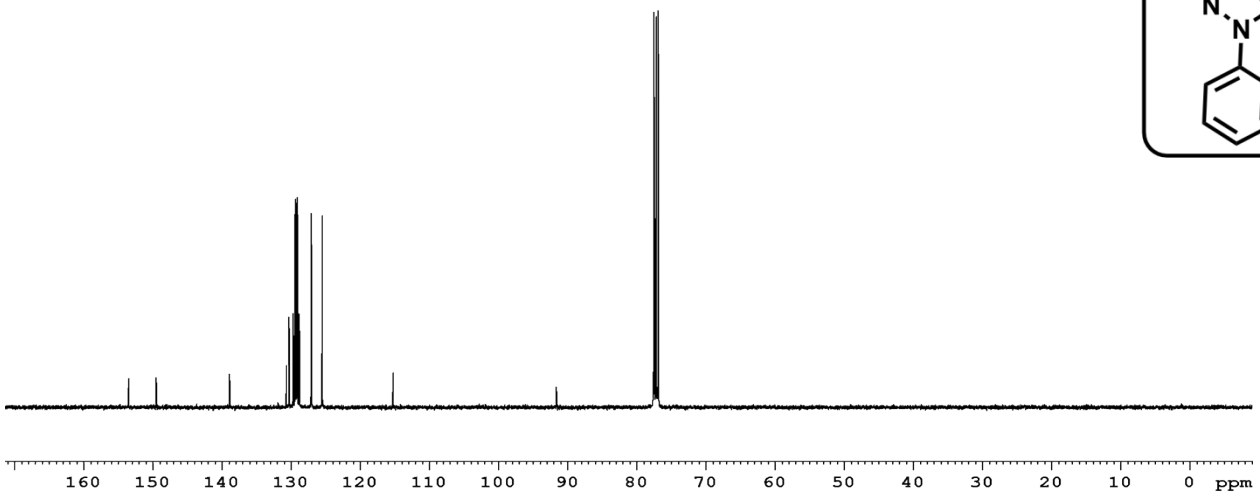




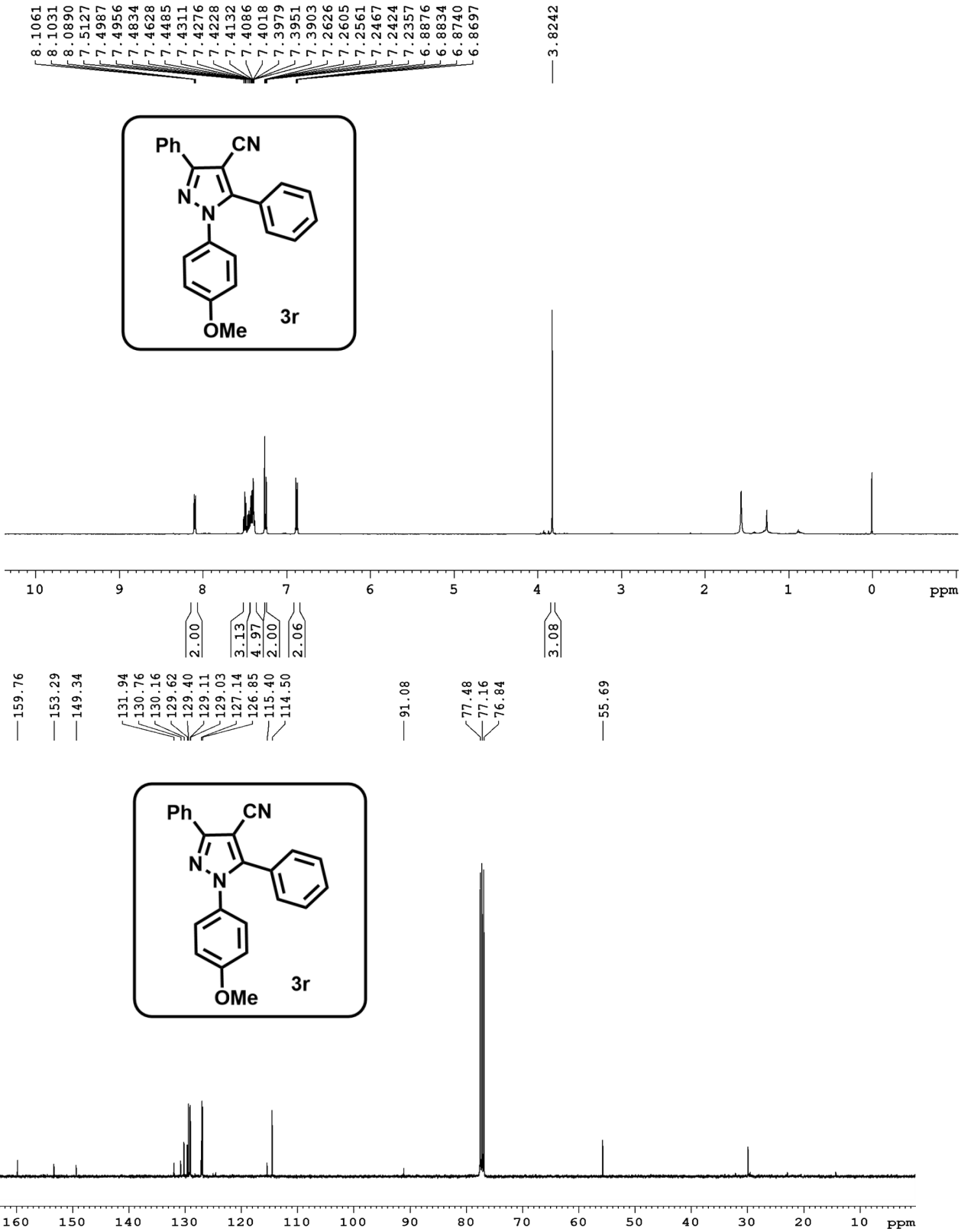




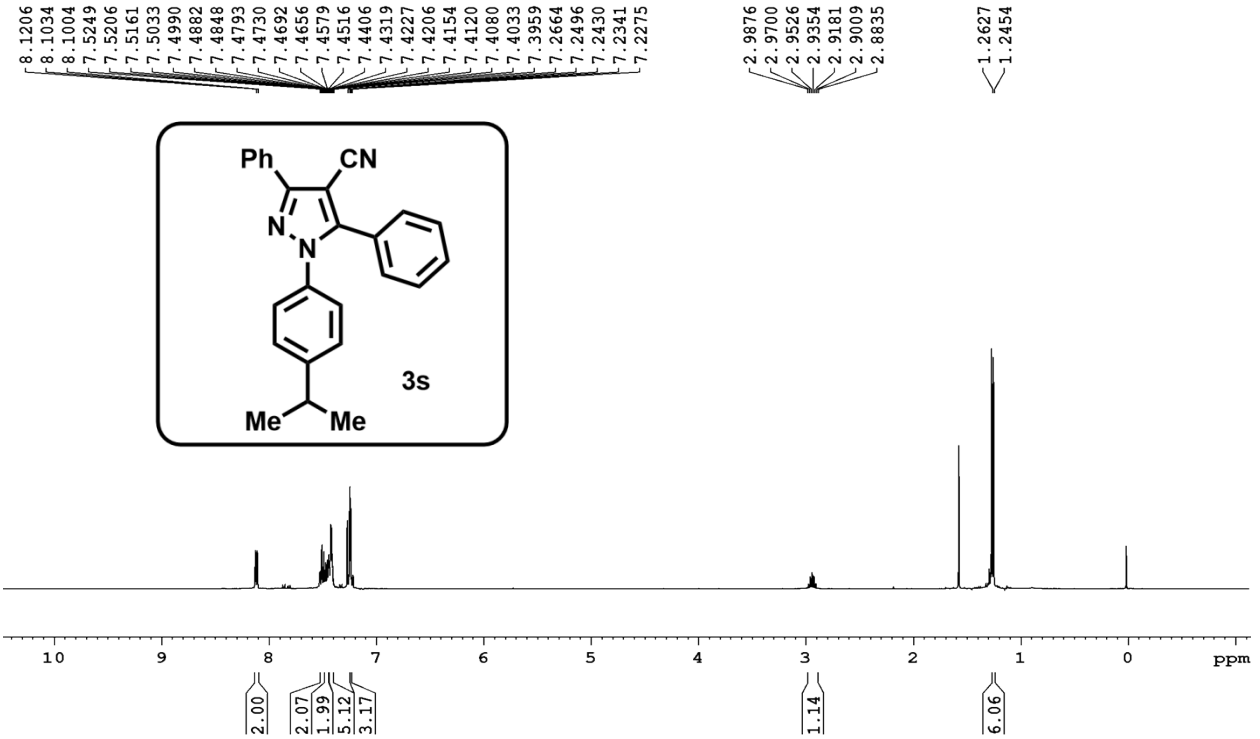


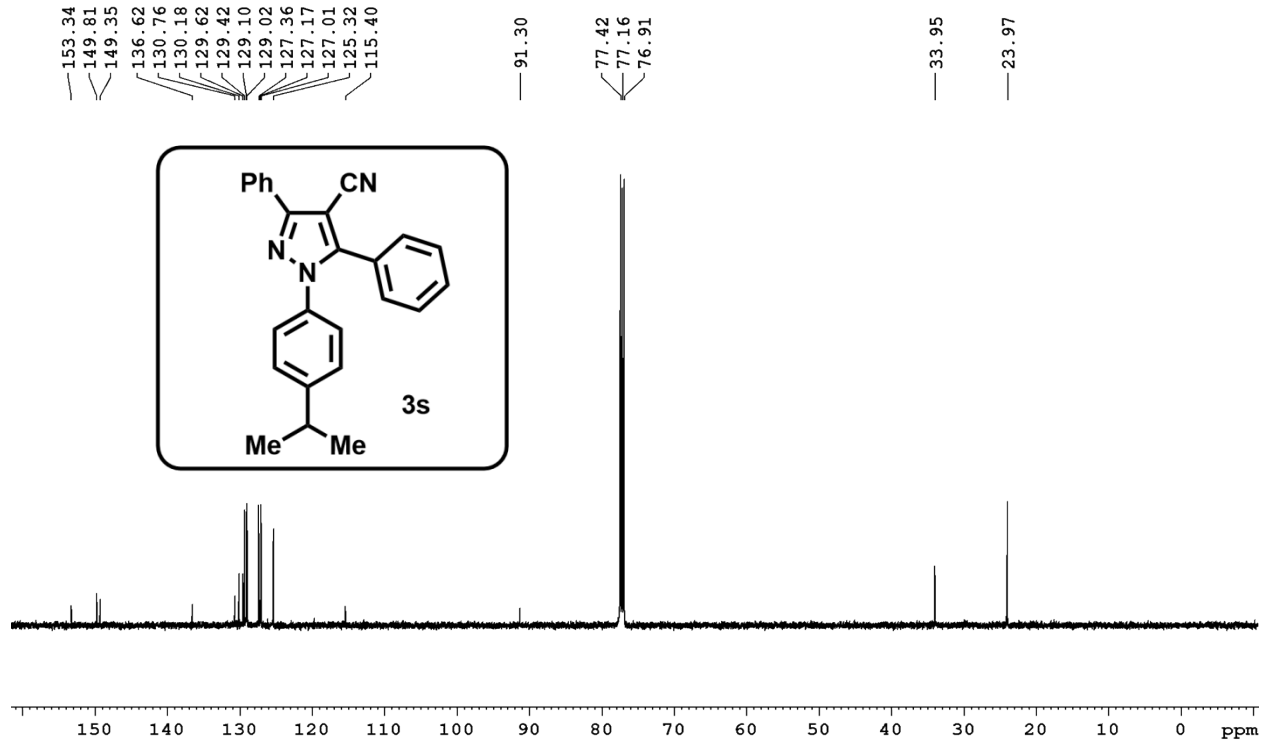


^{1}H NMR and ^{13}C NMR Spectra (3r)

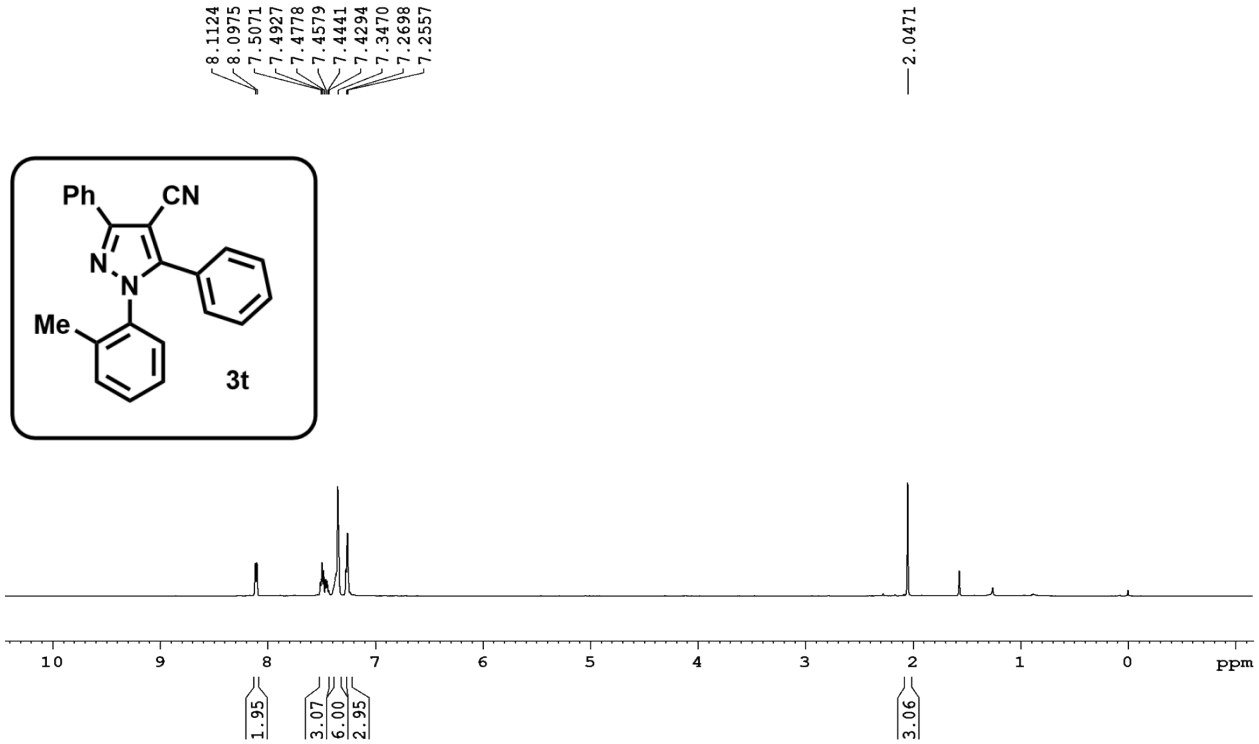


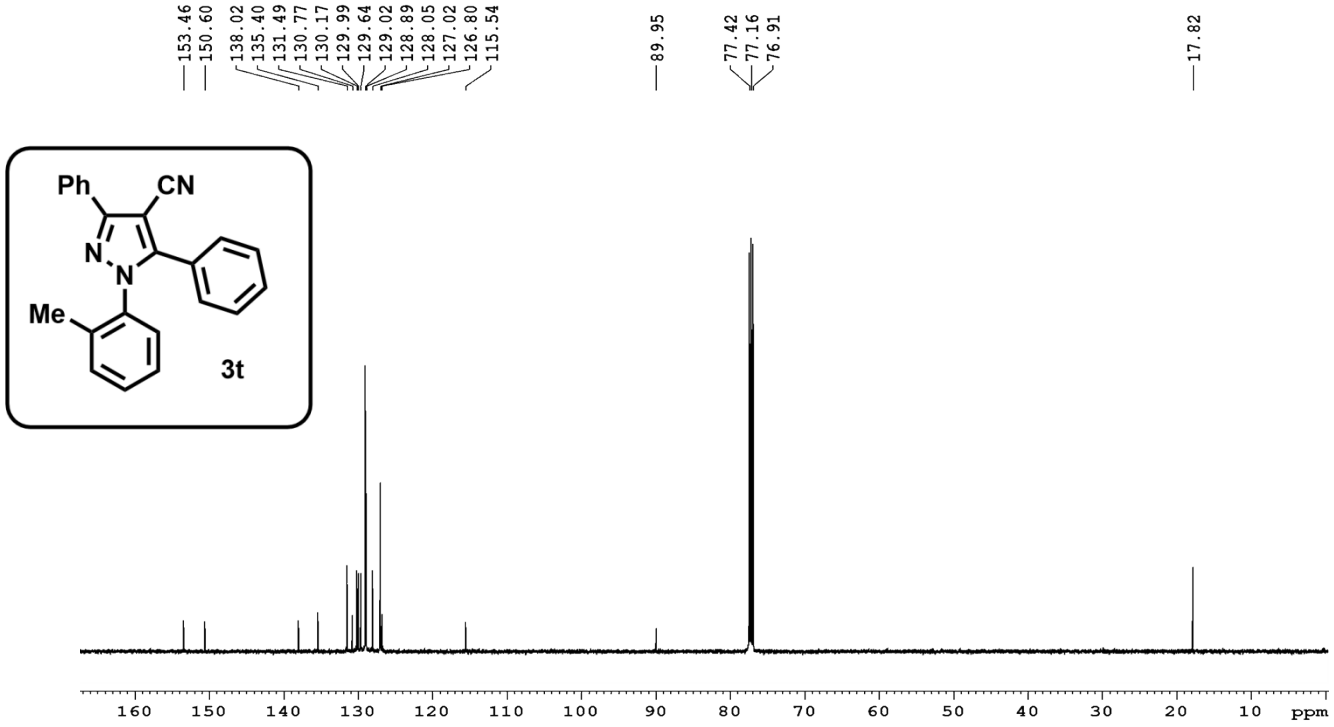
^{1}H NMR and ^{13}C NMR Spectra (3s)



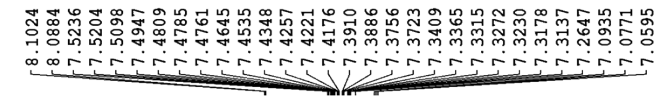


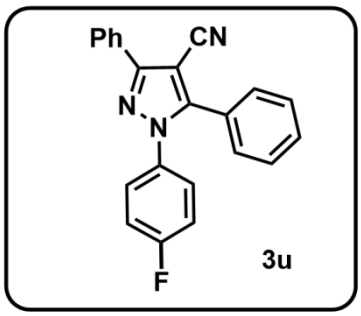
^{1}H NMR and ^{13}C NMR Spectra (3t)

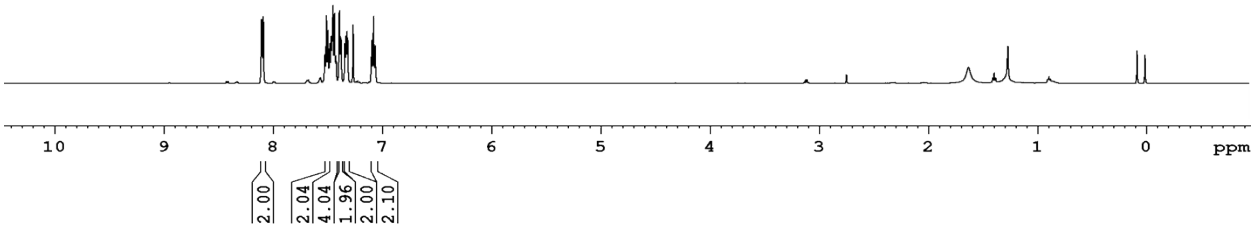


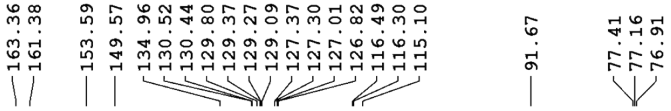


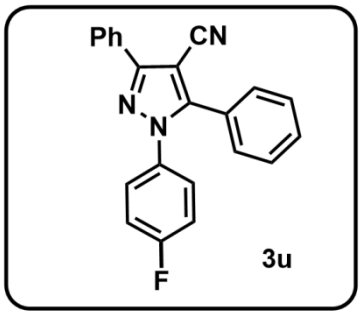
^{1}H NMR and ^{13}C NMR Spectra (3u)

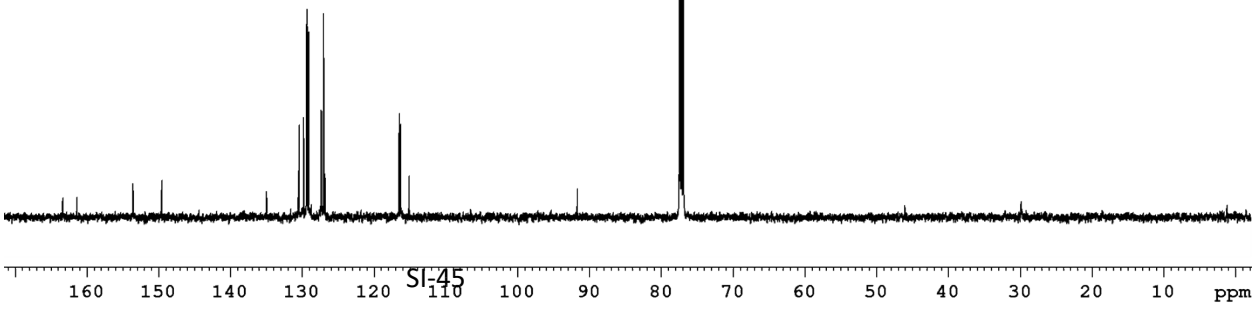


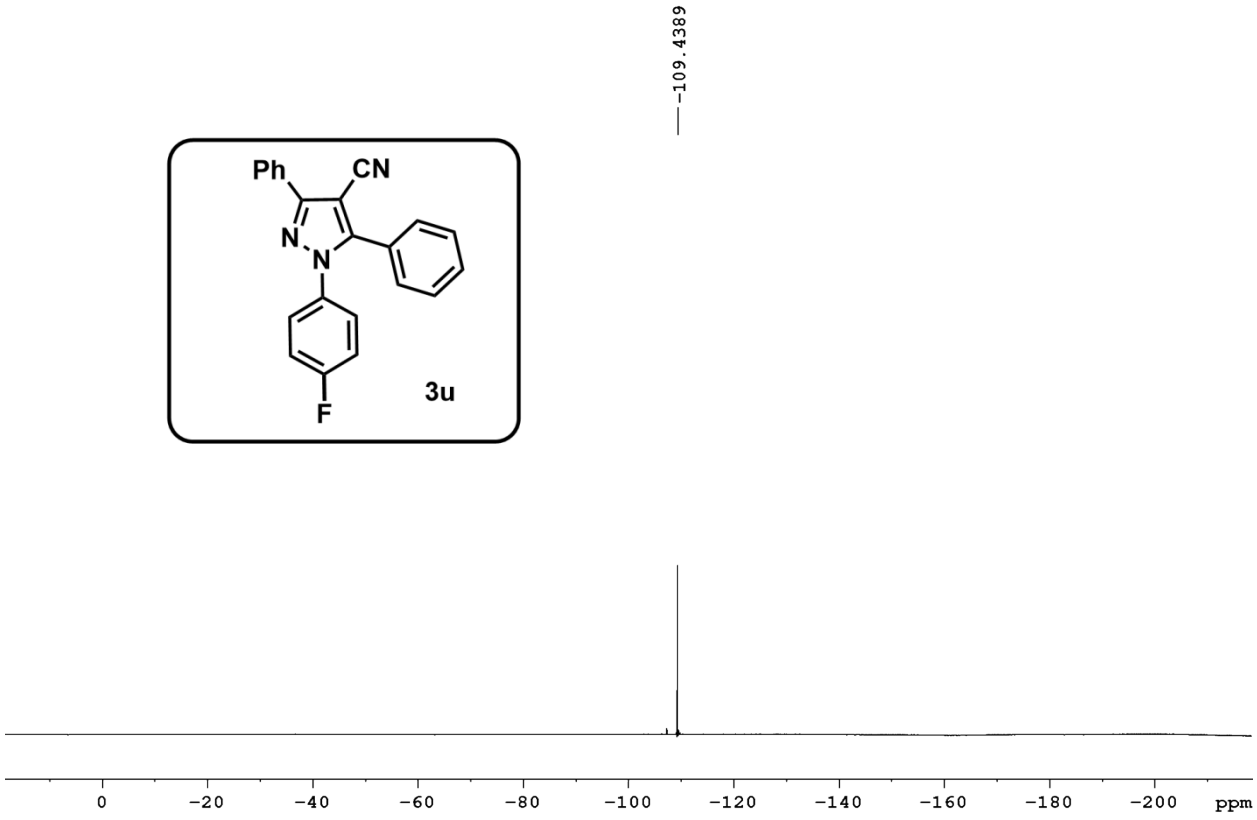








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N
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-140
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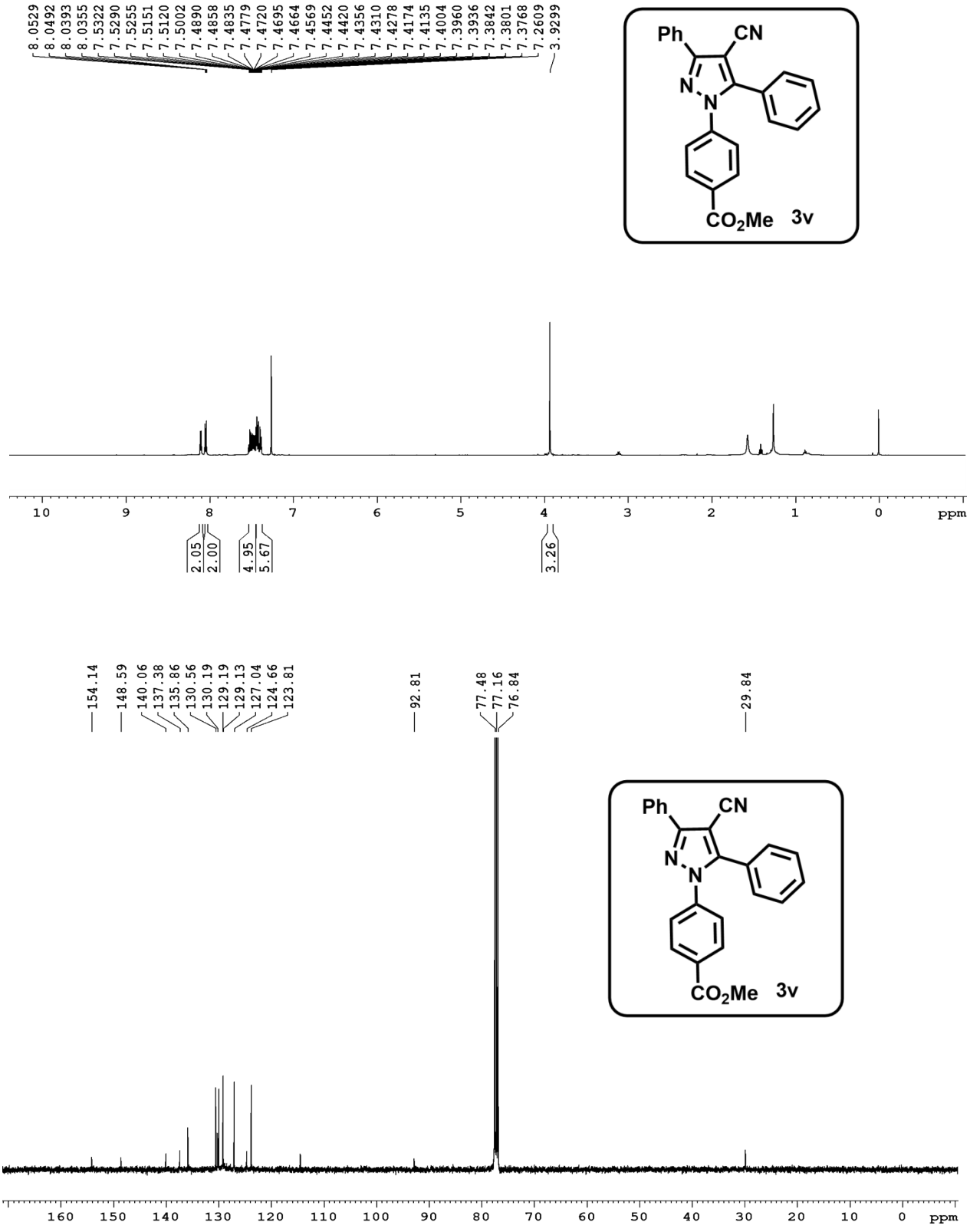
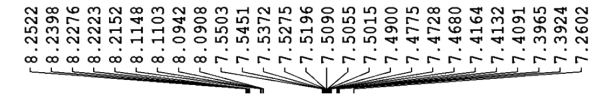
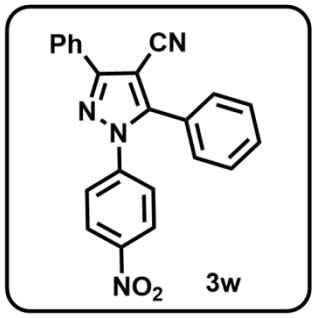
-180
-200
ppm

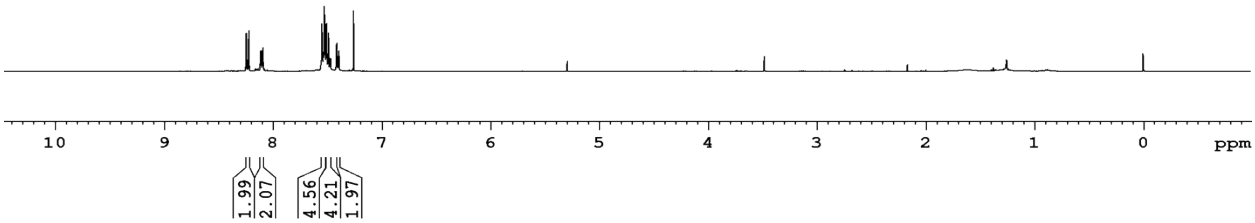
^{1}H NMR and ^{13}C NMR Spectra (3v)

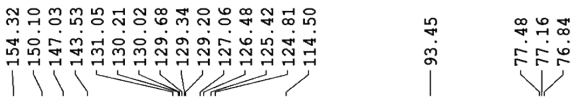


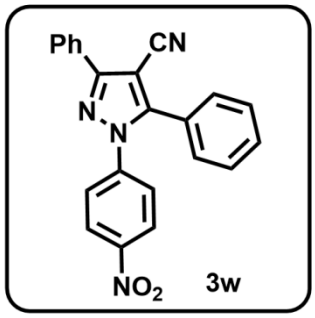
^{1}H NMR and ^{13}C NMR Spectra (3w)

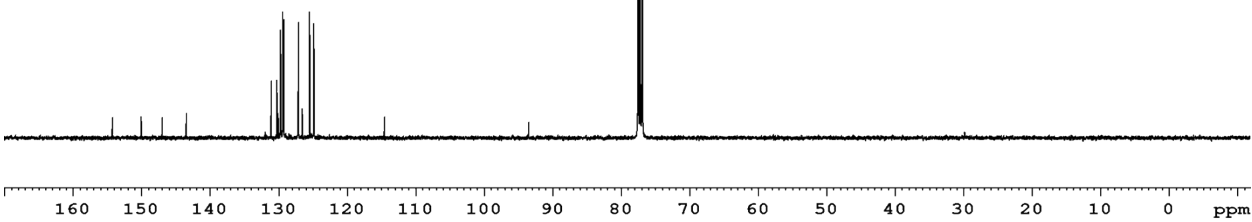




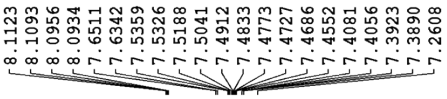


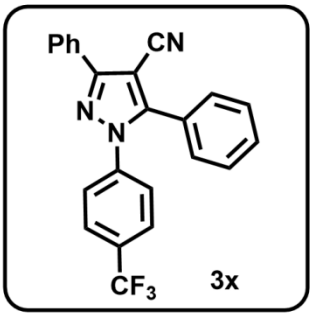


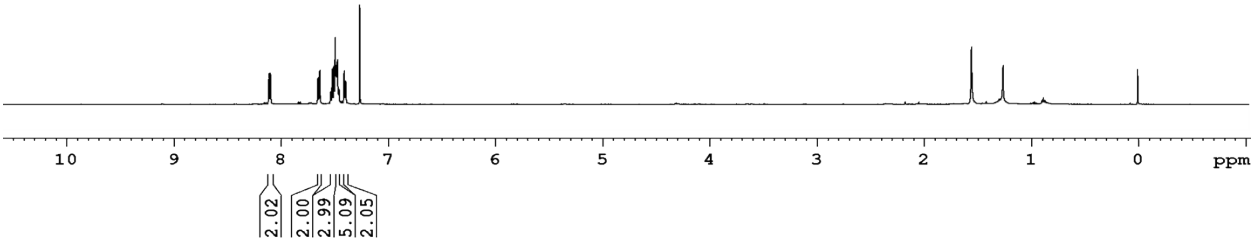


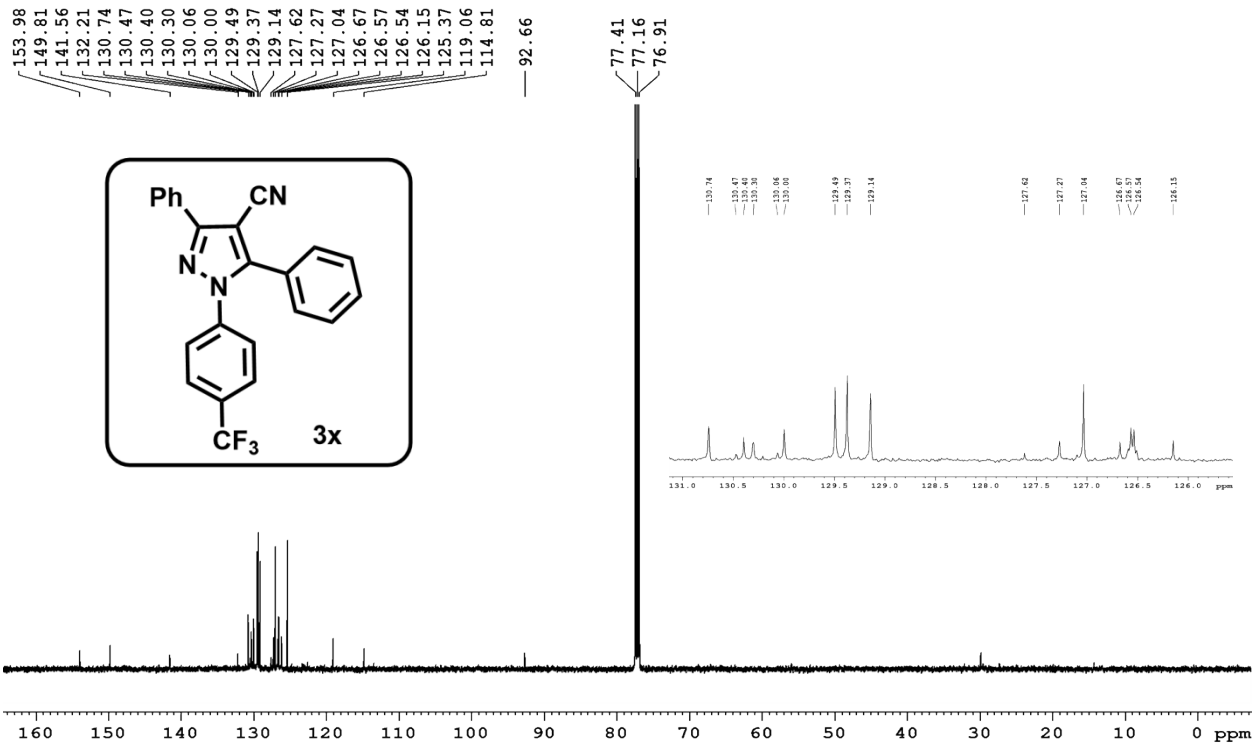


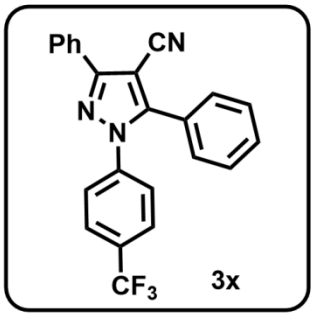
^{1}H NMR and ^{13}C NMR Spectra (3x)







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3x

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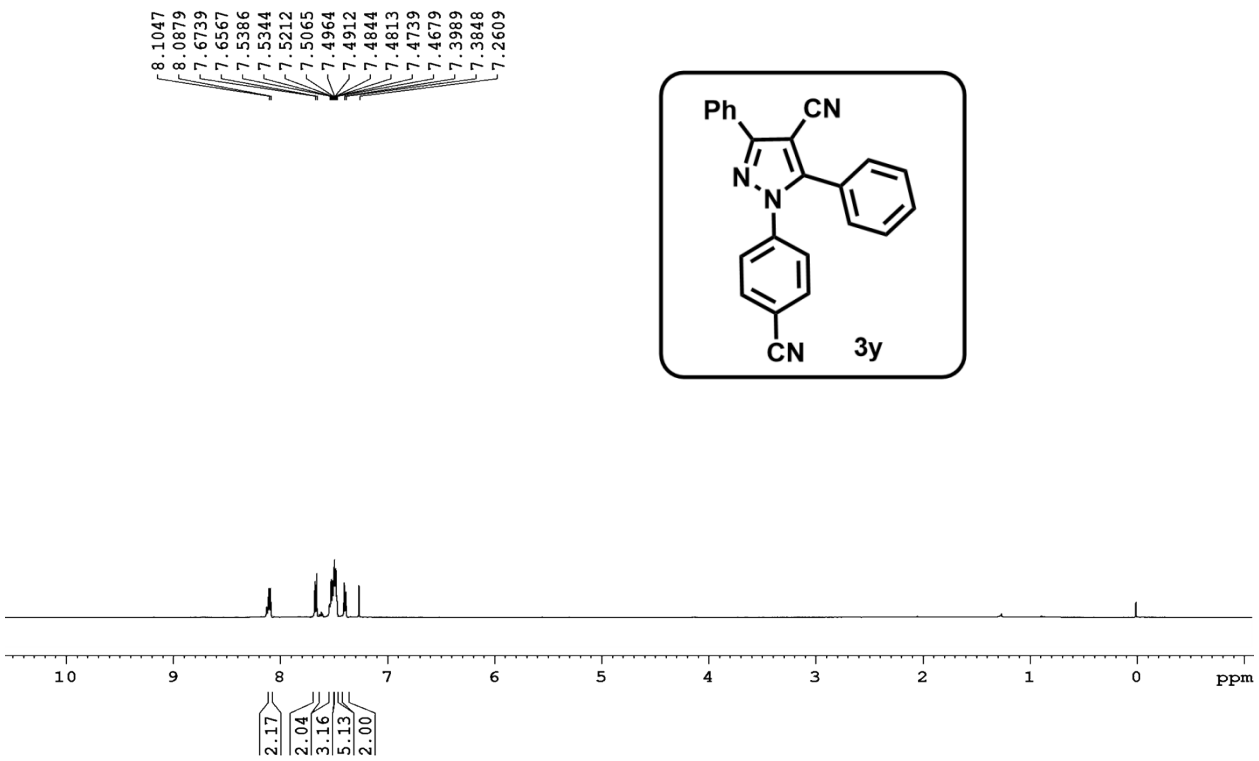
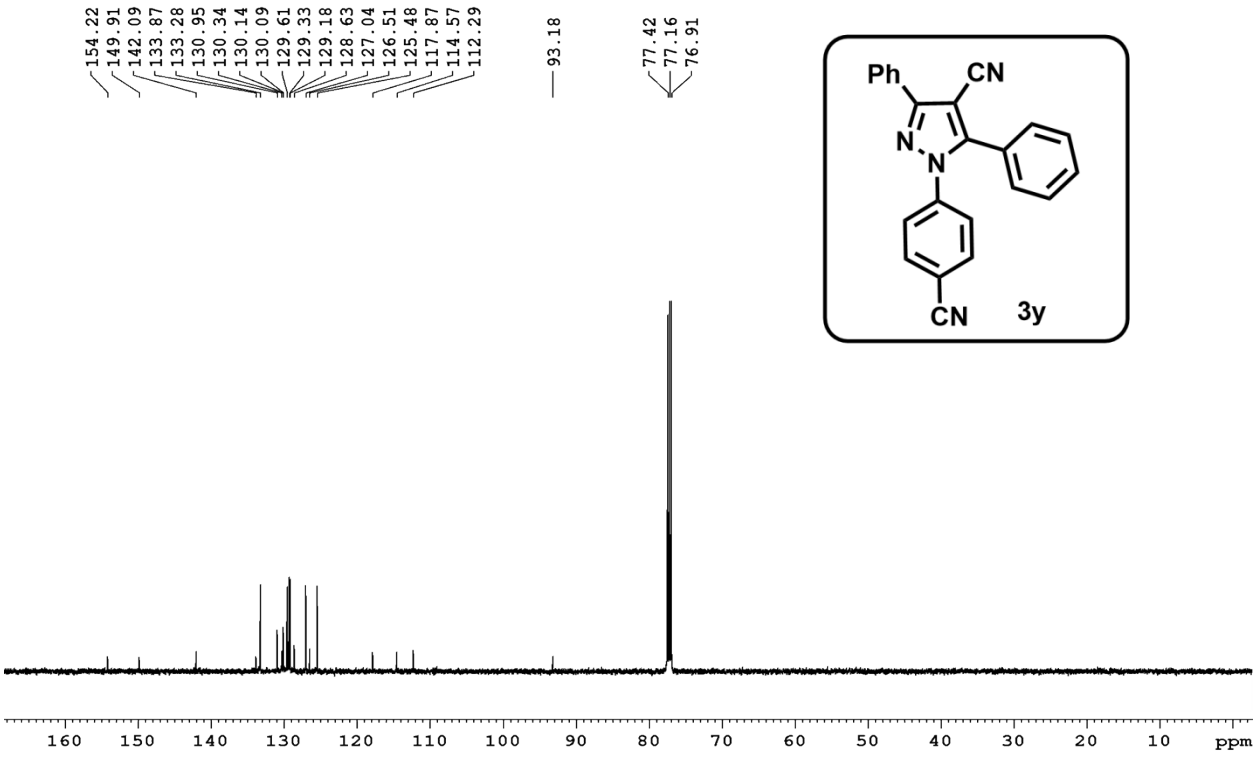
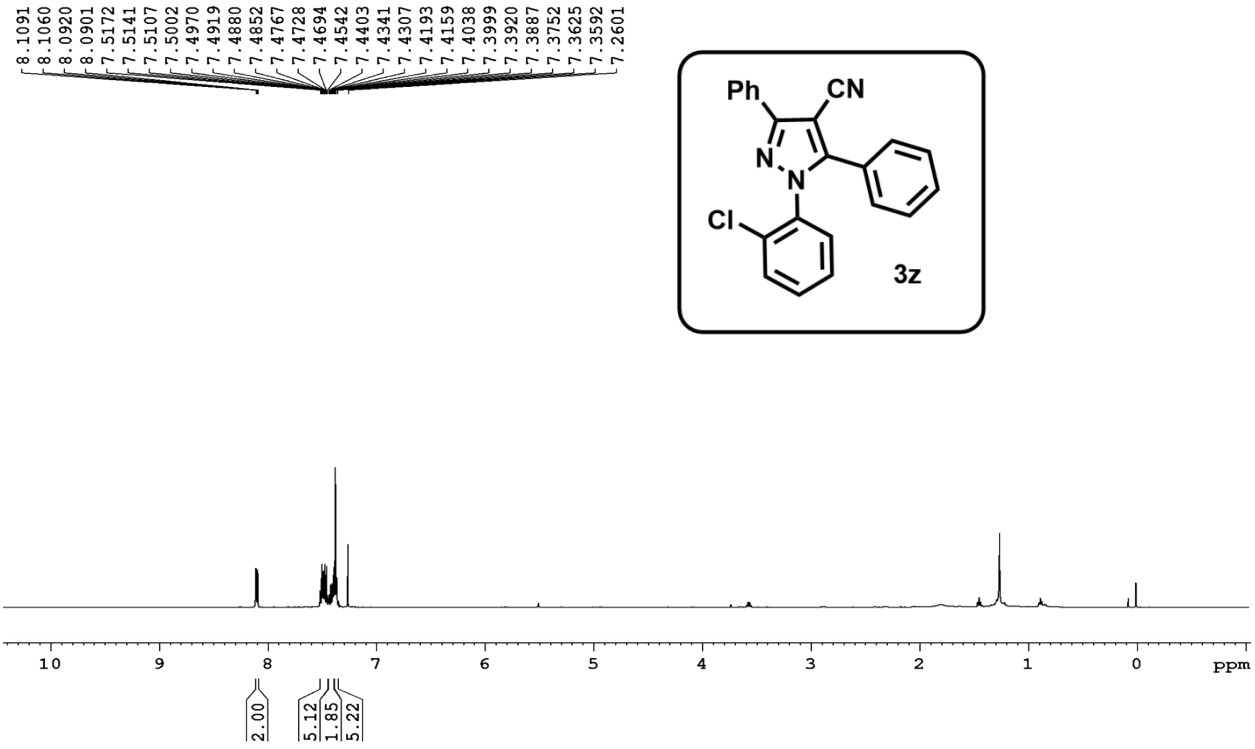
ppm

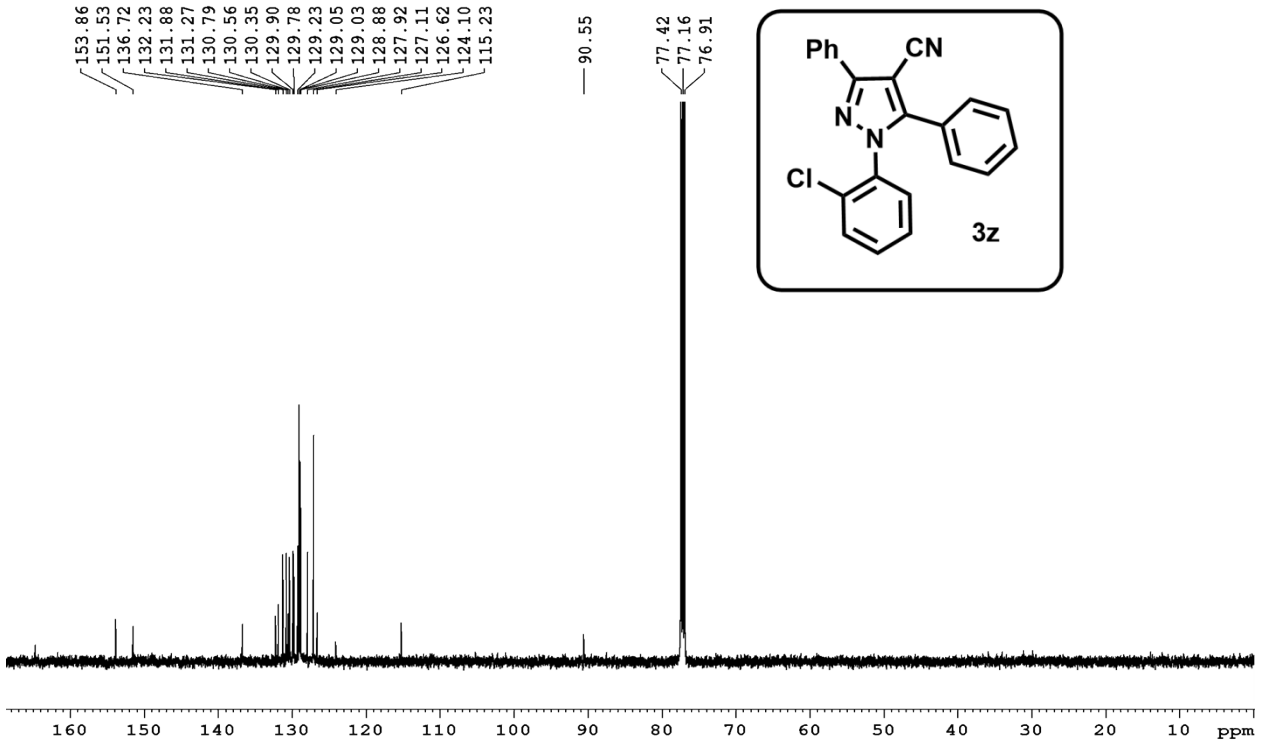
^{1}H NMR and ^{13}C NMR Spectra (3y)



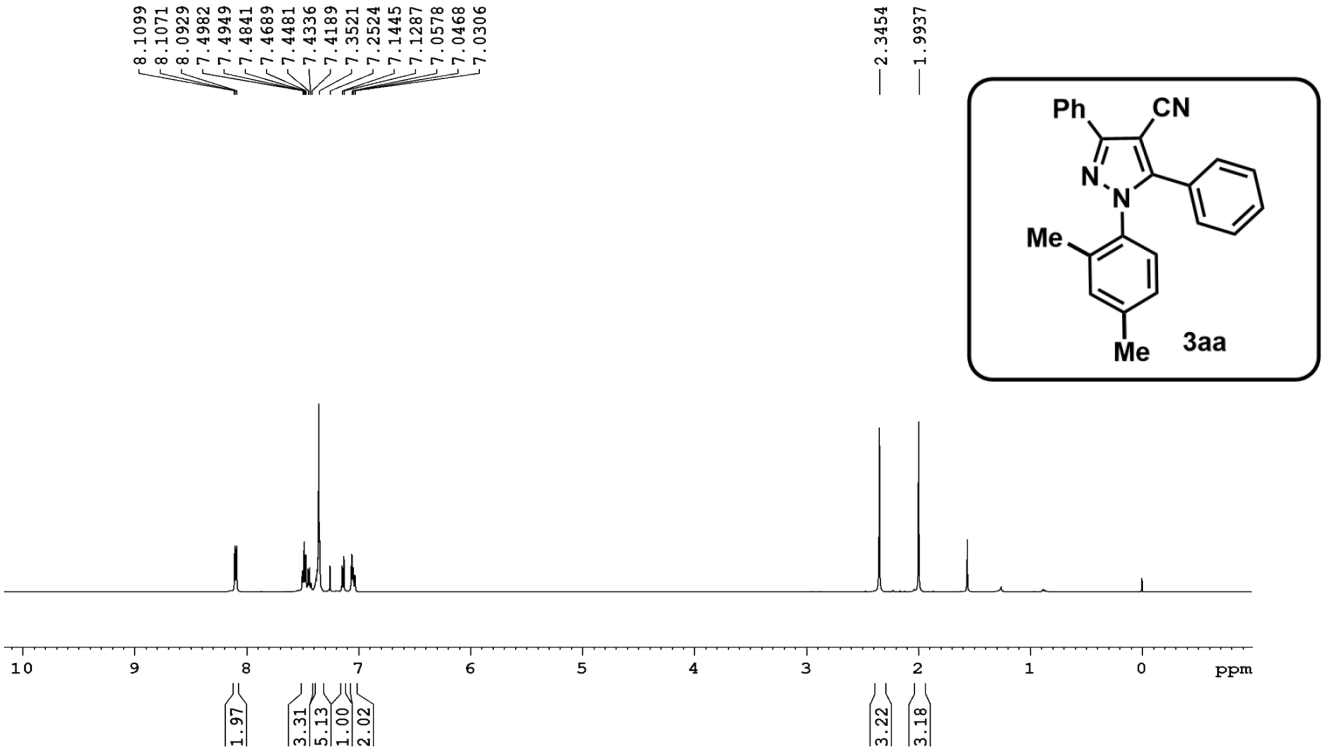


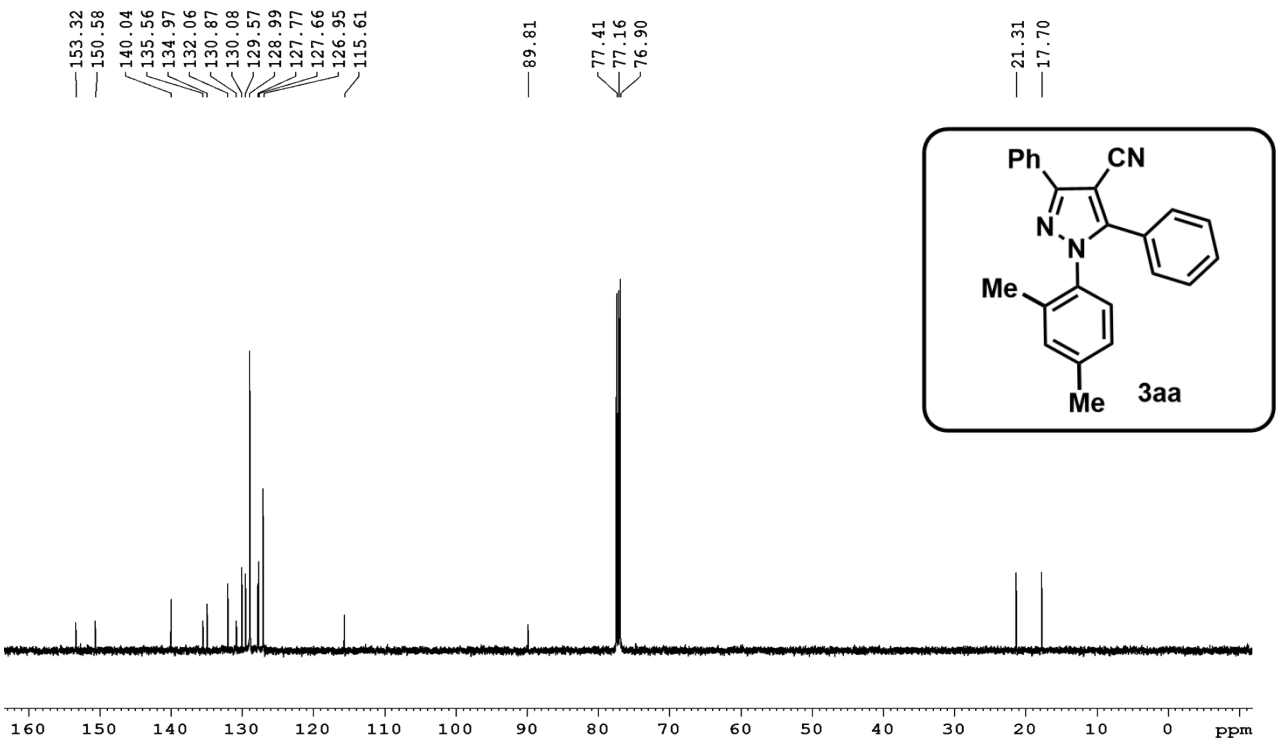
^{1}H NMR and ^{13}C NMR Spectra (3z)



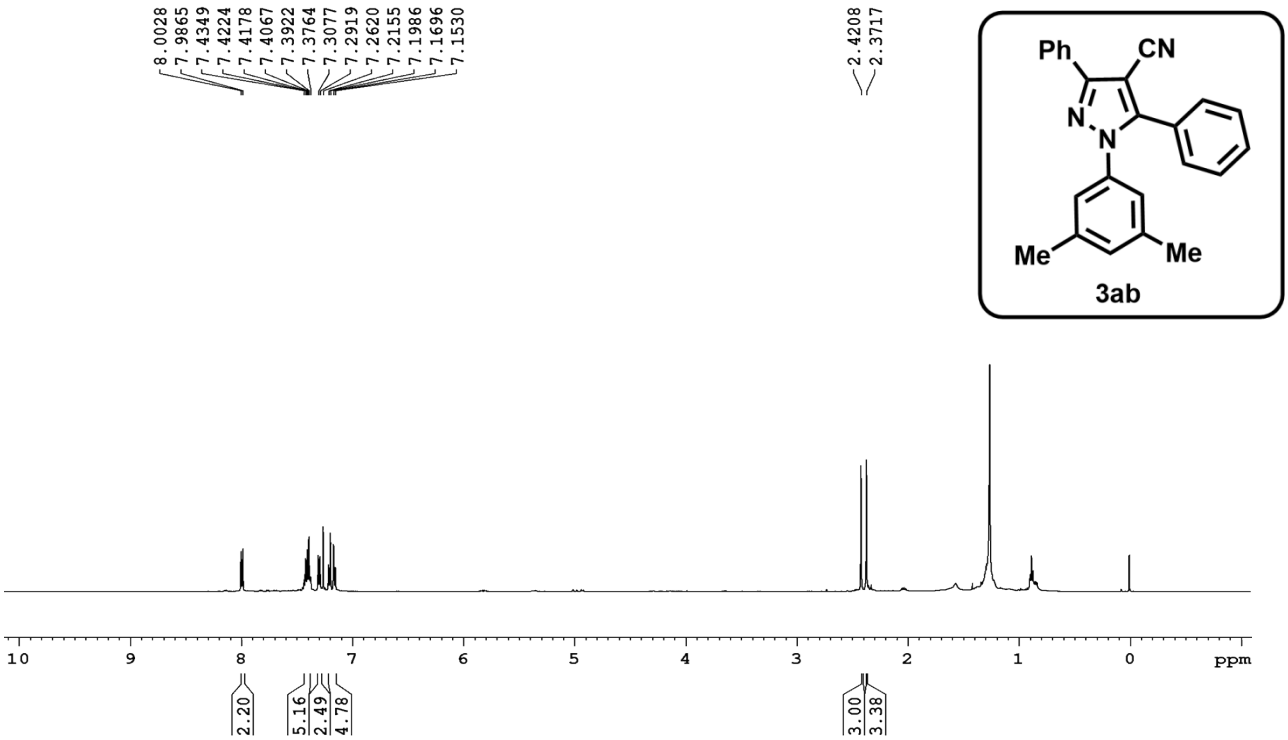


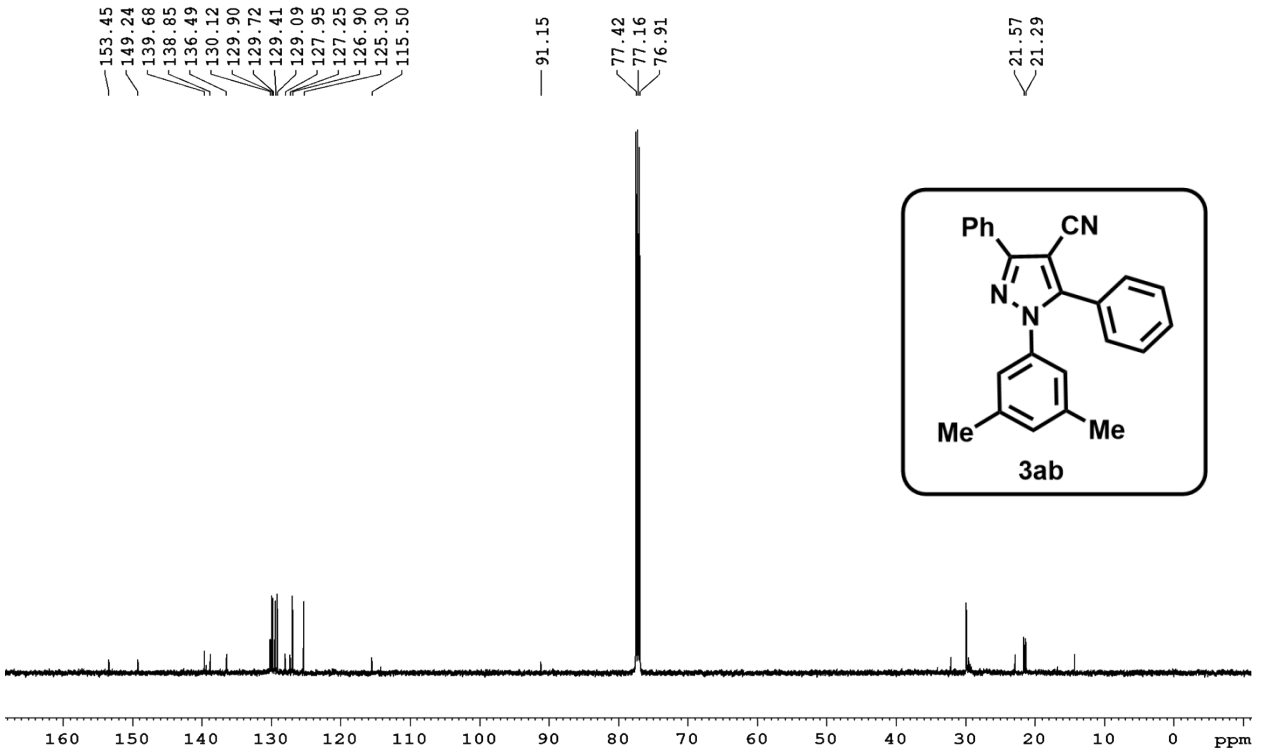
^{1}H NMR and ^{13}C NMR Spectra (3aa)



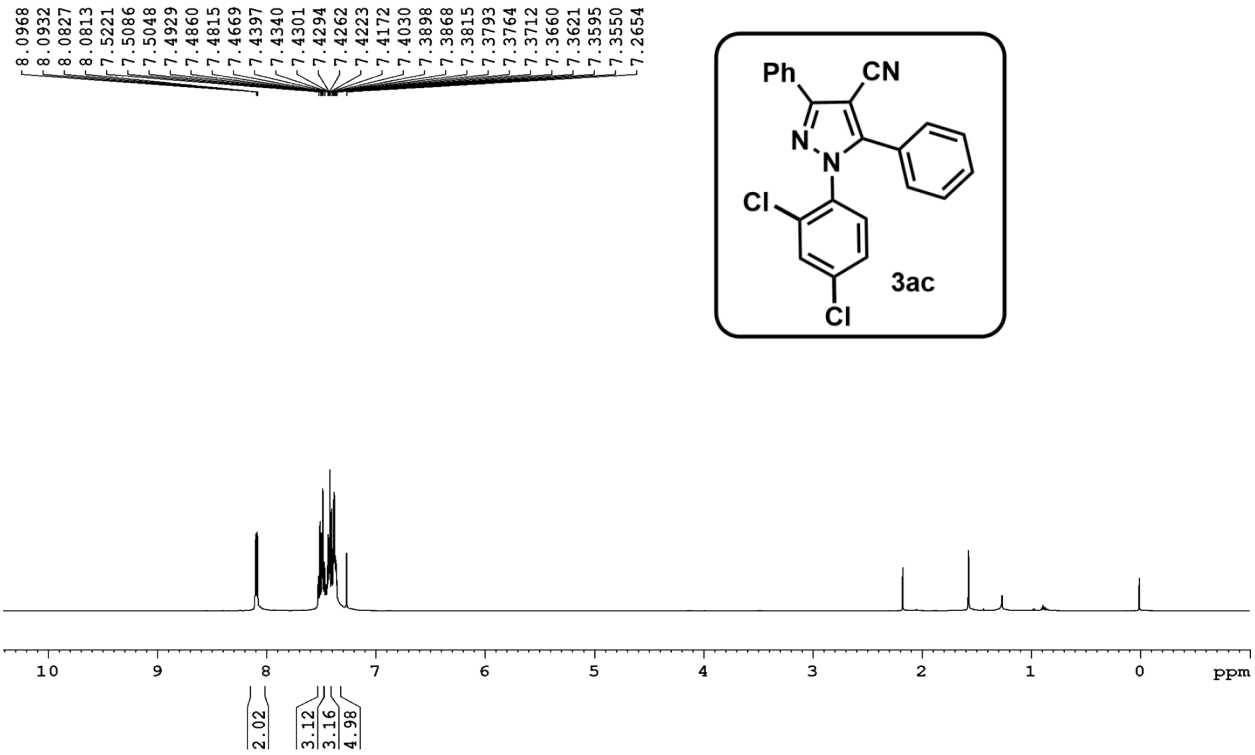


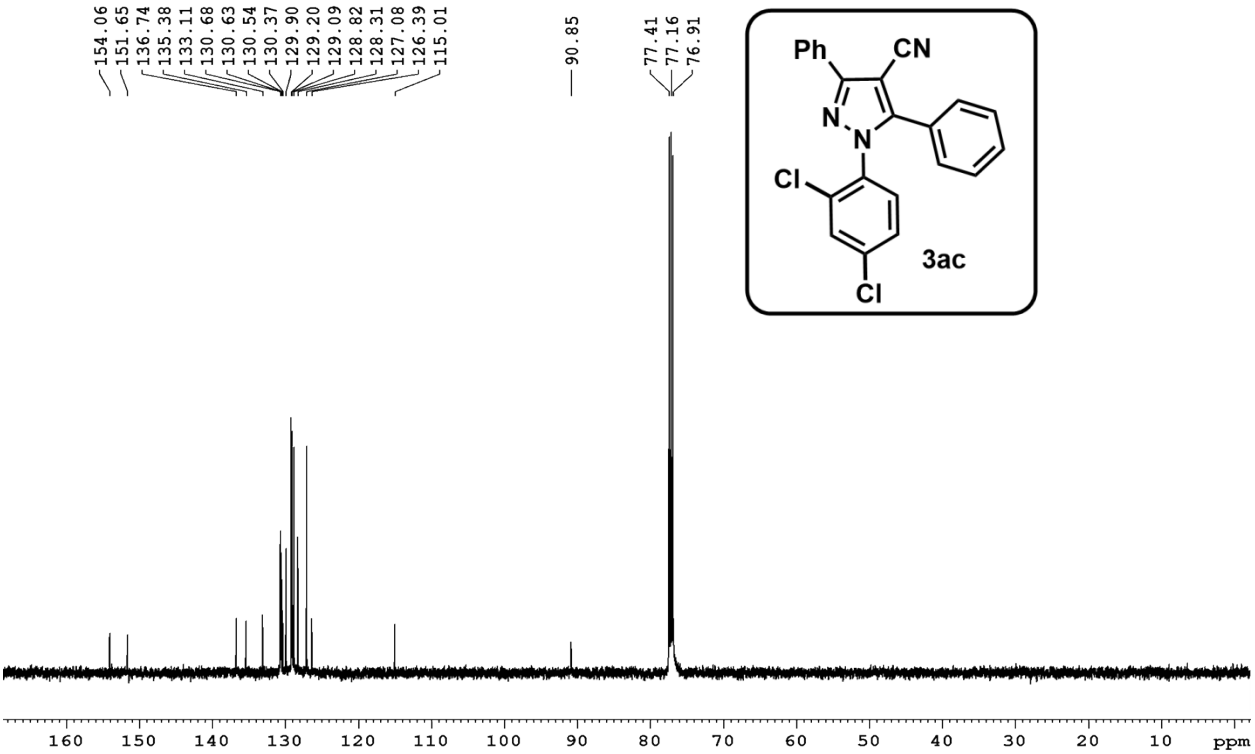
^{1}H NMR and ^{13}C NMR Spectra (3ab)



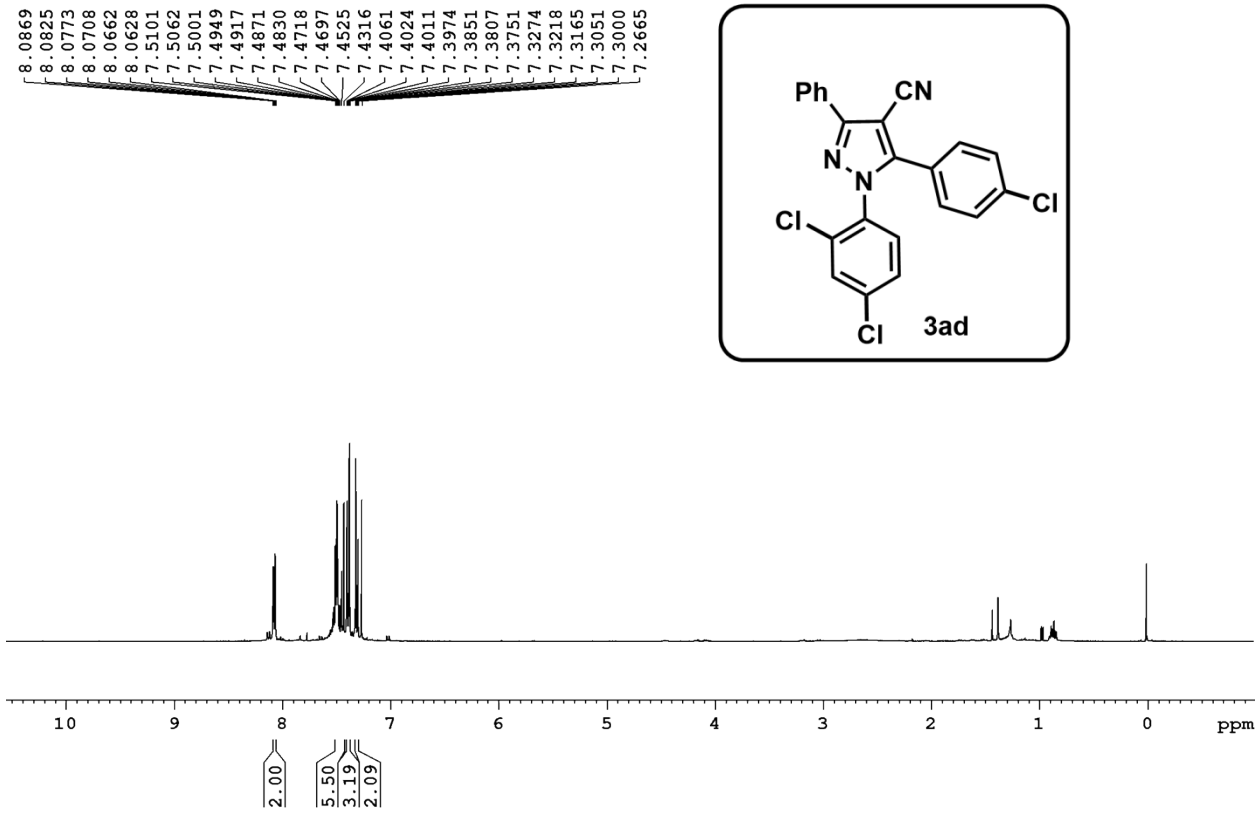


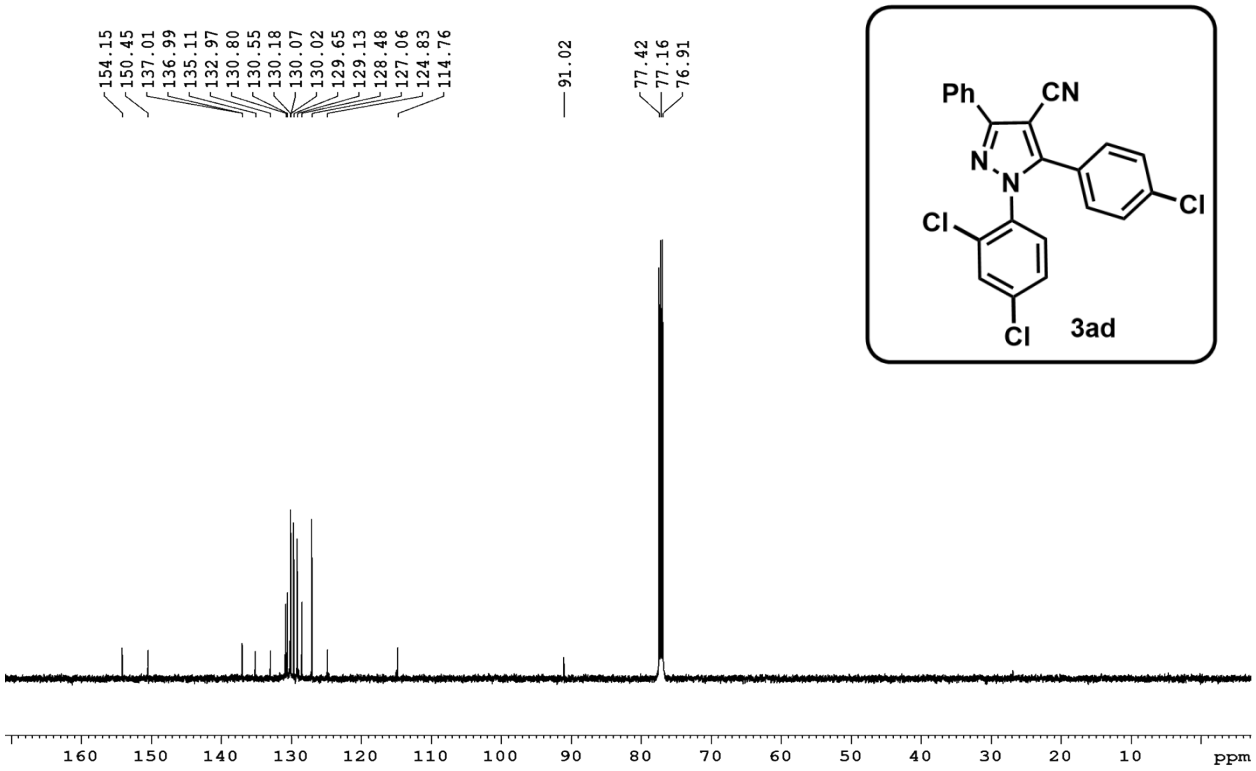
^{1}H NMR and ^{13}C NMR Spectra (3ac)



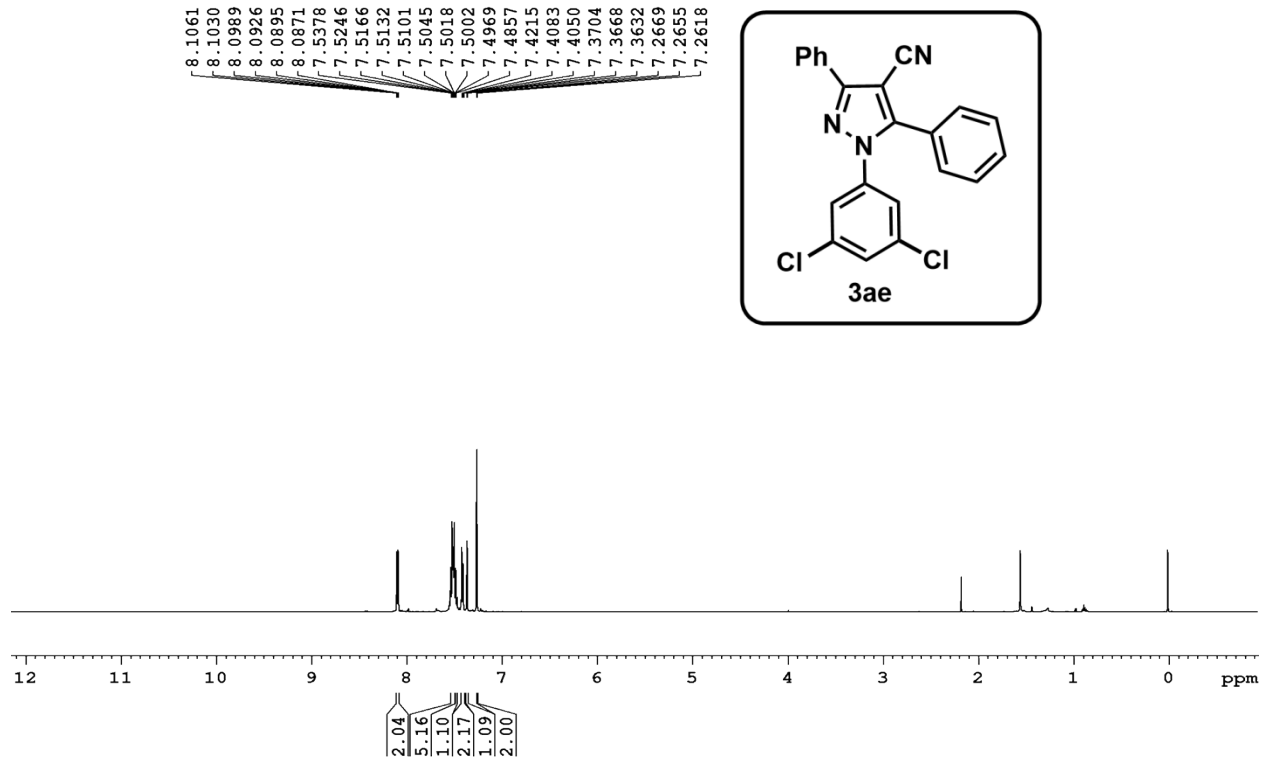


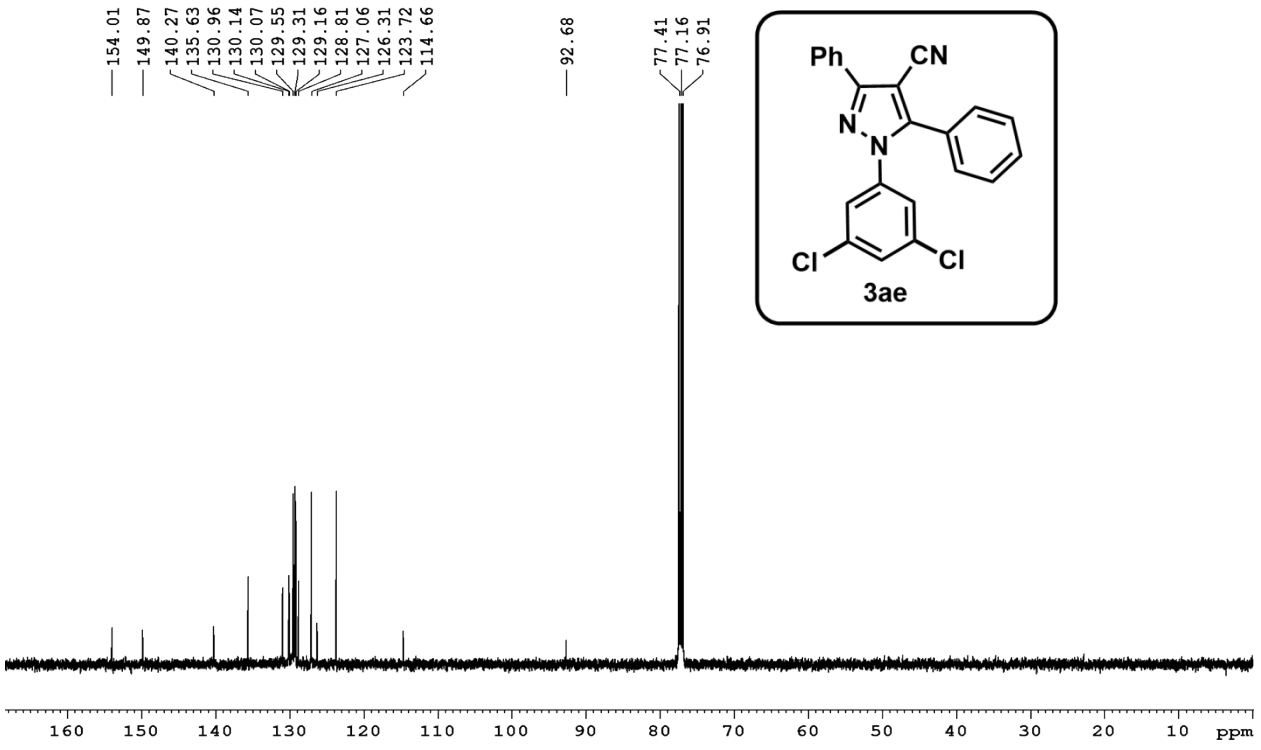
^{1}H NMR and ^{13}C NMR Spectra (3ad)



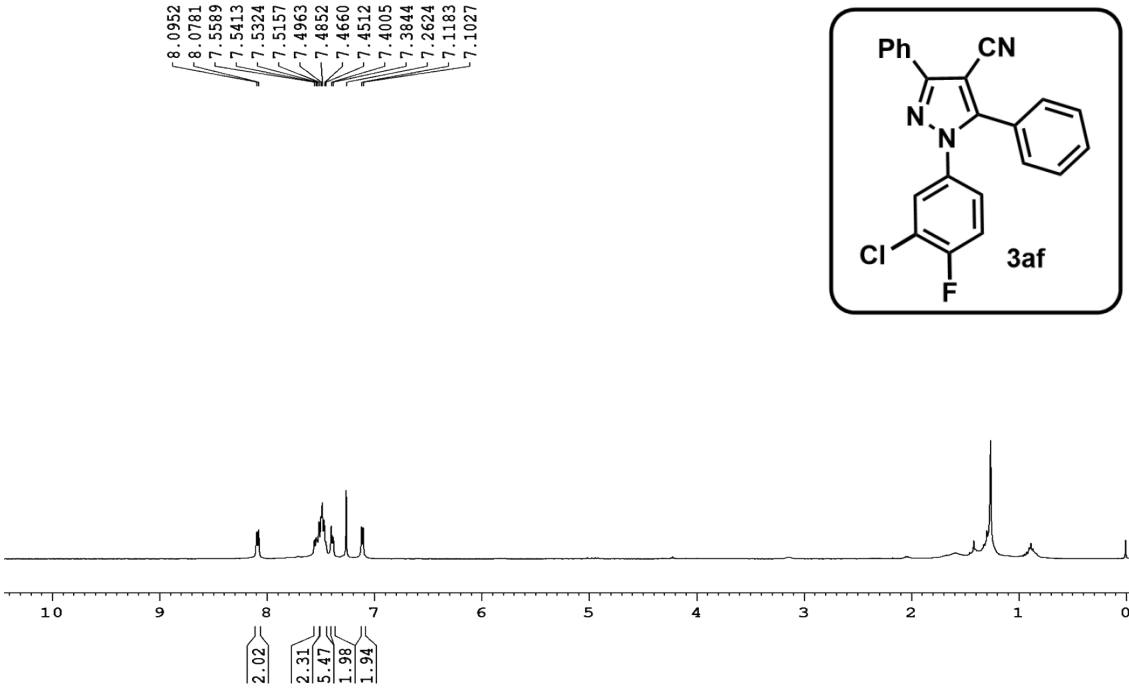


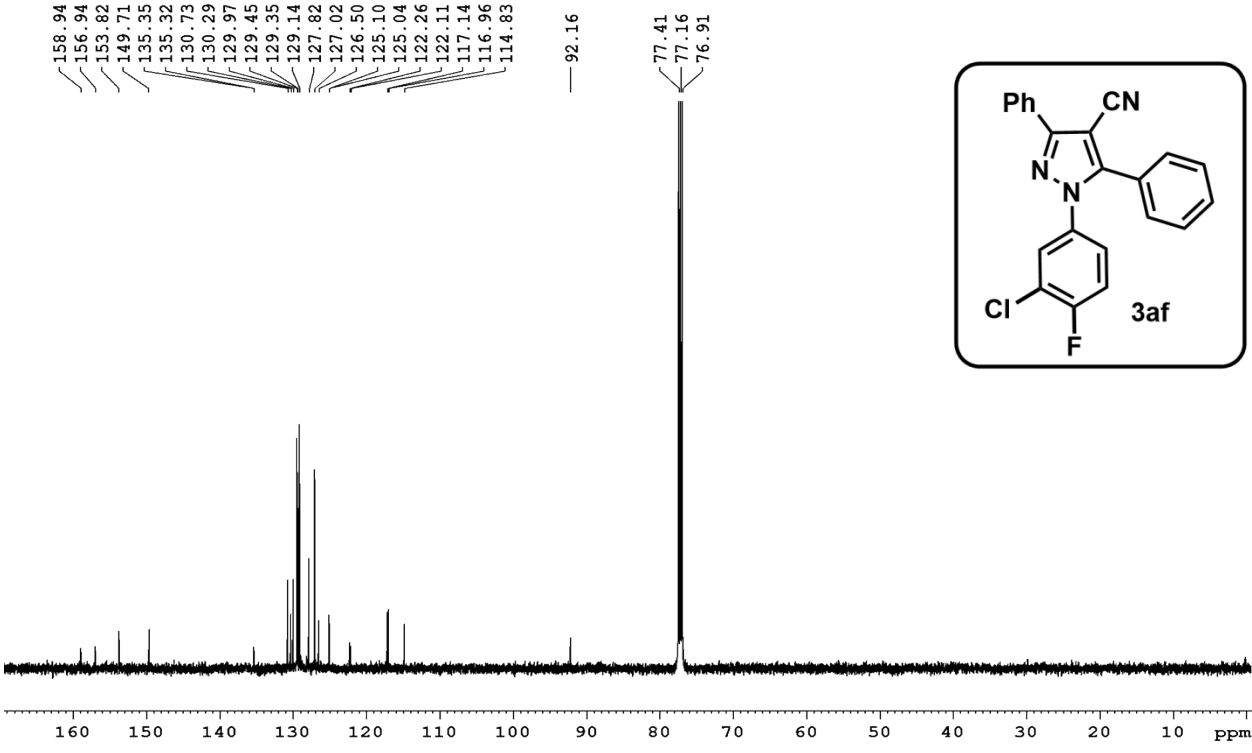
^{1}H NMR and ^{13}C NMR Spectra (3ae)



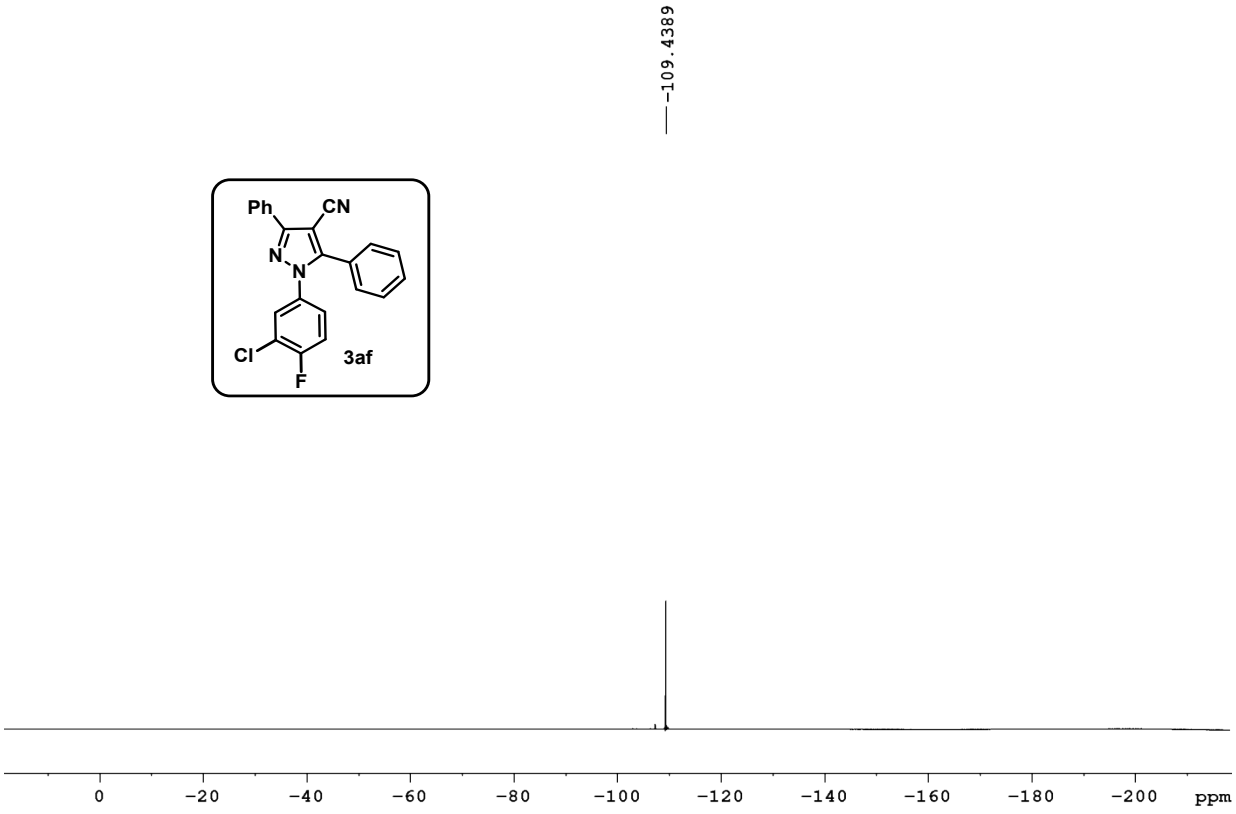


^{1}H NMR and ^{13}C NMR Spectra (3af)

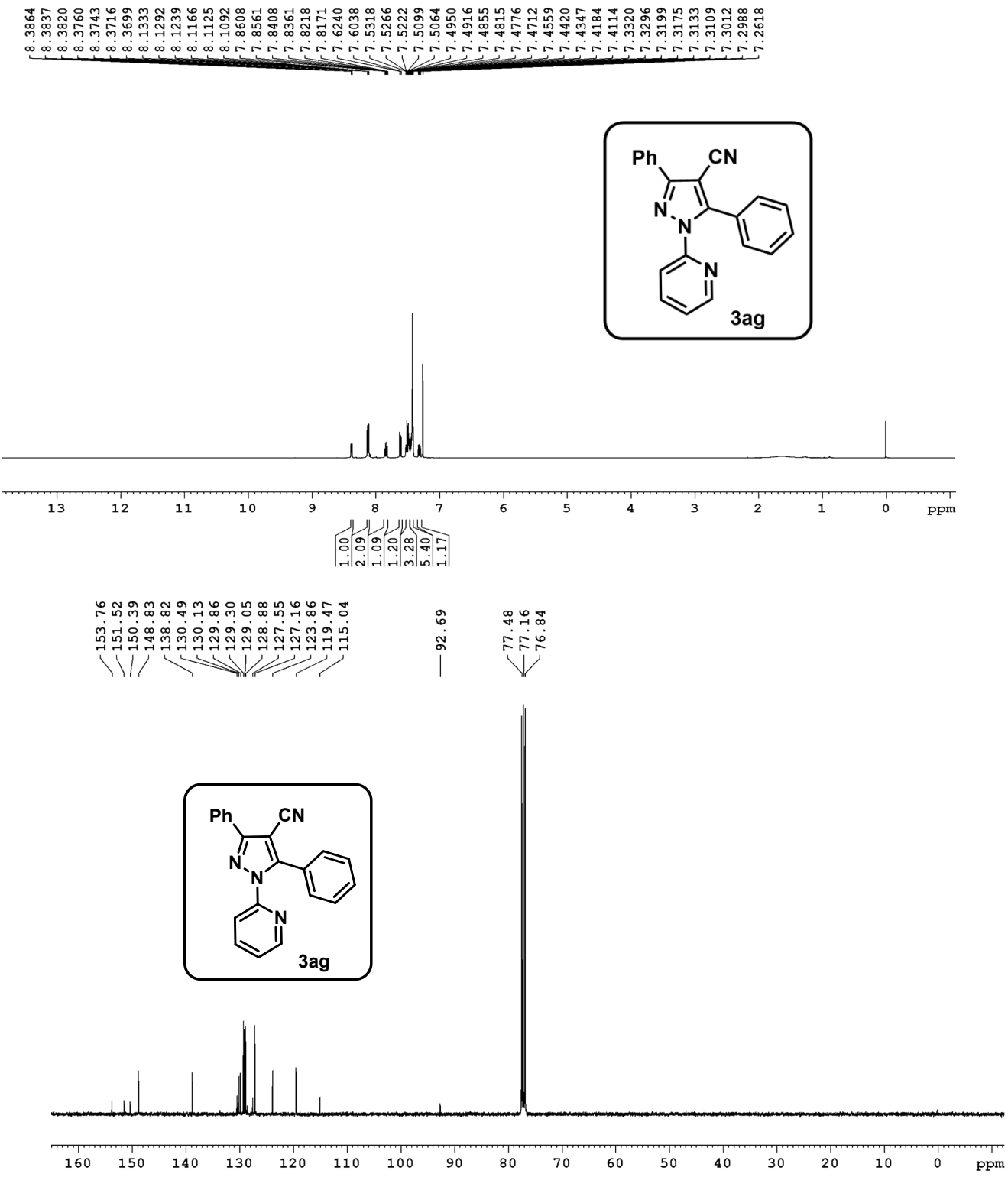




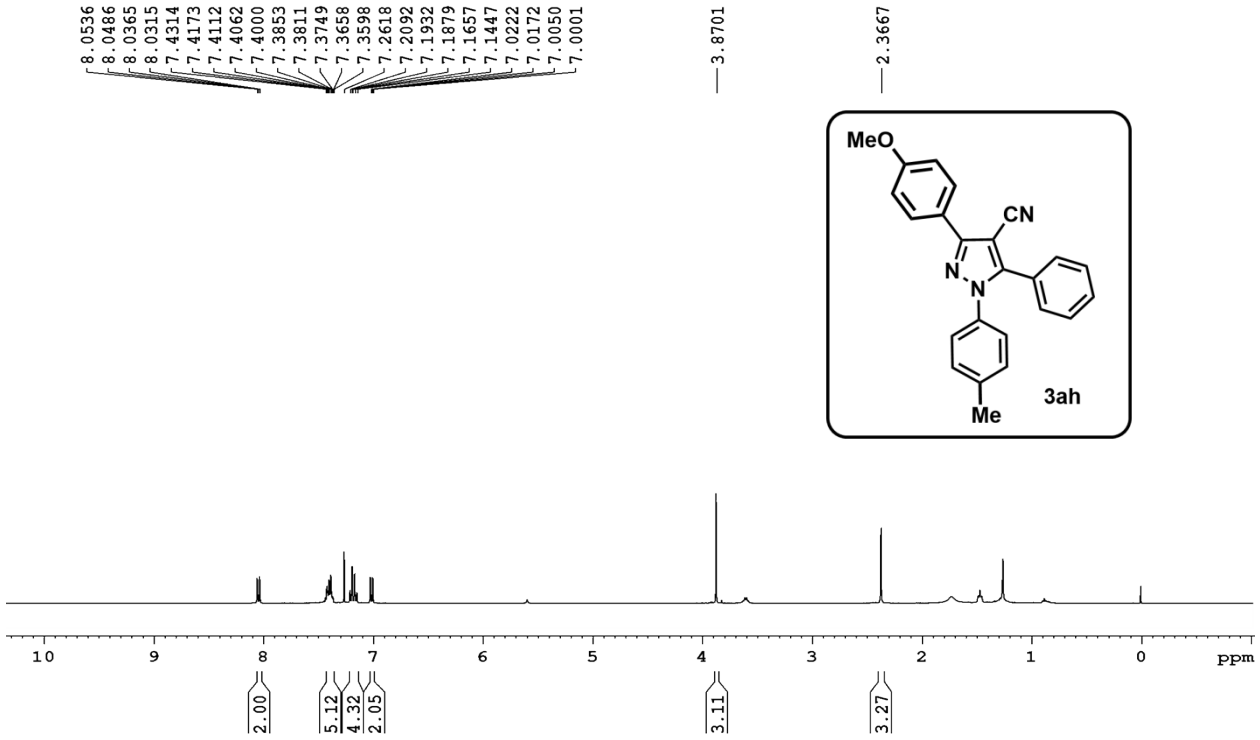
^{19}F NMR Spectra (3af)

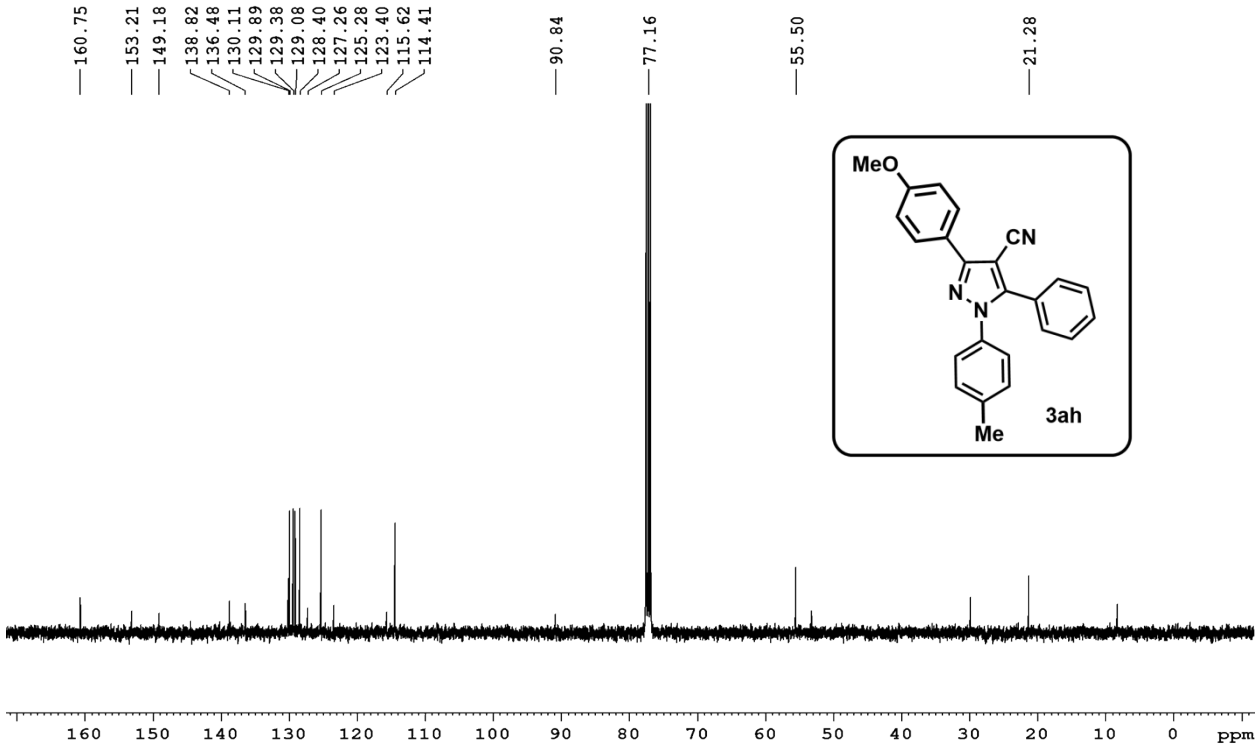


^{1}H NMR and ^{13}C NMR Spectra (3ag)

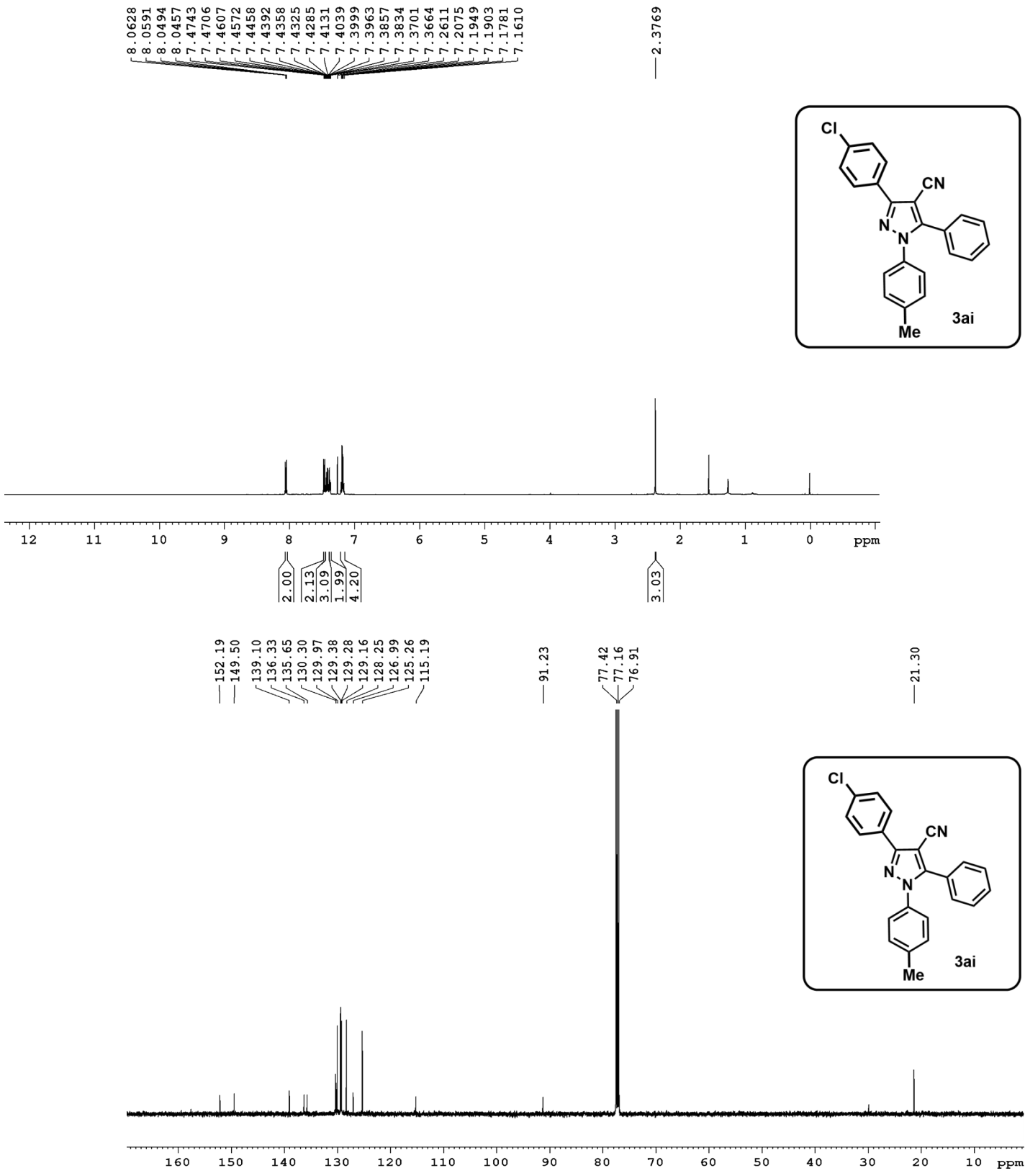


^{1}H NMR and ^{13}C NMR Spectra (3ah)

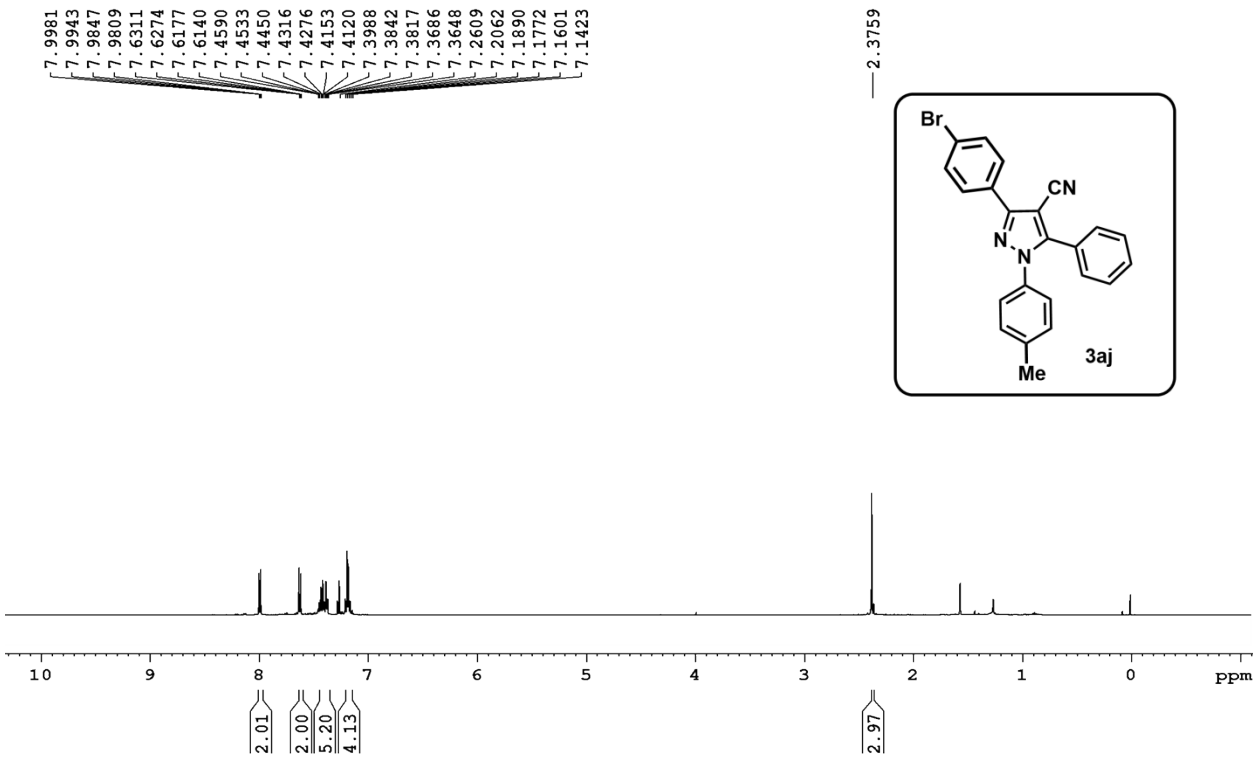


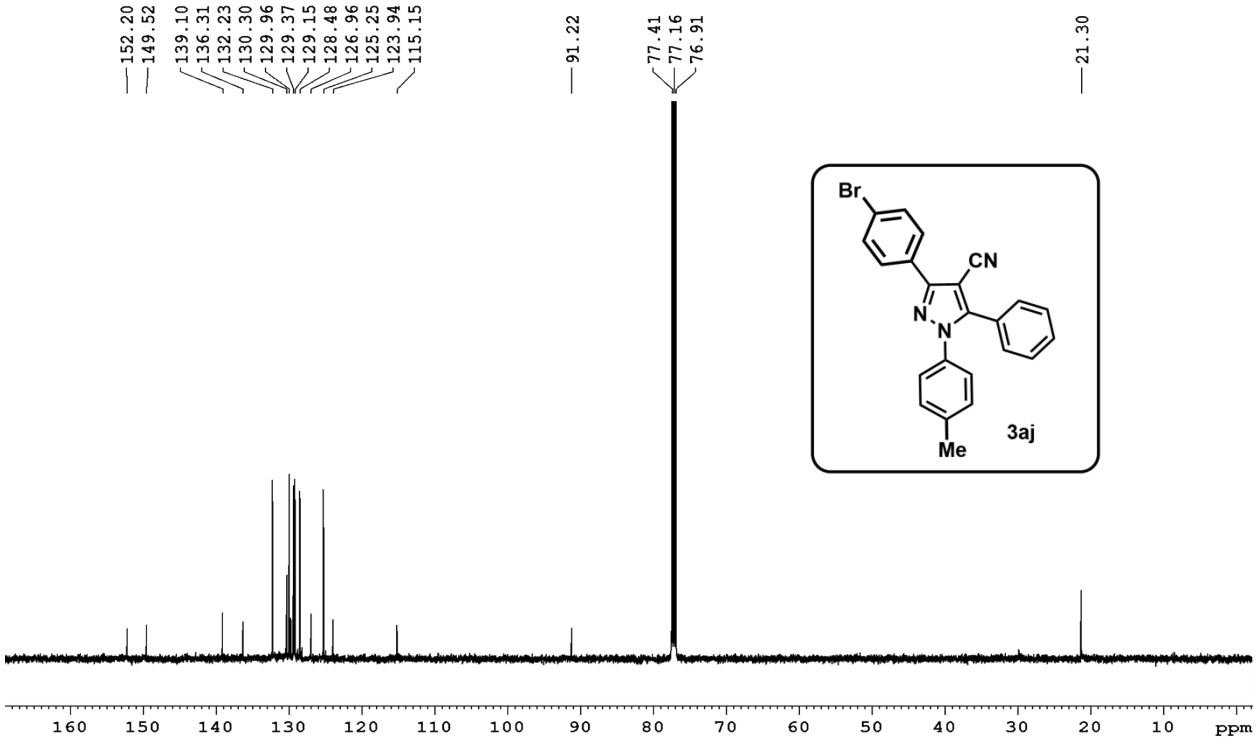


^{1}H NMR and ^{13}C NMR Spectra (3ai)

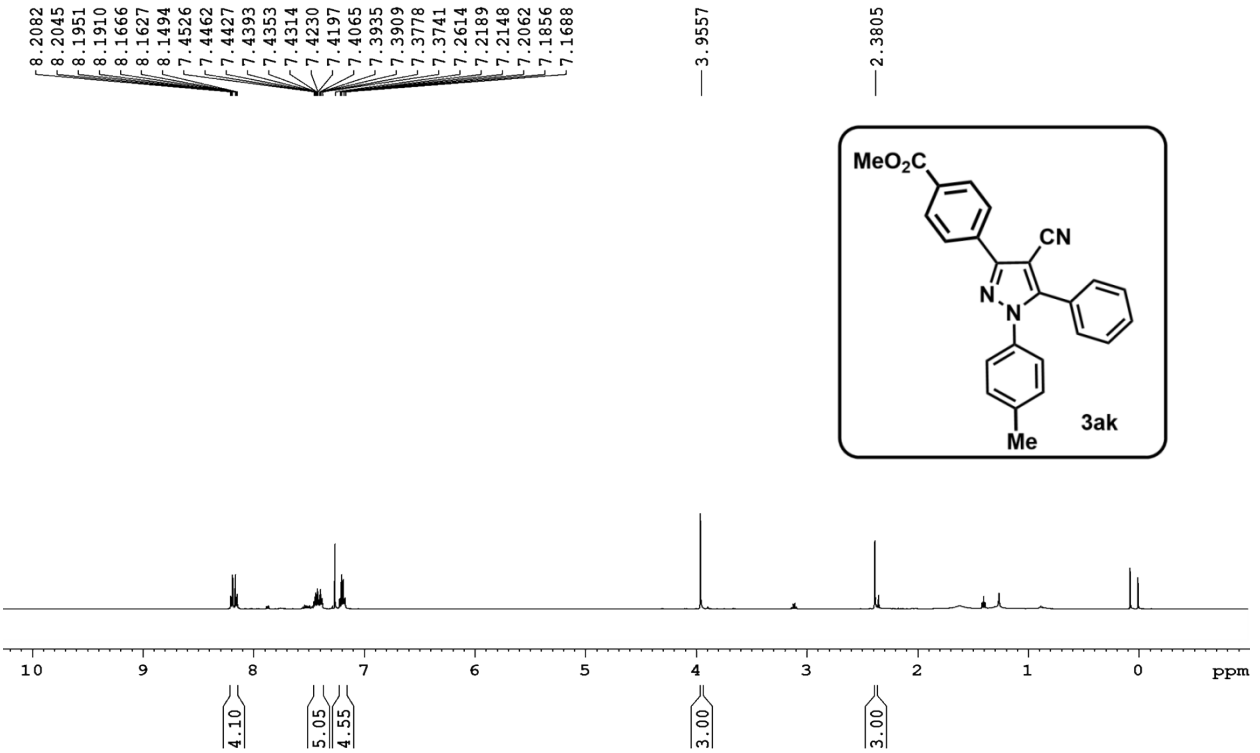


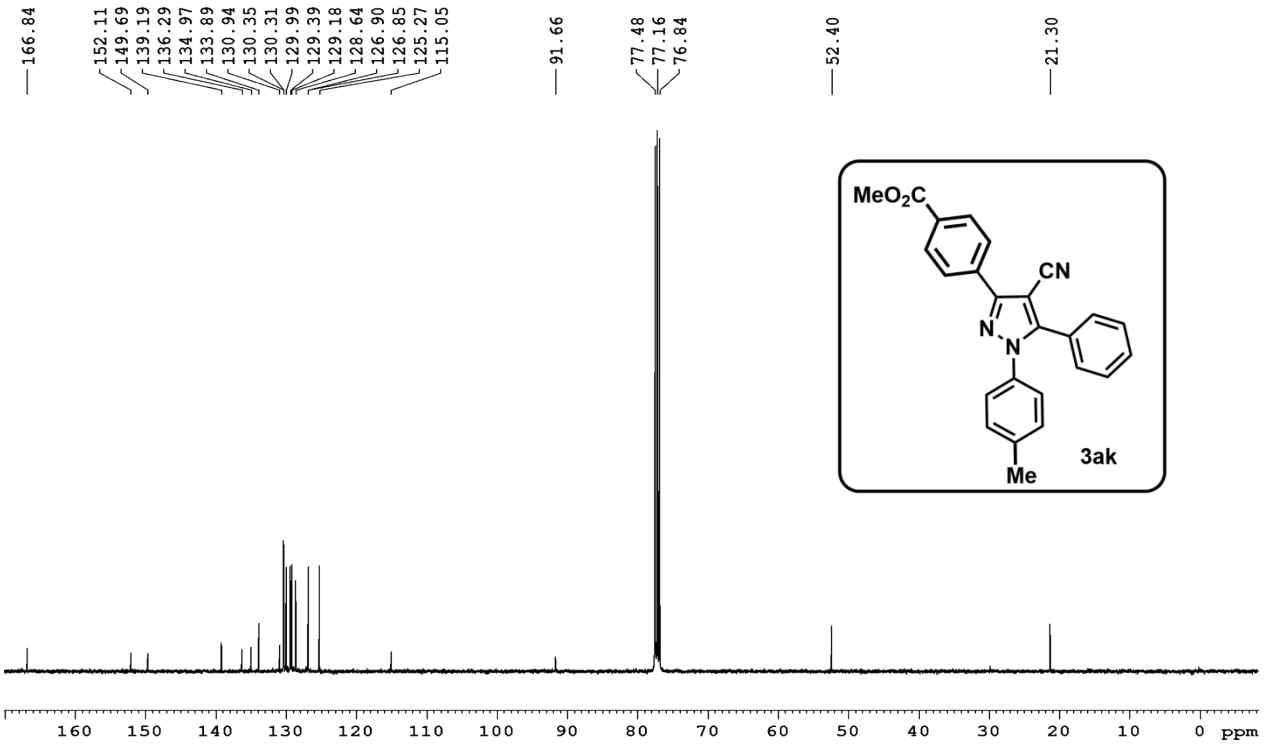
^{1}H NMR and ^{13}C NMR Spectra (3aj)



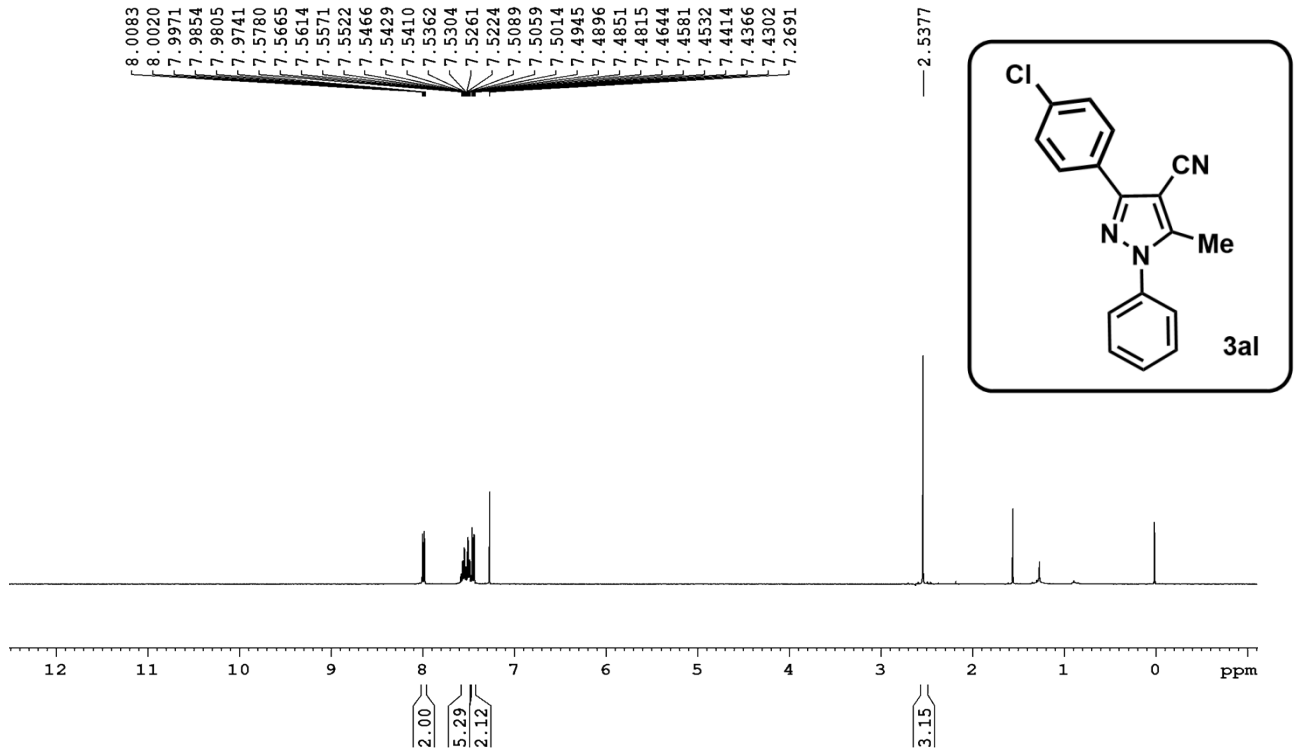


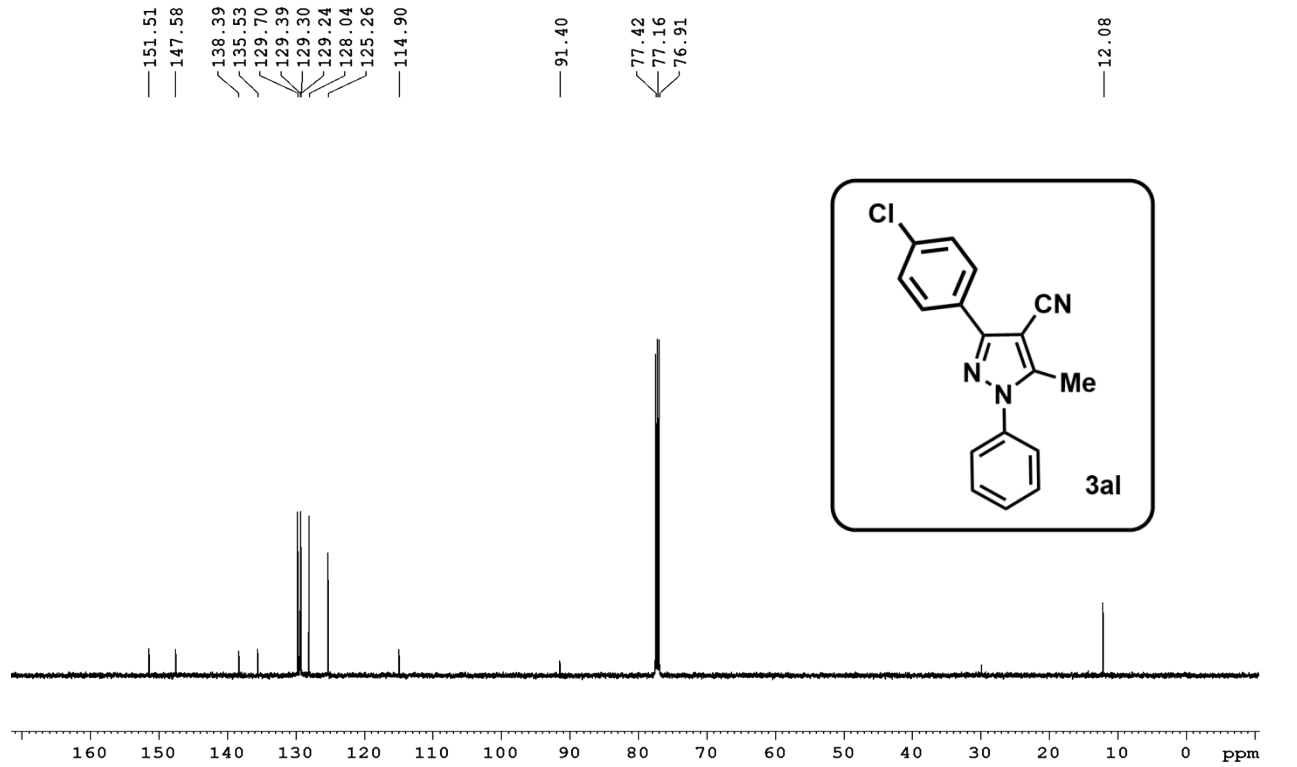
^{1}H NMR and ^{13}C NMR Spectra (3ak)



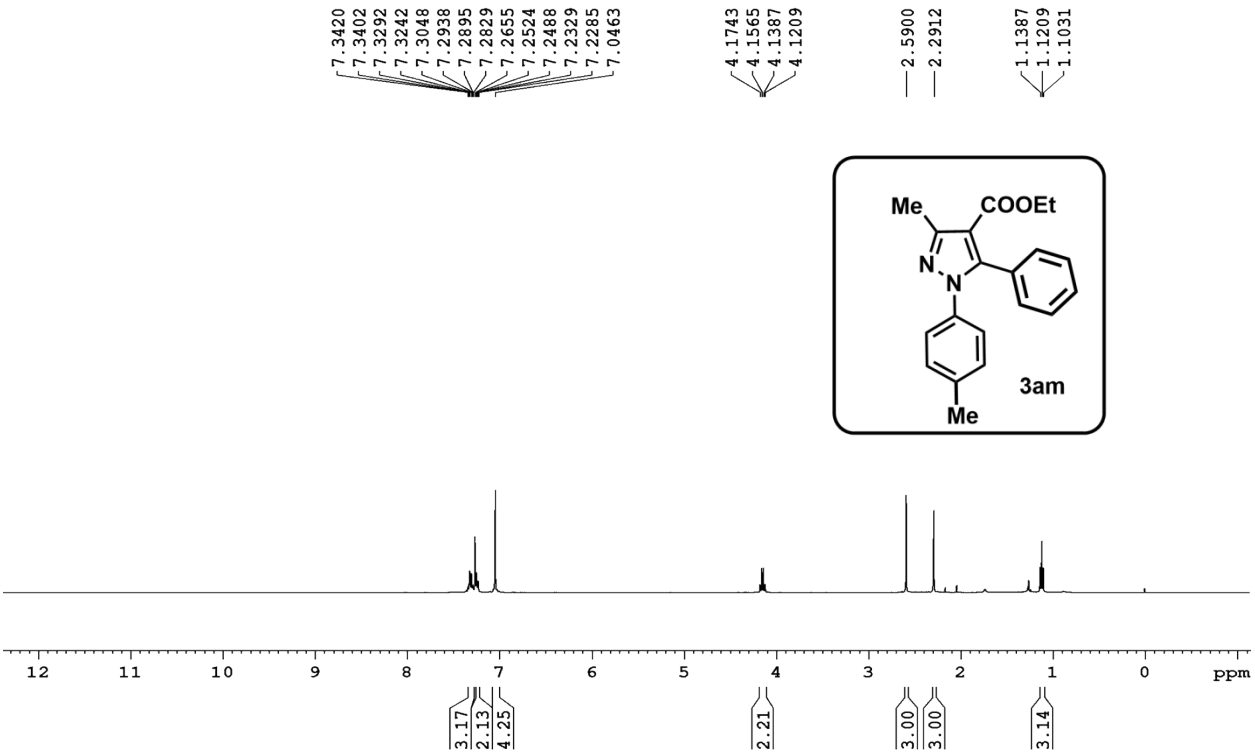


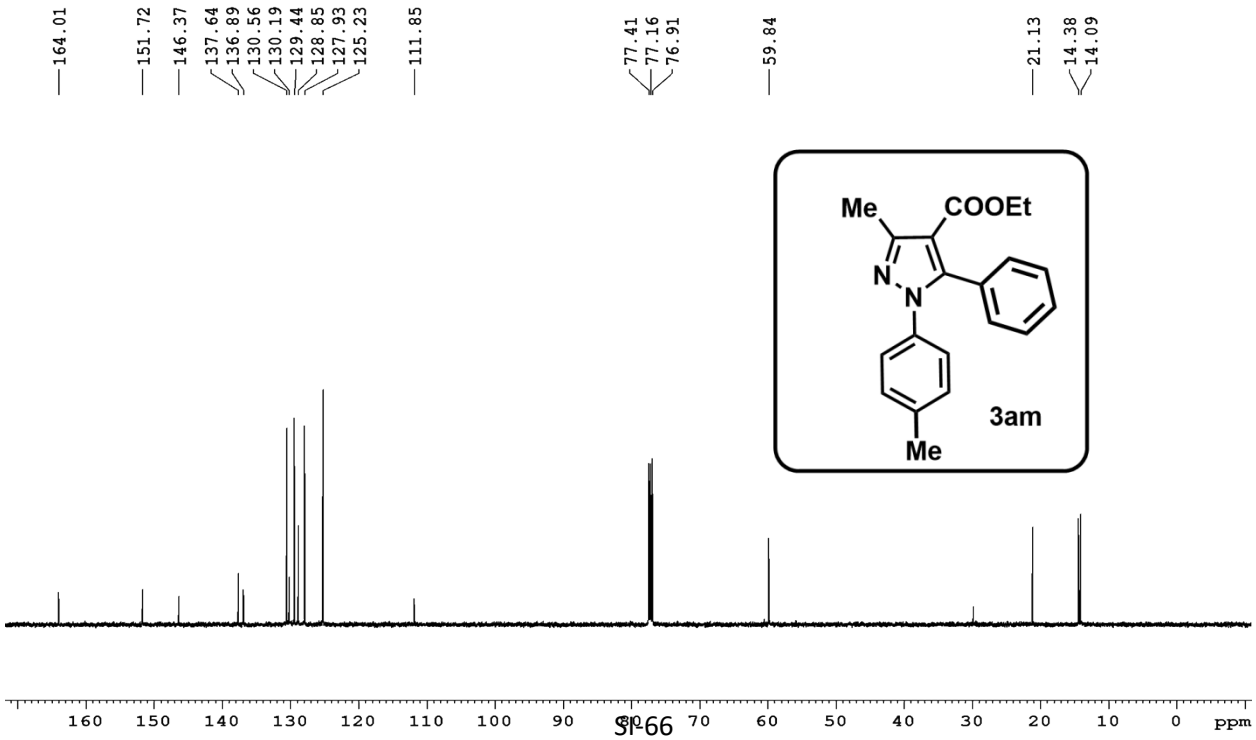
^{1}H NMR and ^{13}C NMR Spectra (3al)



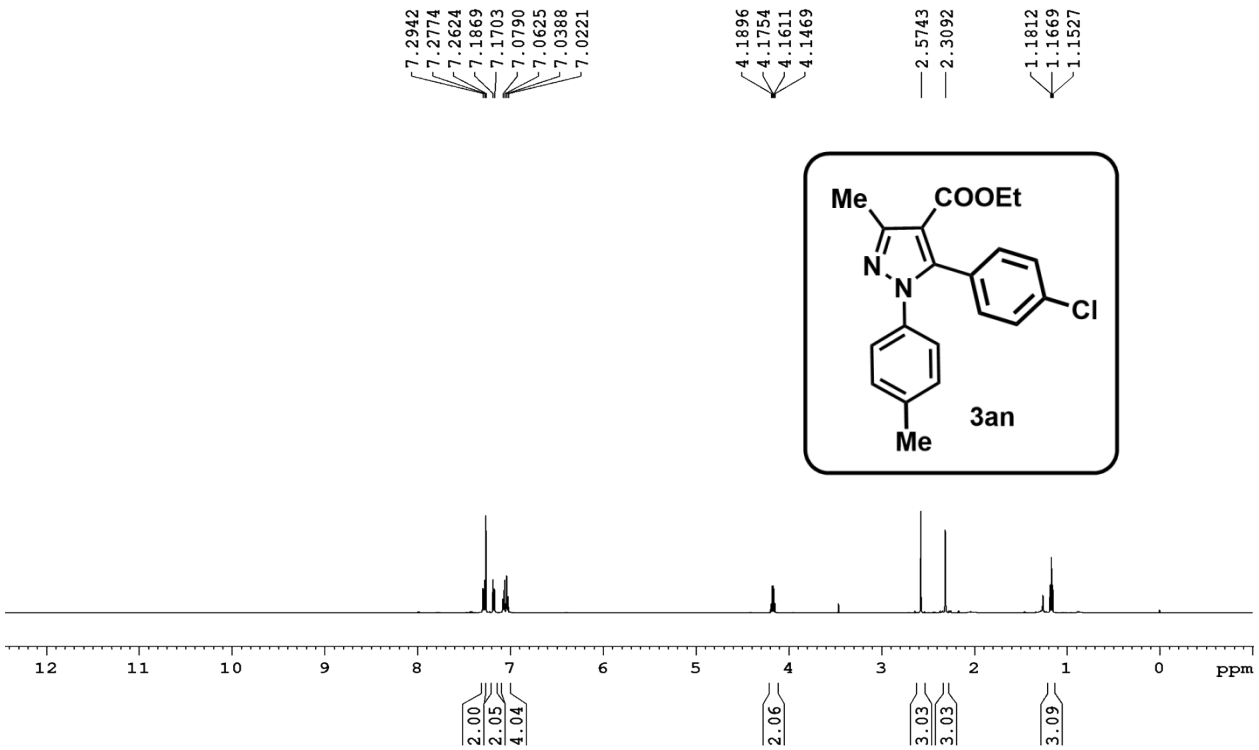


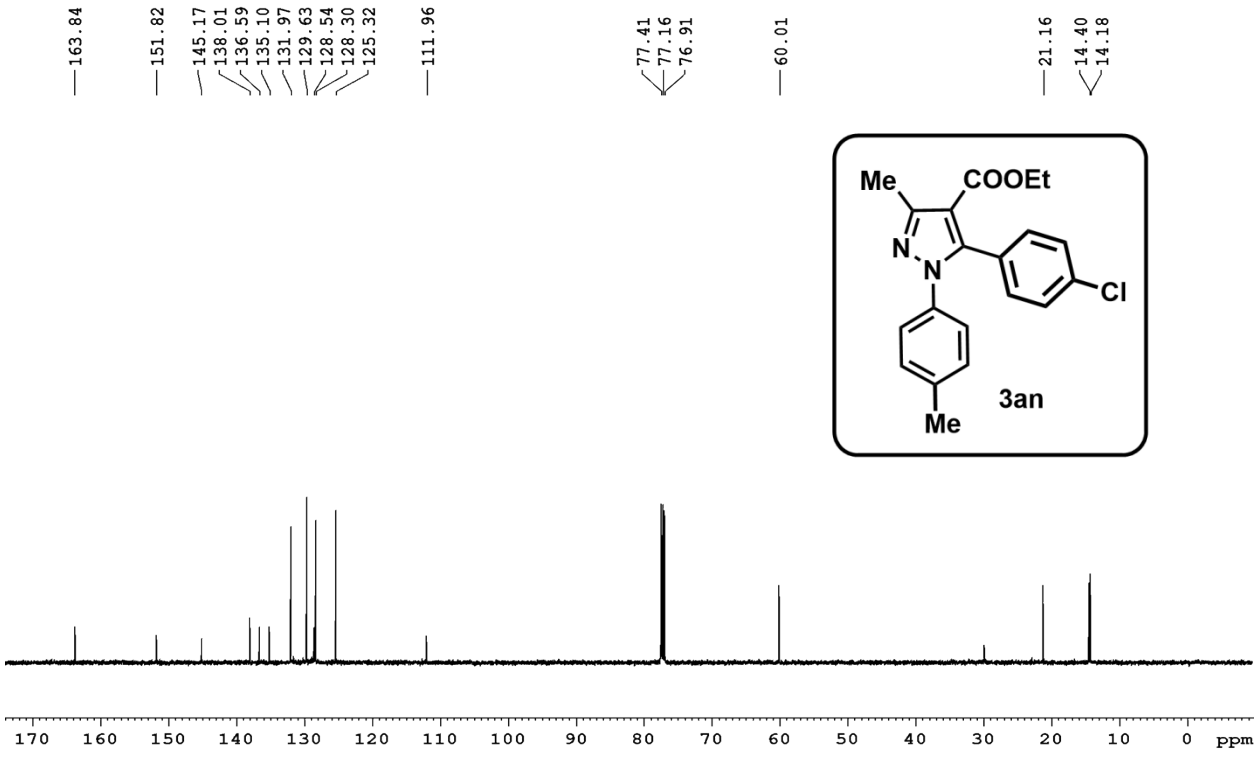
^{1}H NMR and ^{13}C NMR Spectra (3am)



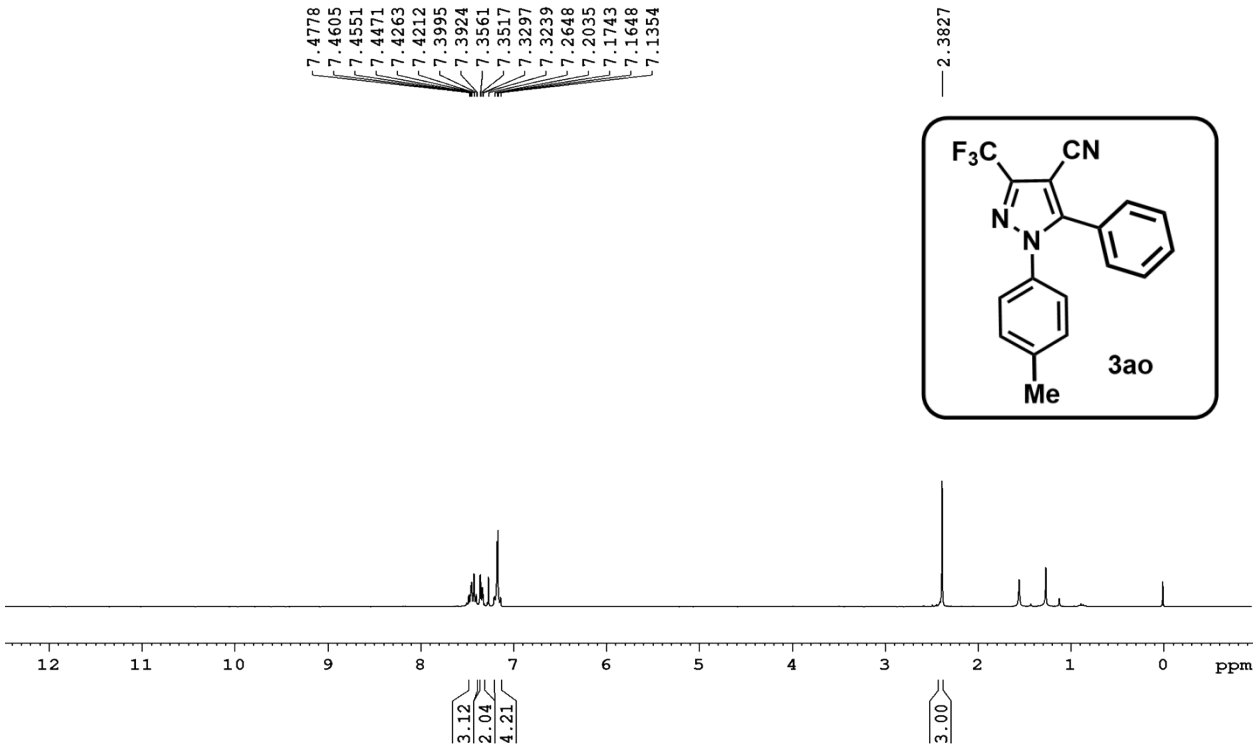


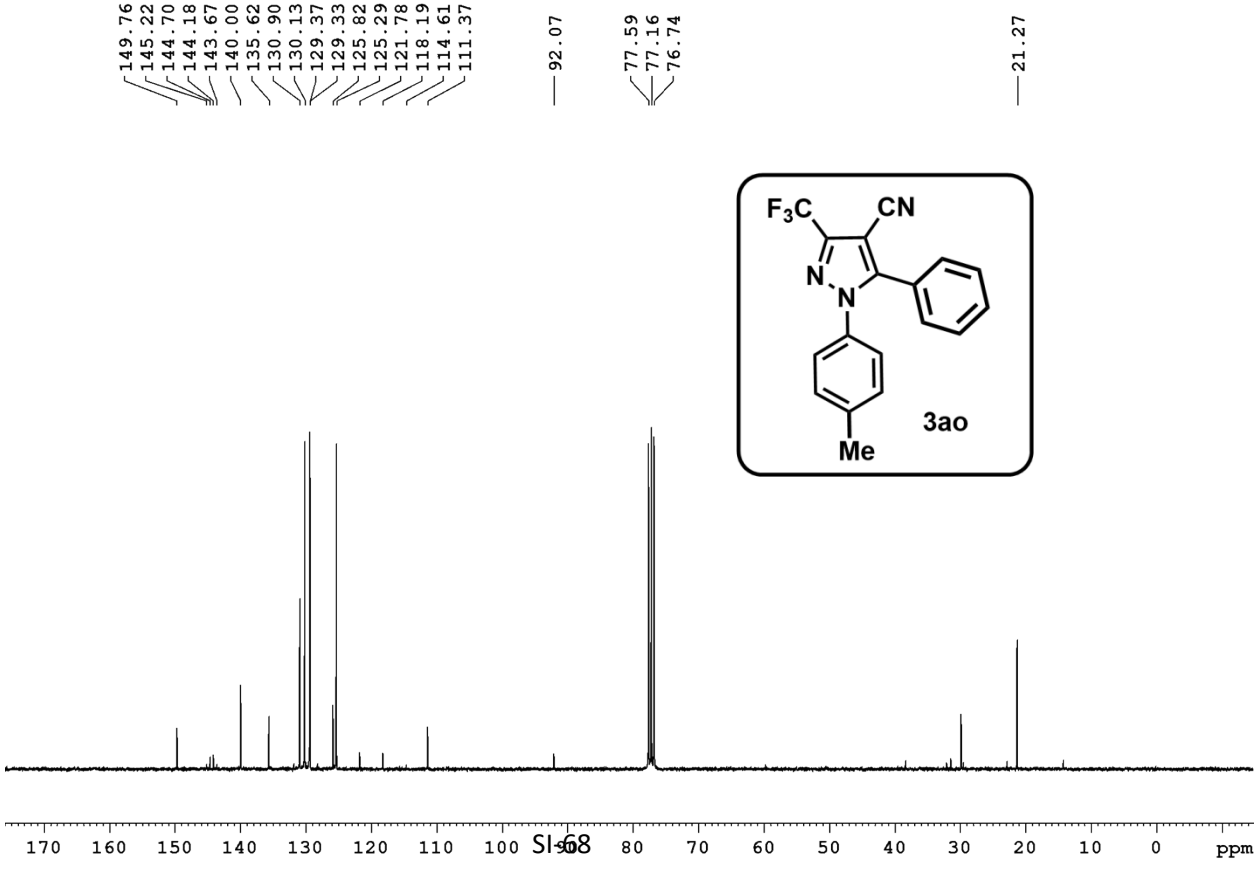
^{1}H NMR and ^{13}C NMR Spectra (3an)



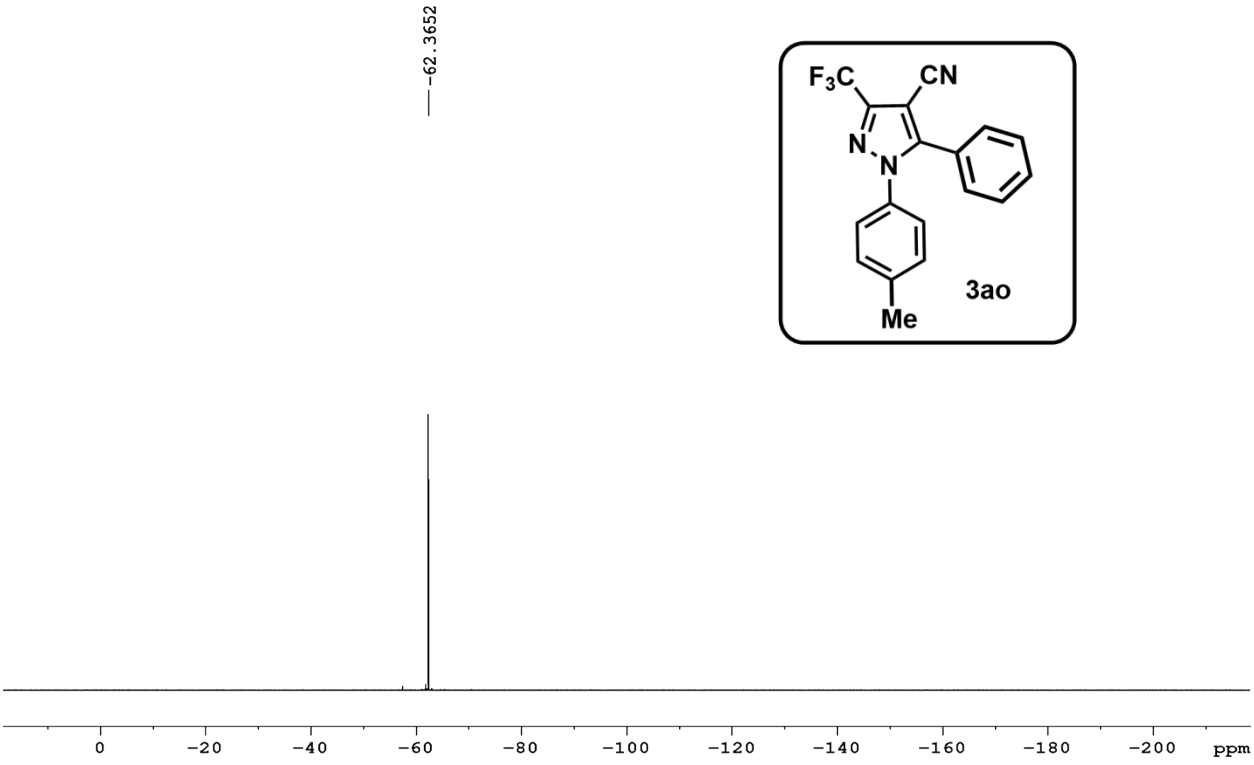


^{1}H NMR and ^{13}C NMR Spectra (3ao)

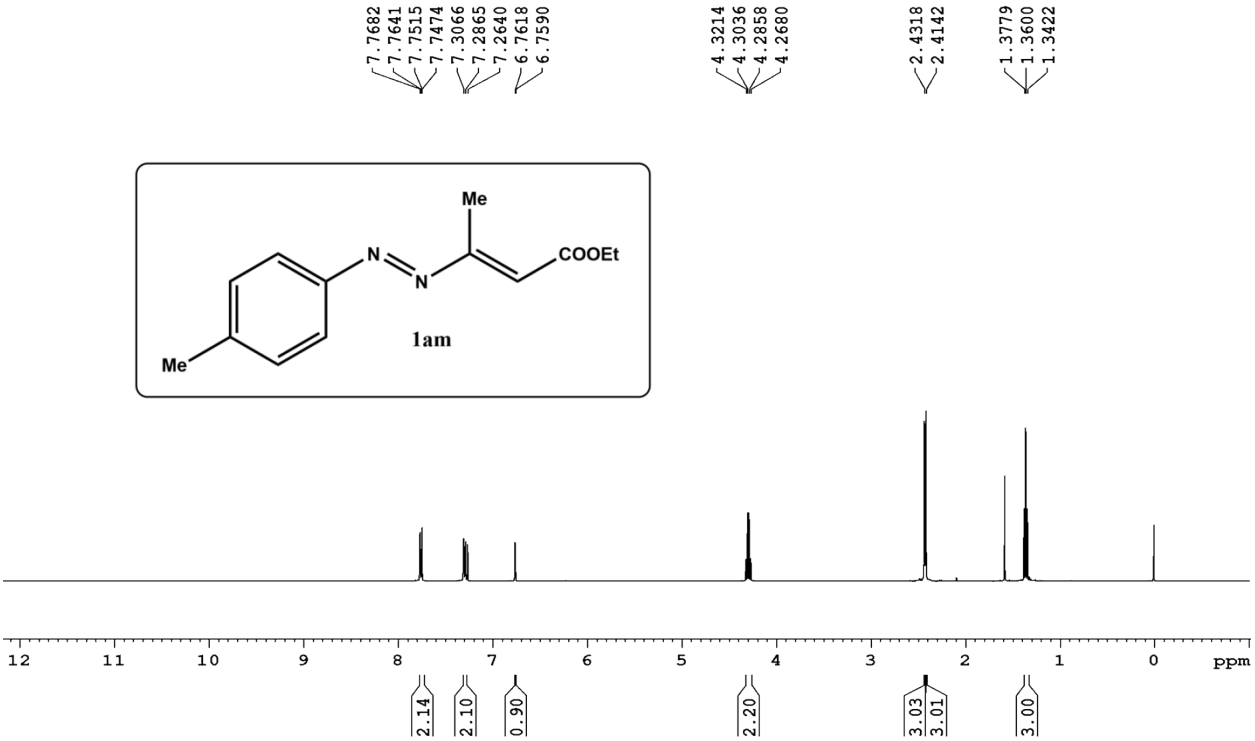


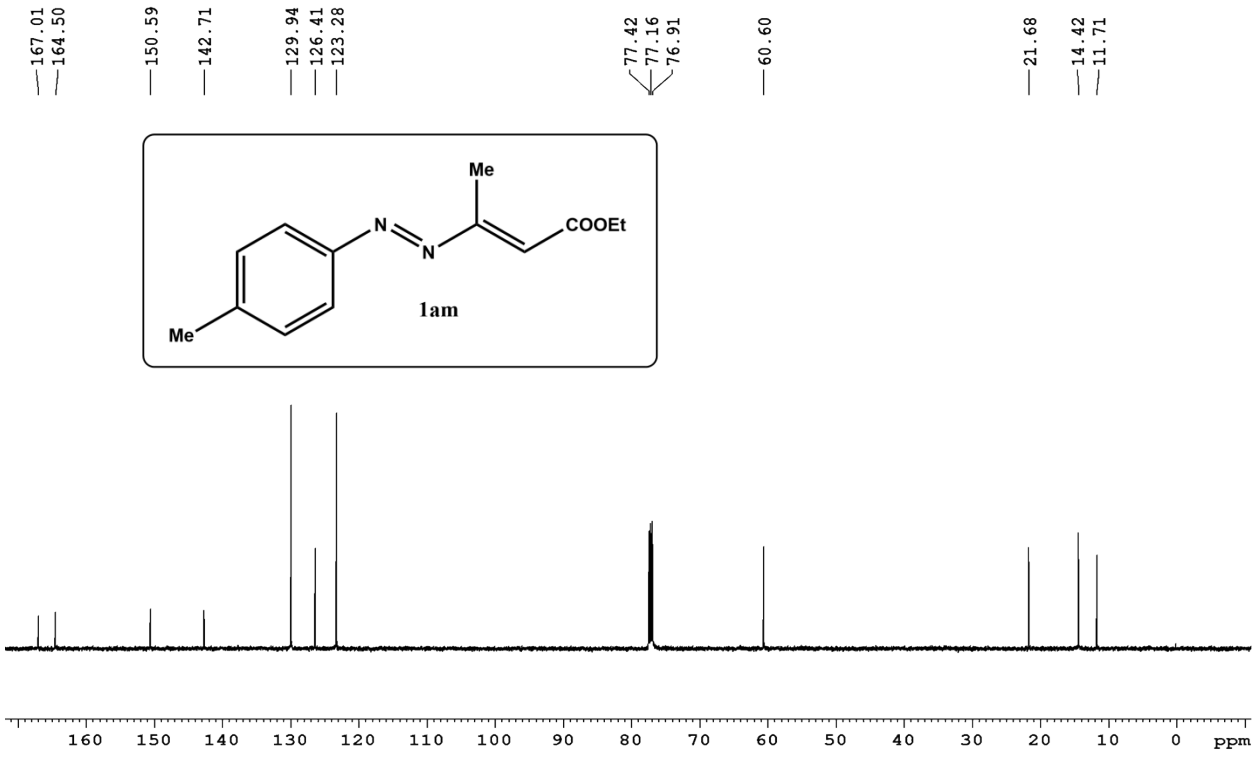


^{19}F NMR Spectra (3ao)

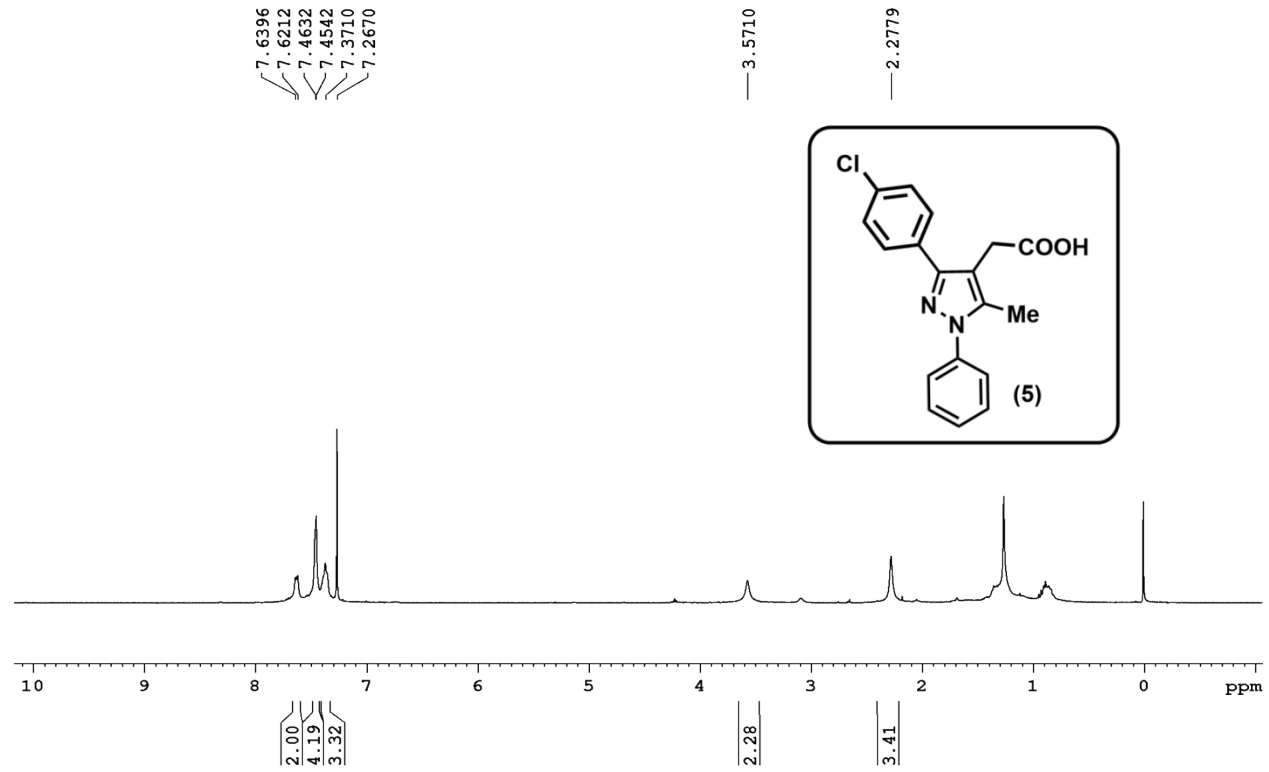


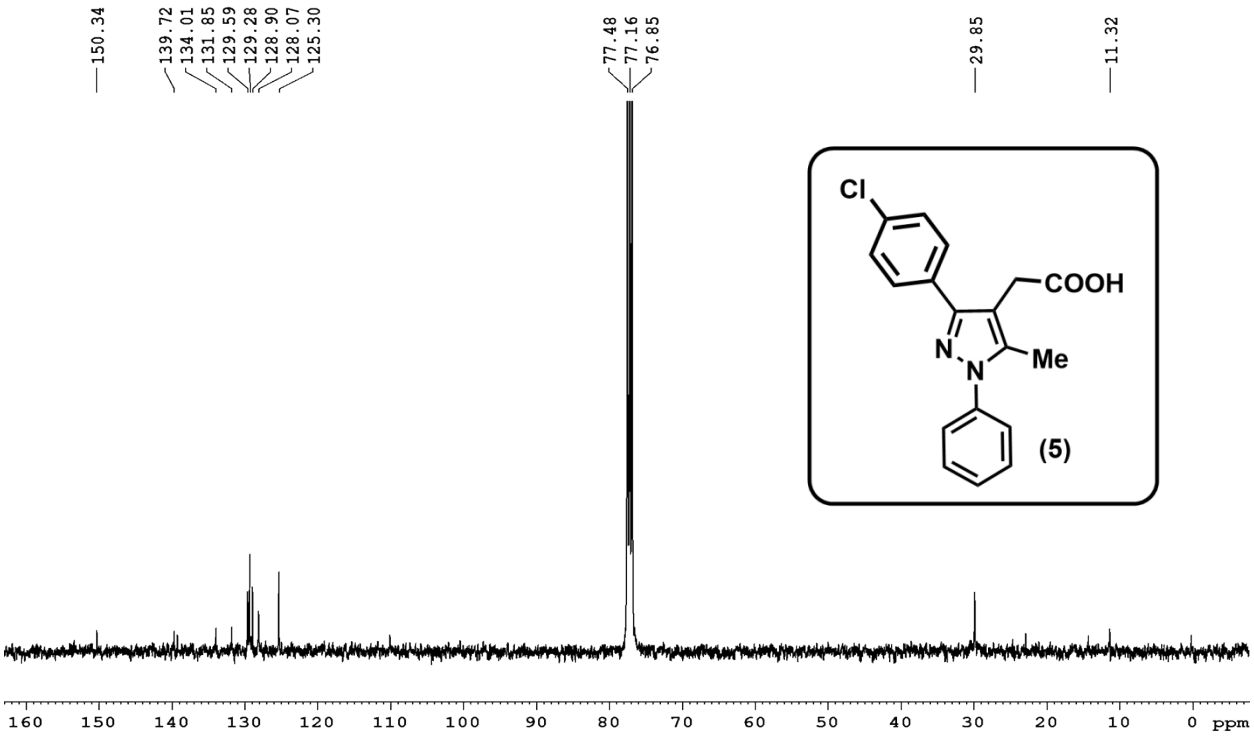
^{1}H NMR and ^{13}C NMR Spectra (1am)



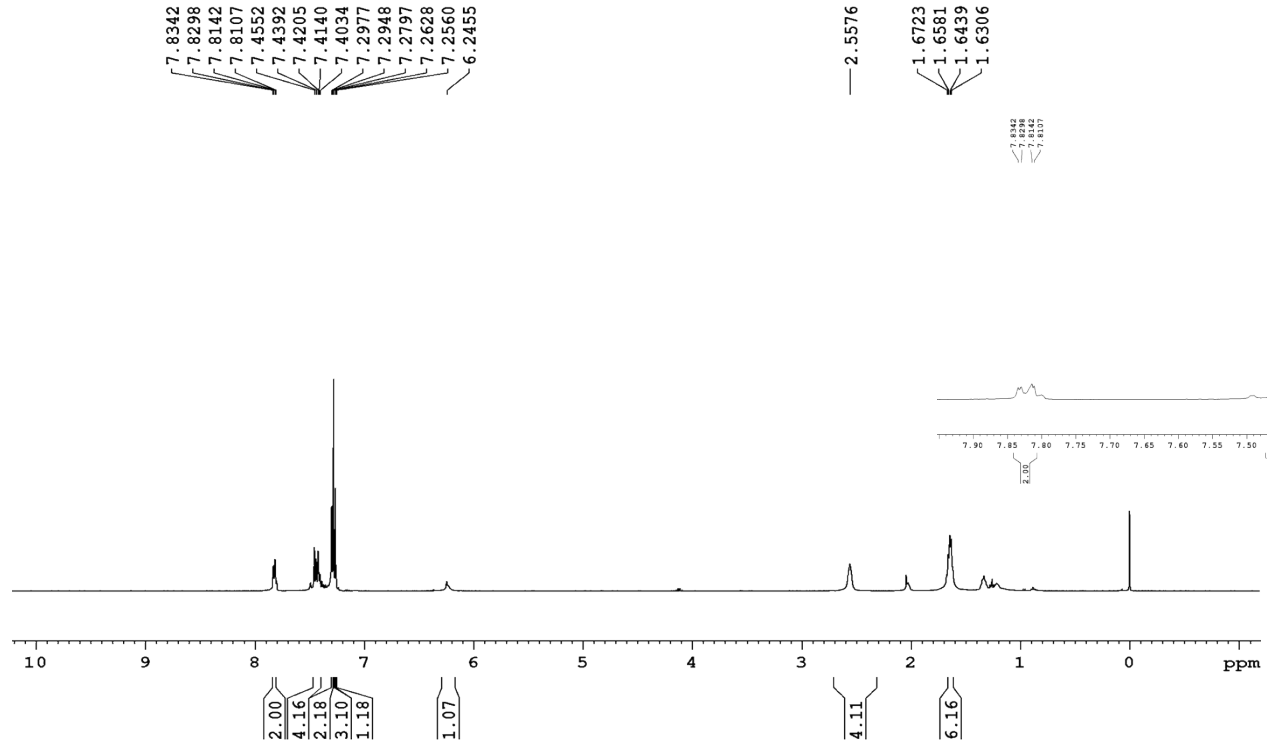


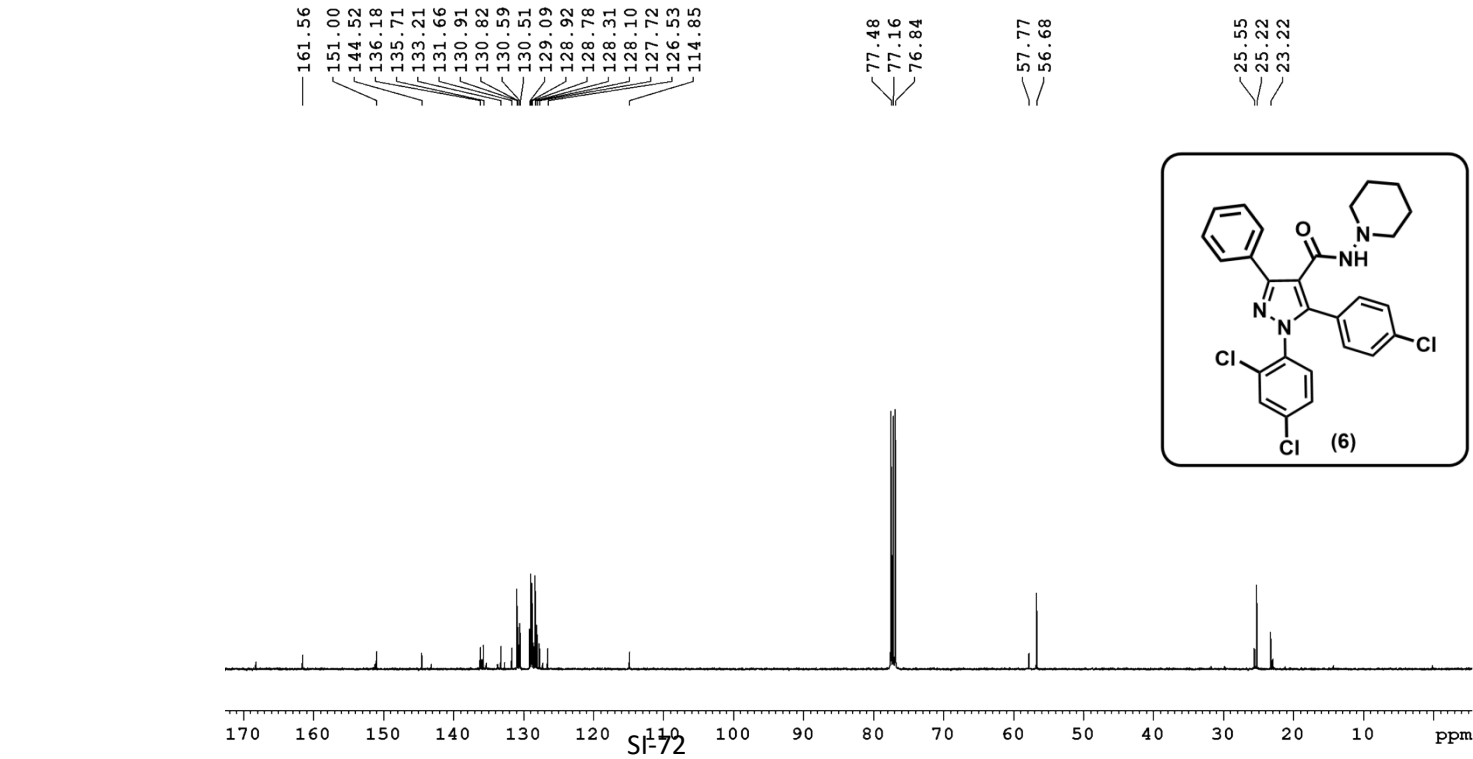
^{1}H NMR and ^{13}C NMR Spectra (5)

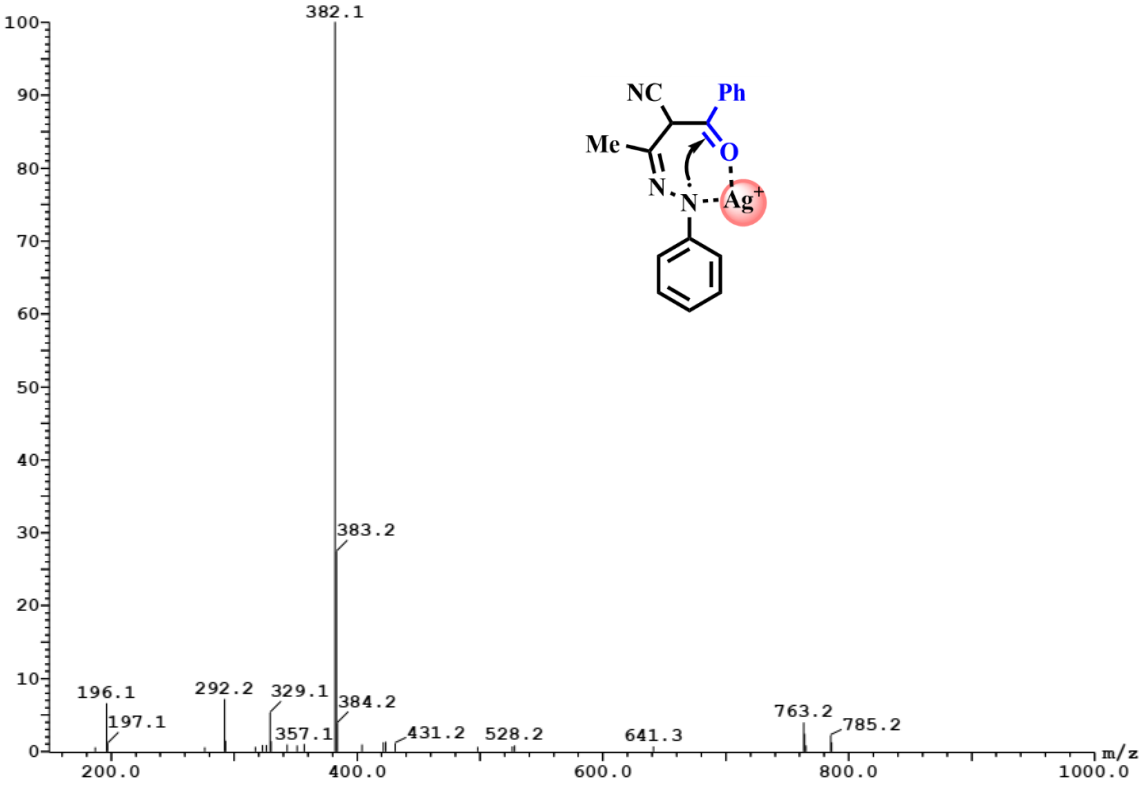


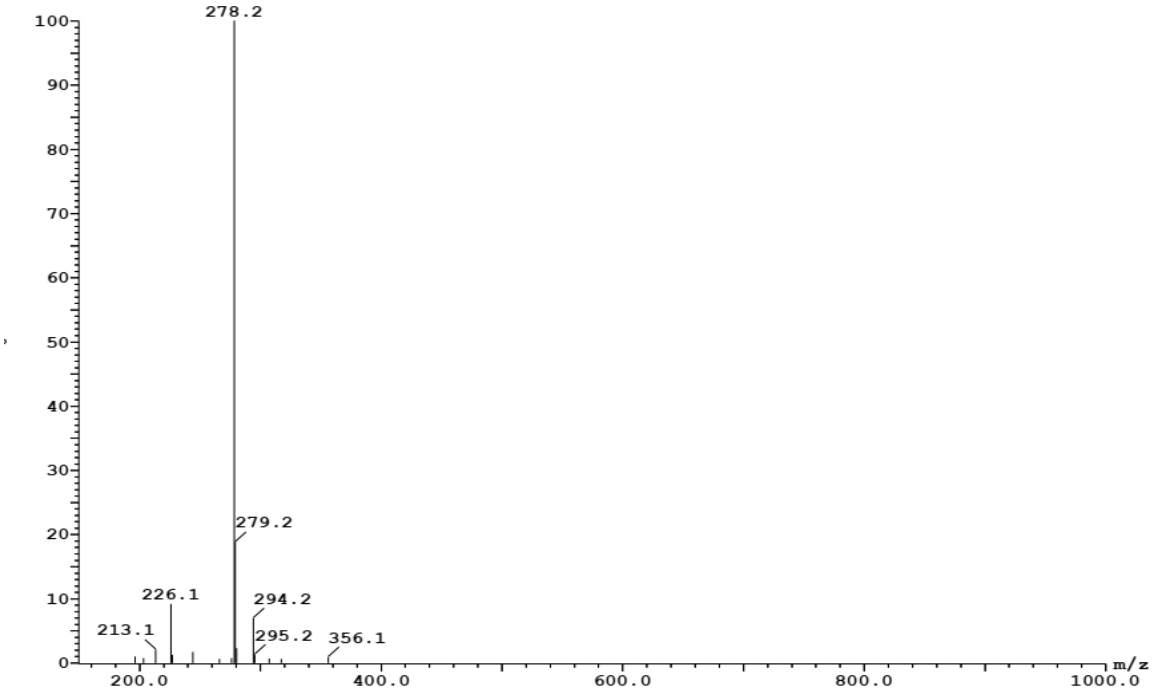


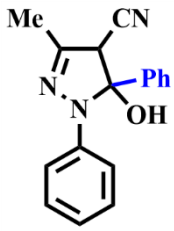
^{1}H NMR and ^{13}C NMR Spectra (6)



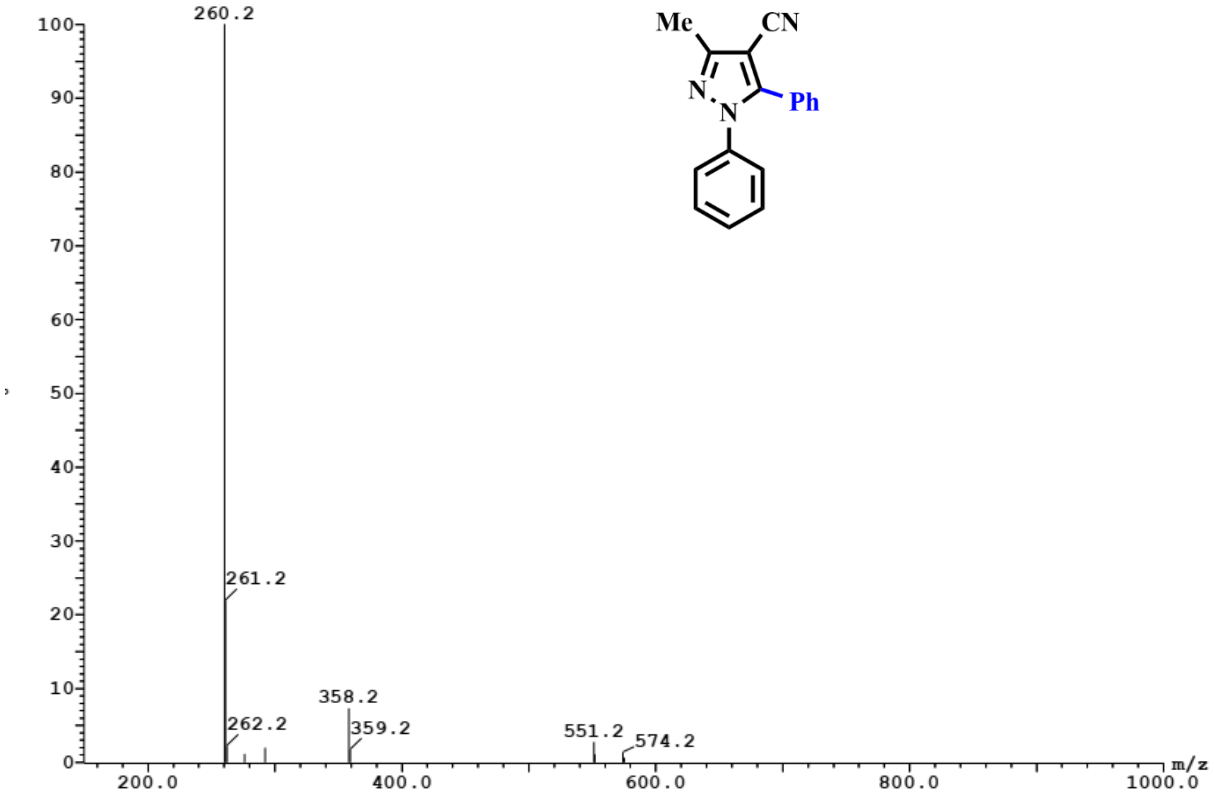



382.1
383.2
196.1
197.1
292.2
329.1
357.1
384.2
431.2
528.2
641.3
763.2
785.2
m/z
NC
Ph
Me
O
N
N
Ag+


278.2
279.2
226.1
213.1
294.2
295.2
356.1
m/z


Me
CN
Ph
OH
N
N

S.


260.2
261.2
262.2
358.2
359.2
551.2
574.2
Me
CN
Ph
N
N
100
90
80
70
60
50
40
30
20
10
0
200.0
400.0
600.0
800.0
1000.0
m/z